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EEVA RANTALA

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Intervention implementation, acceptability, and effectiveness

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ABSTRACT

Background: Healthy eating and physical activity are lifestyle behaviours which are essential for wellbeing and health, and for the prevention and treatment of many chronic conditions, such as obesity and type 2 diabetes. Efforts to promote the adoption and maintenance of healthy lifestyles have mainly targeted reflective, intra-individual processes related to motivation or capability. Lifestyle behaviours, however, often occur automatically, with little deliberation, influenced by the surrounding environment. The choice architecture framework (aka "nudge") aims to support behaviour change by modifying the environments in which behaviours take place. The framework holds potential for population-level health promotion, but little is known of real-world implementation, acceptability, and effectiveness.

Aims: This dissertation consists of four empirical studies that aimed to evaluate the implementation (Study I), acceptability (II), and effectiveness (III–IV) of choice architecture modification for healthy eating and daily physical activity at the workplace. The work was conducted under the umbrella of a type 2 diabetes prevention study, Stop Diabetes (StopDia).

Methods: The studies were based on a year-long quasi-experimental pre-post intervention, StopDia at Work, which was tailored to and integrated into the routine operations of diverse worksites (n=53) in

collaboration between the research team and the sites. In addition, a sub-intervention at one worksite cafeteria more closely examined a subset of intervention strategies used in the main trial. The outcomes reflected the fidelity (i.e., dose and quality) and the facilitators and barriers of implementation; acceptance among implementers and influenced employees; and effectiveness on food consumption and physical activity patterns at work, intervention perception and response, and visual attention and food choices at the worksite cafeteria. The studies used qualitative and quantitative methods to analyse data collected by interviews, observation, questionnaires, eye tracking, and by weighing of foods consumed.

Results: In total the intervention sites implemented 23 choice architecture strategies (median 3, range 0–14). Targeted contexts included coffee rooms, meetings, worksite cafeterias, stairs, and other common spaces at the worksite. The strategies modified the availability, information, position, presentation, functionality, or size of choice options or aimed at supporting self-regulation. Two thirds of the implementations were rated as successful. The implementation was influenced by numerous facilitators and barriers related to the organisation, intervention, worksite environment, and implementer. Acceptance was high among the implementers and employees. However, factors were also identified that could reduce acceptance. Among the implementers, these involved personal preferences, poor understanding of the intervention, perceived burden (particularly at the beginning of the intervention), perceived ineffectiveness, and costs of intensive implementation. Among employees, intrusive intervention strategies and a high proportion of male employees per site predicted lower acceptance. The strongest evidence of effectiveness concerned fruit and berry consumption at work, which was more common post vs. pre intervention. This finding was related to the use of intervention strategies that reduced the physical effort required to choose and consume fruit or berries at work, and with an implementation that targeted several eating-related contexts at the worksite. The effectiveness was estimated based on the interaction effect of time (post vs. pre intervention) and site-specific implementation (dose×quality).

Positive associations emerged between the quality of implementation and visual attention to, the perceptions of, and/or responses to specific strategies that relied on visual cues. Strategy effectiveness, however, seemed dependent on the target audience's preferences and habits.

Conclusions: A contextualised, multicomponent choice architecture intervention for healthy eating and daily physical activity at the workplace proved feasible for implementation, was well accepted, and appeared capable of positively influencing health behaviour in diverse real-world settings over a one-year period. Results also indicated that a high-quality implementation can enhance the perception of and response to the intervention. The choice architecture framework could complement conventional, individual-level approaches to promote healthy lifestyles. For interventions to be successful and sustained, however, their content and implementation must be carefully designed, considering the target context and audience.

Keywords: choice architecture, nudge, food choice, food consumption, eating behaviour, physical activity, lifestyle, behaviour change, health promotion, prevention, type 2 diabetes, workplace, cafeteria, intervention, feasibility, implementation, acceptability, effectiveness, real-world research, mixed methods, eye tracking, Stop Diabetes, StopDia

Rantala, Eeva
Terveyttä edistävää syömistä ja arkiaktiivisuutta edistävä valinta-arkkitehtuuri työpaikalla: interventiotutkimuksen toimeenpano, hyväksyttävyys ja vaikuttavuus
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TIIVISTELMÄ (ABSTRACT IN FINNISH)

Tausta: Terveyttä edistävä syöminen ja fyysinen aktiivisuus ovat edellytyksiä hyvinvoinnille ja terveydelle sekä monien kansanterveys-ongelmien, kuten lihavuuden ja tyypin 2 diabeteksen, ehkäisylle ja hoidolle. Terveyttä tukevia ruoka- ja liikkumistottumuksia on edistetty pääasiassa yksilön tietoiseen harkintaan, motivaatioon ja kykyihin vaikuttamalla. Syömiseen ja liikkumiseen liittyvä toiminta on kuitenkin suurelta osin automaattista ja herkkää ympäristön vaikutuksille. Valinta-arkkitehtuurin muokkaaminen eli tuuppaus on käyttäytymisen muutokseen tähtäävä lähestymistapa, joka kohdistuu valintatilanteessa saatavilla oleviin vaihtoehtoihin tai tapaan, jolla vaihtoehdot tarjotaan. Lähestymistapa on osoittautunut lupaavaksi väestötasoiseen terveyden edistämiseen, mutta tietoa toimeenpanosta, hyväksyttävyydestä ja vaikuttavuudesta tosielämän olosuhteissa on vähän.

Tavoitteet: Tämä väitöstutkimus koostuu neljästä osatyöstä, joiden tavoitteena oli tutkia valinta-arkkitehtuurin muokkaamisen toimeenpanoa (osatyö I), hyväksyttävyyttä (II) ja vaikuttavuutta (III–IV) terveyttä edistävän syömisen ja arkiaktiivisuuden edistämisessä työpaikalla. Työt olivat osa tyypin 2 diabeteksen ehkäisytutkimusta Stop Diabetes (StopDia).

Menetelmät: Osatyöt perustuvat vuoden kestoiseen, ennen–jälkeen-asetelmassa toteutettuun StopDia töissä -interventiotutkimukseen ja sen alatutkimukseen työpaikkaravintolassa. Tutkimukseen osallistui 53 eri aloja edustavaa työyksikköä kolmen maakunnan alueelta. Intervention sisältö ja toimeenpano räätälöitiin kullekin työyksikölle ja suunniteltiin osaksi yksiköiden toimintaa. Osatyöt tarkastelivat toimeenpanon määrää (interventiokeinojen lukumäärä) ja laatua sekä edistäviä ja estäviä tekijöitä, hyväksyntää toimeenpanijoiden ja kohderyhmään kuuluneiden työntekijöiden keskuudessa sekä vaikuttavuutta työaikaisiin ruoka- ja liikkumistottumuksiin, intervention havaitsemiseen ja interventioon reagoimiseen sekä visuaaliseen tarkkaavaisuuteen ja ruoanvalintaan työpaikkaravintolassa. Tulokset perustuvat haastatteluin, havainnoimalla, kyselyin, katseenseurannalla ja ruoan menekkiä mittaamalla kerättyyn aineistoon, jota analysoitiin laadullisin ja määrällisin menetelmin.

Tulokset: Työyksiköt ottivat käyttöön yhteensä 23 interventiokeinoa (mediaani 3, vaihteluväli 0–14). Keinot kohdistuivat ruokaan tai liikkumiseen liittyvien vaihtoehtojen saatavuuteen, sijoitteluun, esillepanoon, toiminnallisuuteen tai kokoon, vaihtoehdoista annettuun tietoon tai tavoitellun toiminnan vaatimaan itsesäätelyyn. Kohdeympäristöjä olivat taukohuoneet, kokoukset, työpaikkaravintolat, portaikot ynnä muut yhteiset tilat työyksiköissä. Toimeenpanosta kaksi kolmasosaa onnistui. Toimeenpanoon vaikuttivat lukuisat organisaatioon, interventioon, työpaikkaympäristöön ja toimeenpanijaan liittyvät edistävät ja estävät tekijät. Toimeenpanijat ja työntekijät hyväksyivät intervention hyvin, mutta hyväksyntää heikentäviäkin tekijöitä havaittiin. Toimeenpanijoilla näitä olivat yksilölliset mieltymykset, intervention heikko ymmärtäminen, koettu kuormittavuus erityisesti toimeenpanon alkuvaiheessa, koettu tehottomuus ja intensiivisen toimeenpanon kustannukset. Työntekijöillä heikompaa hyväksyntää ennustivat valintoja rajoittavat interventiokeinot ja työyhteisön miesvaltaisuus. Vahvin näyttö vaikuttavuudesta koski työaikaista hedelmien ja marjojen käyttöä, joka oli yleisempää intervention lopussa kuin alussa. Tähän havaintoon liittyivät valitsemisen ja syömisen fyysistä vaivannäköä vähentäneiden keinojen käyttö sekä useisiin työpaikan ruokaympäristöihin ulottunut toimeenpano.

Arvio intervention vaikuttavuudesta perustui ajan (jälkeen vs. ennen) ja toimeenpanon (keinojen lukumäärä×laatu) yhdysvaikutukseen. Toimeenpanon laadulla havaittiin positiivisia yhteyksiä tiettyjen, visuaalisia vihjeitä hyödyntäneiden interventiokeinojen havaitsemiseen, keinoihin kohdistuneeseen visuaaliseen tarkkaavaisuuteen, ja/tai keinoihin reagoimiseen. Keinojen vaikuttavuus näytti kuitenkin riippuvan kohderyhmän mieltymyksistä ja tottumuksista.

Johtopäätökset: Työpaikan valinta-arkkitehtuuriin kohdistunut, kohdeympäristöön räätälöity ja useita keinoja hyödyntänyt interventio terveyttä edistävän syömisen ja arkiaktiivisuuden edistämiseksi osoittautui toteuttamiskelpoiseksi, otettiin hyvin vastaan ja näytti voivan vaikuttaa suotuisasti terveyskäyttäytymiseen vaihtelevissa tosielämän ympäristöissä vuoden ajanjaksolla. Tulokset myös viittasivat siihen, että laadukas toimeenpano voi parantaa intervention havaitsemista ja interventioon reagoimista. Valinta-arkkitehtuurin muokkaaminen voisi täydentää perinteisiä, yksilöön kohdistuvia lähestymistapoja terveyttä edistävien elintapojen edistämisessä. Interventioiden onnistuminen ja jatkuminen edellyttää kuitenkin niiden sisällön ja toimeenpanon huolellista suunnittelua, kohdeympäristö ja -yleisö huomioiden.

Avainsanat: valinta-arkkitehtuuri, tuuppaus, ruoan valinta, ruoan kulutus, syömiskäyttäytyminen, fyysinen aktiivisuus, elintavat, käyttäytymisen muutos, terveyden edistäminen, ehkäisy, tyypin 2 diabetes, työpaikka, ravintola, interventio, käyttökelpoisuus, toimeenpano, hyväksyttävyys, vaikuttavuus, tosielämän tutkimus, monimenetelmätutkimus, katseenseuranta, Stop Diabetes, StopDia

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I wish to express a warm, humble thank you collectively to each of you who trusted in me, supported my ideas, and helped me to turn them into reality along this eventful, ever so surprising, often frustrating, yet in the end rewarding journey into the exciting world of science. I never planned to become a researcher. Quite the contrary, in fact. But if I am one now, you enabled it to happen.

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Helsinki, 17 April 2024
Eeva Rantala

LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following original publications:

I Rantala E, Vanhatalo S, Tilles-Tirkkonen T, Kanerva M, Hansen PG, Kolehmainen M, Männikkö R, Lindström J, Pihlajamäki J, Poutanen K, Karhunen L, Absetz P. Choice Architecture Cueing to Healthier Dietary Choices and Physical Activity at the Workplace: Implementation and Feasibility Evaluation. Nutrients 13: 3592, 2021.

II Rantala E, Vanhatalo S, Perez-Cueto FJA, Pihlajamäki J, Poutanen K, Karhunen L, Absetz P. Acceptability of workplace choice architecture modification for healthy behaviours. BMC Public Health 23: 2451, 2023.

III Rantala E, Vanhatalo S, Valtanen M, Lindström J, Pihlajamäki J, Poutanen K, Absetz P, Karhunen L. Effectiveness of workplace choice architecture modification for healthy eating and daily physical activity. BMC Public Health 24: 939, 2024.

IV Rantala E, Järvelä-Reijonen E, Pettersson K, Laine J, Vartiainen P, Närväinen J, Pihlajamäki J, Poutanen K, Absetz P, Karhunen L. Sensory Appeal and Routines Beat Health Messages and Visibility Enhancements: Mixed-Methods Analysis of a Choice-Architecture Intervention in a Workplace Cafeteria. Nutrients 14: 3731, 2022.

CONTENTS

ABBREVIATIONS

ANGELO	Analysis Grid for Environments Linked to Obesity	NPT	Normalization Process Theory
BCT	Behaviour Change Technique	OR	Odds ratio
BMI	Body mass index	ORR	Ratio of two odds ratios
CFIR	Consolidated Framework of Implementation Research	SD	Standard deviation
CI	Confidence interval	SE	Standard error
COM-B	Capability, Opportunity, Motivation - Behaviour	TDF	Theoretical Domains Framework
DIT	Diffusion of Innovations Theory	TFA	Theoretical Framework of Acceptability
HR	Human resources	TIPPME	Typology of Interventions in Proximal Physical Micro-Environments
IQR	Interquartile range	T_{new1}	Partially overlapping samples t-test
ISF	Interactive Systems Framework for Dissemination and Implementation	T_{RNK1}	Non-parametric partially overlapping samples t-test

1 INTRODUCTION

Healthy eating and physical activity are essential for wellbeing and health and for the prevention and treatment of major public health challenges, such as obesity, type 2 diabetes, and cardiovascular diseases (1–3). These chronic health conditions and their lifestyle-related risk factors, including a high body mass index (BMI, kg/m^2), elevated blood pressure, and adverse blood sugar and lipid profiles, are among the leading causes of disability and mortality, and severely burden individuals, healthcare systems, and economies worldwide (4–7). Yet, people's eating and physical activity habits remain far from optimal across the globe, for example, due to low fruit and vegetable and high sugar-sweetened beverage consumption and due to sedentary occupations (5,8,9). In 2019, poor diet, physical inactivity, and a high BMI together were attributed to 12% of global disability-adjusted life-years, meaning healthy life years lost to disability and premature death (4). In 2022 in Finland, the proportion of the working age population who fell short of the guideline to eat fruit, berries, and vegetables several times per day was 73%, the proportion who did not meet physical activity guidelines was 56%, and the proportion who lived with obesity (BMI ≥ 30 kg/m^2) was 24% (10).

In the labour market, lifestyle-related chronic health conditions are associated with a lower likelihood of being employed, lower productivity when employed, and a greater likelihood of retiring early (7,11,12). At the same time, ageing societies such as Finland desperately need a healthy workforce to sustain the welfare state while the birth rate declines, the post-war baby boom generation retires, and many sectors suffer from labour shortages. Workplaces have an excellent opportunity to promote healthy lifestyles and consequently the wellbeing, health, and work ability of adults because they reach the majority of the working age population and because the workforce spend a substantial part of their waking hours at work (11,13). Workplace health promotion holds promise to benefit the employees, the employer, and the society in many ways. Besides improving employees' lifestyles and health outcomes (14–18), workplace health

promotion can enhance employees' job satisfaction, work engagement, and productivity; reduce absenteeism, staff turnover, and occupational healthcare costs; and strengthen the company's competitive advantage through improved corporate image, greater ability to recruit and retain talent, and higher market value (11,19,20). A healthier workforce benefits society with enhanced employment prospects, longer careers, and higher incomes, which translate into greater tax revenues and lower social protection expenditures (11,12).

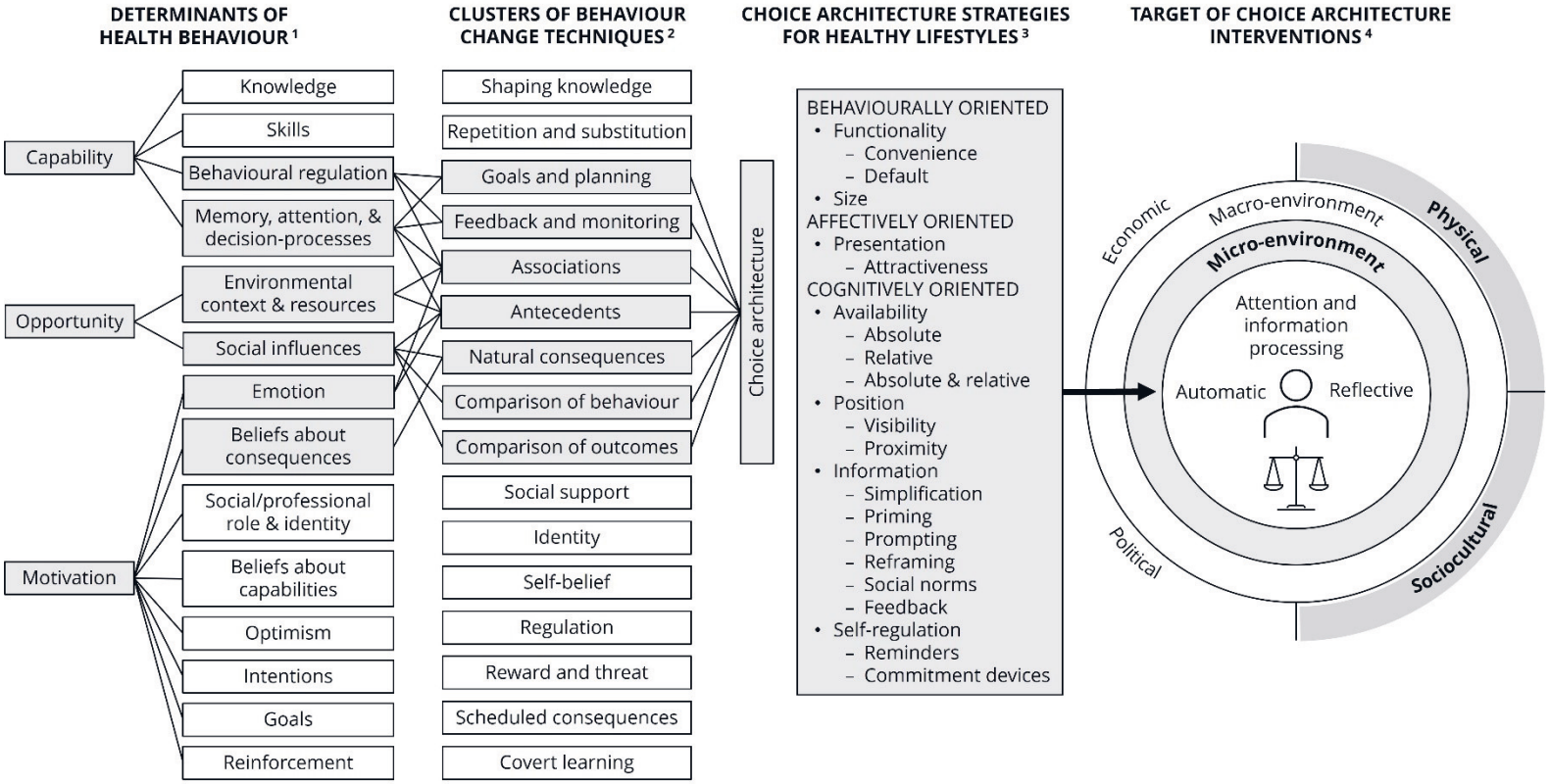
Failure to adopt and maintain recommended dietary and physical activity patterns is no surprise in the contemporary living environment, which is conducive to energy-dense and nutritionally poor food choices and sedentariness. Much of human behaviour occurs automatically with little deliberation, cued by the surrounding environment (21,22). Yet, interventions for health behaviour change have mainly targeted reflective intra-individual processes (23–25). Efforts to develop living environments supportive of healthy behaviours are thus needed to reach global goals and commitments to prevent and control lifestyle-related chronic diseases (13,26–30).

Choice architecture is a framework developed for designing choice environments that facilitate favourable behaviours (21,31). The approach offers a variety of strategies that have shown potential in advancing behaviour change (32,33), are supposedly easy to implement (34,35), and that can reach large audiences. The approach seems thus ideal for population-level health promotion, for example, in the workplace context. Limited evidence exists, however, of the implementation, acceptability, and effectiveness of real-world interventions. Transfer from research to practice is thus challenging. This dissertation aimed to contribute to filling this knowledge gap.

2 REVIEW OF THE LITERATURE

This chapter reviews the theoretical background and empirical evidence relevant to the dissertation. The aim is to build the framing and rationale of the work. The review provides a concise overview of various determinants of health behaviour and approaches to promote health behaviour change. The emphasis is on determinants and behaviour change techniques that are relevant to the choice architecture framework. Thereafter, the review describes the choice architecture framework, related intervention strategies, and evidence of intervention implementation, acceptability, and effectiveness.

Figure 1 synthesises the theoretical background described in this chapter. The left-hand side of the figure shows key determinants of health behaviour based on prominent behaviour change theories (36,37) and techniques used to change these determinants (38). The grey colour highlights the determinants and techniques relevant to the choice architecture framework. The right-hand side of the figure focuses on choice architecture strategies and their targets in the living environment.



[1] Determinants based on the COM-B system of behaviour (Michie et al. 2011) and the Theoretical Domains Framework (TDF) (Cane et al. 2012)
[2] Clusters based on the Behavior Change Technique Taxonomy v1 (Michie et al. 2013)
[3] Strategies compiled from and categorised according to Cadario & Chandon (2020), Hollands et al. (2017), Münscher et al. (2016), and Pechey et al. (2020)
[4] Illustration of the living environment built on the Analysis Grid for Environments Linked to Obesity (ANGELO) (Swinburn et al. 1999)

Figure 1. The choice architecture framework mapped onto the field of behaviour change research. Grey shading indicates content relevant to the choice architecture framework. The citations equal references: (32,36–42).

2.1 DETERMINANTS OF HEALTH BEHAVIOUR

2.1.1 Overview of behavioural determinants

A plethora of theories exist that can be used to predict or explain health-related behaviour (23). Many of these theories overlap and define similar constructs with varying terms and conceptualisations (23). Hence, two overarching frameworks were developed to facilitate the understanding of behaviour and the use of theory in behaviour change intervention research: the COM-B system (36) and the Theoretical Domains Framework (TDF) (37,43).

The COM-B system is a generic model of behaviour that specifies three interacting conditions necessary for a behaviour to occur: capability, opportunity, and motivation (36) (Figure 1). Capability refers to the psychological and physical capacity to engage in a particular activity. Opportunity refers to the social and physical factors outside the individual that make a behaviour possible or prompt it. Motivation refers to all the brain processes that energise and direct behaviour (36).

The TDF integrated and broke down 33 behaviour change theories and 128 explanatory constructs into 14 theoretical domains that can be mapped onto the components of the COM-B system (37,43) (Figure 1). Domains related to capability comprise “knowledge”, “skills”, “memory, attention, and decision processes”, and “behavioural regulation”. Domains related to opportunity comprise “environmental context and resources” and “social influences”. Domains related to motivation comprise “social/professional role and identity”, “beliefs about capabilities”, “optimism”, “beliefs about consequences”, “intentions”, “goals”, “reinforcement”, and “emotions” (37).

The TDF-domains most relevant to the choice architecture framework are “environmental context and resources”, “social influences”, and “memory, attention, and decision processes”. These themes are elaborated in the following sections that focus on contextual and environmental influences on behaviour, characteristics of attention and information processing, and mental shortcuts to behavioural decisions.

2.1.2 Contextual and environmental influences on behaviour

The most widely used theories in the behaviour change field focus on intra-individual determinants of behaviour (23). Consequently, behaviour change interventions have largely targeted motivation- or capability-related individual factors, whereas opportunity-related contextual and environmental influences have received relatively little attention (23–25). The Theoretical Domains Framework (TDF) reflects this imbalance, as only two of its fourteen domains focus on determinants external to the individual. The TDF-domain “environmental context and resources” refers to any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour (37). The TDF-domain “social influences” refers to interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours (37).

The living environment is a broad, multi-layered, and multidimensional complex that can be classified in various ways. The ANGELO-framework (Analysis Grid for Environments Linked to Obesity) aims to assist in identifying contextual and environmental influences on food intake and physical activity (42). The framework dissects the living environment by size (micro and macro) and type (physical, economic, political, and sociocultural) (Figure 2). Micro-environments are local, geographically distinct settings where people gather for specific purposes (e.g., workplaces, cafeterias). Macro-environments are broader, geographically diffuse sectors that shape micro-environments (e.g., governments, industry). The physical environment refers to availability and accessibility, such as healthy food options and their presentation at the worksite cafeteria. The economic environment refers to costs such as the price of healthy food in a cafeteria. The political environment refers to rules such as policies that guide availability and costs. The sociocultural environment refers to social and cultural attitudes, beliefs, values, and norms such as the work community’s attitudes to healthy eating (42).

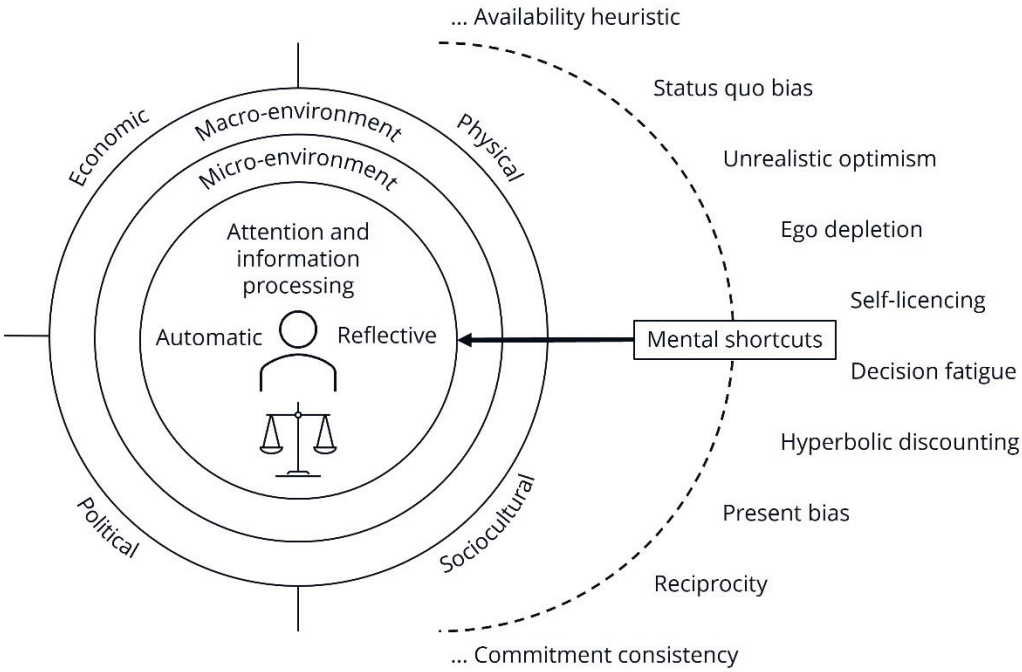


Figure 2. Illustration of contextual and environmental influences, attention and information processing, and mental shortcuts that underlie behaviour.

2.1.3 Characteristics of attention and information processing

The domain "memory, attention, and decision processes" of the Theoretical Domains Framework (TDF) refers to the ability to retain information, focus selectively on aspects of the environment, and choose between two or more alternatives (37). The domain relates to the dual-process theories of cognition that propose behaviour to result from the interplay of two operationally and qualitatively distinct systems (or sets of processes), automatic and reflective, which operate under different conditions (22,44) (Figure 2). These systems are dependent on attention, which functions as a gateway to information processing and behaviour (45,46). Attention is a limited resource and process that enables us to perceive selected stimuli we are exposed to and decide how to act upon them (47,48). Attention can be captured by external stimuli that stick out from the sensorily perceptible environment (i.e., bottom-up processing), or by internal

influences, such as prevailing motivations and goals (i.e., top-down processing) (47–49).

The automatic system, also known as System 1, is characterised as fast, intuitive, and effortless; excellent in habitual situations; and capable of operating under suboptimal conditions, for example, when hungry or fatigued (45,50,51). On the other hand, the system is driven by contextual cues and the associations and anticipated hedonic rewards that the cues activate in the mind, without the ability to consider causal relations or potential consequences (45). Thus, the automatic system has been proposed to work in a similar fashion to perception (50).

The reflective system, also known as System 2, is characterised as deliberate, loyal to personal values and goals, and capable of regulating behaviour based on higher-order mental operations, such as reasoning, planning, and anticipating consequences (45,50,51). On the other hand, the reflective system is slow, effortful, and easily distracted (45,50). Common factors that impair the functioning of the reflective system include cognitive load, unfulfillment of basic needs (e.g., food or sleep), habitualness, mood, affect, ego depletion (i.e., a state of weakened self-control), and low self-regulation or working memory capacity (45,51). These factors can create conditions under which the responsibility for regulating behaviour shifts to the automatic system (51). Hence, behaviour change interventions are needed that target contextual and environmental determinants of behaviour and that appeal to the automatic system.

The dual-process dichotomy has been criticised as oversimplified, and a debate is ongoing over how many sets of processes there really are (44). In reality, behaviour is always likely to result from a mixture of automatic and reflective processes that each vary in the degree to which they exhibit diverse qualities, such as consciousness, efficiency, intentionality, and controllability (52). Dual-process theories have nevertheless increased the understanding of the varying operating principles of mental processes that underlie behaviour and the conditions under which diverse processes operate.

2.1.4 Mental shortcuts to behavioural decisions

Research has demonstrated that the processes that regulate behaviour, whether automatic or reflective, are not flawless (34,53). Instead, they exhibit tendencies that often lead people to outcomes that contradict their reasoned preferences and that are not beneficial to them. These tendencies—sometimes called biases, heuristics, or errors—serve as mental shortcuts that simplify and quicken decision-making yet may result in behaviours that deviate from what could be considered rational (53,54) (Figure 2). Rational, here, refers to the expected utility theory; a model used to explain behaviour in standard economics and public policy (34). The theory assumes that people have stable preferences, which they are aware of and able to prioritise, and that in any given situation, people can choose the action that is best for them (i.e., maximises their utility) by evaluating available information, probabilities of events, and potential costs and benefits (34). The expected utility theory thus sees human beings as reflections of the so-called homo economicus; the flawlessly-thinking economic man with a computer-like information processing capacity and endless willpower (31). In reality, however, people are fallible and forgetful, struggle with mental arithmetic, and yield to temptations. Even if determined to do something, people struggle translating their intentions into action; a phenomenon known as the intention–behaviour gap (55). These human characteristics further emphasise the need to create environments that facilitate healthy behaviours.

Behavioural sciences have identified numerous ways in which decision-making can deviate from the expected utility theory (Figure 2). Examples include people's tendency to make decisions based on salient, easily-retrievable events and information (availability heuristic) (54,56,57) and to remain at the current state or choose the default option that requires no action (status quo bias) (58). People tend to overestimate their chances of succeeding and immunity to harm (unrealistic optimism, overconfidence) (31). People often discount the future when sacrifices are required immediately, which appears in preferences for small immediate rewards or payoffs over larger ones in the future (hyperbolic discounting, present bias)

(56). People tend to give in to temptations when stressed or fatigued (ego depletion, decision fatigue) (34) and find justifications for indulgence in unhealthy pleasures that contradict deliberate goals (self-licencing) (59,60). People also tend to respond to information with strong emotional content (affect heuristic), act as other people do (social norms), and put effort into keeping promises (commitment consistency, reciprocity) (56).

2.2 PROMOTION OF HEALTH BEHAVIOUR CHANGE

2.2.1 Overview of approaches to support behaviour change

Behaviour change can be supported with numerous approaches. The Behaviour Change Wheel framework specifies nine generic intervention functions, or activities aimed at changing behaviour: education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, and enablement (36). At a more detailed level, interventions can apply diverse behaviour change techniques (BCTs) that represent the observable, replicable, and irreducible components and active ingredients of interventions (38). The Behavior Change Technique Taxonomy v1 defines 93 distinct BCTs grouped into 16 clusters (38) (Figure 1).

The BCT-clusters most relevant to the choice architecture framework include: “Antecedents” (BCTs: Restructuring the physical/social environment), “Associations” (Prompts/cues), “Goals and planning” (Behavioural contract, Commitment), “Comparison of behaviour” (Demonstration of the behaviour, Social comparison, Information about others’ approval), “Comparison of outcomes” (Credible source), “Feedback and monitoring” (Feedback on behaviour, Biofeedback, Feedback on outcome(s) of behaviour), and “Natural consequences” (Salience of consequences, Information about social and environmental consequences) (Figure 1). The following sections elaborate the choice architecture framework and specific intervention strategies used within the framework.

2.2.2 The choice architecture framework

Choice architecture refers to the way in which available choice options are presented and arranged in contexts in which people act and make decisions (31). Modifying such contexts by encouraging or adding more favourable options and/or by discouraging or removing unfavourable options can shift people's choices in a more desirable direction (34). The shift can occur with varying levels of consciousness, depending on the degree of people's awareness of the intervention, the behaviour the intervention aims to influence, and the link between the intervention and the influenced behaviour (61). Accordingly, the choice architecture framework emphasises that context is a powerful predictor of behaviour and that behaviour change can occur without conscious processing (21).

Choice architecture was developed as a general framework for interventions that aim to change behaviour by altering the context in which the behaviour occurs (21). Such interventions have also become known as "nudges"—a concept that behavioural economists Richard Thaler and Cass Sunstein used in their bestselling book "Nudge: Improving decisions about health, wealth, and happiness" (31). The present dissertation considers the concepts choice architecture and nudge to be broadly interchangeable yet favours the more general concept of choice architecture. Simultaneously, the dissertation acknowledges that the definitions and terminology related to the choice architecture framework are still evolving (21,62).

Choice architecture interventions have been characterised as attempts to alter people's judgment, choice, or behaviour in a predictable way without forbidding any options, significantly changing economic or other incentives, or relying on the provision of factual information or rational argumentation (31,53). The interventions work because of—and by making use of—known boundaries, biases, and routines of behaviour-regulating processes that often prevent people from acting rationally according to their reasoned preferences (53). The framework relies on the insight that seemingly insignificant details in the decision-making context can have a decisive impact on people's behaviour, and that the power of these details becomes harnessed by focusing people's attention in a particular direction

(31). Choice architecture interventions can influence the behaviour of many people simultaneously, they are not targeted or tailored to specific individuals, and they typically require minimal conscious engagement from the target audience (63).

A key aim of the choice architecture framework has been to apply the principles of economics and psychology to behaviour change and public policy in a "libertarian paternalistic" way that does not force people to change (34). Choice architecture interventions build on the assumption that the nudged option (e.g., healthy food) aligns with the individual's preferences but, at the decision-making moment, the individual ends up selecting a less preferred option (e.g., unhealthy food) (34). The framework rests on more than a century of psychological theory and observation (21), particularly in behavioural economics and cognitive and social psychology, including the research on cognitive heuristics and biases and the dual process theories (53).

2.2.3 Strategies for choice architecture interventions

The choice architecture framework comprises numerous intervention strategies that target the physical or social context, or micro-environment, in which behaviours and related decisions occur. The strategies can influence behaviour (i) directly via automatic processes without the engagement of reflective processes, or (ii) indirectly by attracting automatic processes to trigger reflective processes, which advance deliberation on personal preferences, values, and goals (33,64,65). Choice architecture strategies can be categorised in various ways, for example, based on the assumed behaviour change mechanism (32), type of choice architectural modification (39–41), the spatial focus of the intervention (39), transparency, or the targeted mode of information processing (64). This variability shows in existing typologies that use diverse approaches to organise the strategies into categories and subcategories (Table 1). The suitability of each typology depends on the context. Combined, the typologies can complement one another, allowing a more versatile and fine-grained characterisation of interventions.

Table 1. Selected typologies of choice architecture strategies.

Typology (ref.)	**Main categories/ dimension 1**	**Subcategories/ dimension 2**
Typology based on the tripartite classification of mental activities into behaviour, affect, or cognition (32)	Conceptual level: Behaviourally oriented Affectively oriented Cognitively oriented	Intervention type: Convenience enhancements Size enhancements Healthy eating calls Hedonic enhancements Descriptive labelling Evaluative labelling Visibility enhancements
Typology of Interventions in Proximal Physical Micro-Environments, TIPPME (39)	Intervention type: Availability Position Functionality Presentation Size Information	Spatial focus: Product Product-related object Wider environment
Framework for categorising availability interventions (41)	Intervention type: Availability	Intervention subtype: Absolute availability Relative availability Absolute and relative availability
Taxonomy of choice architecture techniques (40)	Intervention category: Decision information Decision structure Decision assistance	Intervention technique: Translate information. Make information visible. Provide social reference point. Change choice defaults. Change option-related effort. Change option range/composition. Change option consequences. Provide reminders. Facilitate commitment.
Framework for the responsible use of the nudge approach to behaviour change (64)	Transparency: Transparent Non-transparent	Mode of information processing: Automatic (Type 1) Reflective (Type 2)

A simple, tripartite typology categorises choice architecture interventions for healthy eating into behaviourally, affectively, or cognitively oriented strategies, based on the assumed behaviour change mechanism (32) (Table 1). Behaviourally oriented strategies aim to change what people do (i.e., their motor responses) without necessarily changing what they know or how they feel. These strategies typically alter the physical effort required to engage in the desired behaviour and they often work without people being aware of their existence. Examples include modifications to convenience or portion size. Affectively oriented strategies aim to change how people feel without necessarily changing what they know. Examples include attractive presentation and encouraging messages. Cognitively oriented strategies aim to change what people know, for example, with simple nutrition labels or visibility enhancements (32). These strategies typically work by attracting attention to and by conveying decision-relevant information on the promoted option, thus reducing the cognitive effort required to recognise the option and boosting reflective processes that could lead to choosing the option.

A more fine-grained typology, the Typology of Interventions in Proximal (sensorily perceptible) Physical Micro-Environments (TIPPME), distinguishes intervention strategies based on the target of choice architectural modification (39) (Table 1). TIPPME was developed for grouping interventions that aim at changing the selection, purchase, or consumption of food, alcohol, or tobacco. The typology comprises six intervention types (availability, position, functionality, presentation, size, and information) and three spatial foci (product, product-related objects that typically form part of the product's proximal surroundings, and objects or stimuli in the wider environment); thus defining 18 possible intervention categories (39). Later, TIPPME was complemented with a conceptual framework for categorising availability strategies further into three subcategories: (i) altering the absolute availability (i.e., the overall number of options available), (ii) altering the relative availability (i.e., the proportion of a subset of options relative to other subsets), and (iii) altering both the absolute and relative availability simultaneously (41).

While the TIPPME typology focuses on the physical micro-environment, the Taxonomy of choice architecture techniques also covers strategies that aim to support self-regulation and bridging the intention–behaviour gap (40) (Table 1). In addition, this taxonomy suggests more detailed subcategories for strategies that convey information. The taxonomy describes nine strategies that fall under three categories: decision information, decision structure, and decision assistance. Decision information refers to the presentation of decision-relevant information and includes strategies that aim to translate information (e.g., simplifying, reframing), make information visible (e.g., feedback on own behaviour), or provide social reference points (e.g., descriptive norms). The decision structure refers to the arrangement of options and the decision-making format and includes strategies that aim to change choice defaults, option-related effort, the range or composition of options, or option consequences. Decision assistance refers to helping people translate intentions into action and includes strategies that aim to provide reminders of or facilitate commitment to preferred behaviours (40).

Related to an ongoing debate on the acceptability of choice architecture interventions (see section 2.4.2), a framework for the responsible use of the nudge approach to behaviour change categorises strategies along two axes: transparent–non-transparent and automatic–reflective; thus defining four intervention categories (64) (Table 1). The transparency dimension distinguishes between strategies whose intentions and means to pursue behaviour change can reasonably be expected to be recognised by the target audience, and strategies whose intention or means are likely to remain unrecognised. The automatic–reflective dimension distinguishes between strategies that target automatic behaviours, which occur unintentionally without active deliberation, judgment, or choice; and strategies that target reflective behaviours (i.e., intentional choices and actions), which result from active deliberation and judgment. Strategies that are transparent and reflective (e.g., nutrition labels or footprints on the floor guiding from the elevator to the stairs) count as the least intrusive choice architecture interventions that fully maintain the targeted individuals' freedom of choice. Strategies that are non-transparent and

automatic (e.g., changes to portion sizes or the rearrangement of cafeteria serving lines) can be considered more intrusive as their effects are often difficult to avoid (64).

Table 2 adapts and integrates the portrayed typologies to describe practical examples of choice architecture strategies applicable to promoting healthy eating or daily physical activity. In practice, the categorisation of choice architecture strategies according to existing typologies is not always straightforward (32,41,64). For example, strategies that alter availability can simultaneously alter position, and strategies that alter position can qualify as cognitively or behaviourally oriented strategies depending on their implementation (Table 2). Specifically, major changes to position can substantially alter proximity, in which case the intervention modifies the physical effort required to choose targeted options and qualifies as behaviourally oriented. Minor changes to position, in turn, may enhance visibility without considerable changes to proximity, in which case the intervention reduces the cognitive effort required to perceive targeted options and qualifies as cognitively oriented. Similarly, determining whether an intervention is transparent or non-transparent or targets reflective or automatic processes is often ambiguous. Yet, the available typologies serve as reminders of available intervention strategies, help to compare the strategies according to various qualities, and provide support for designing and reporting interventions.

Table 2. Examples of choice architecture strategies for healthy eating or physical activity classified by existing typologies. The table builds on frameworks portrayed in references no: (32,36,39–41,64).

Mechanism[1]	Target/type[2]	Description[2]	Practical example[2]	Transparency /processing[3]	Behaviour change technique[4]
Behavioural	Functionality	Redesign how options or related objects work, are used, or selected.	Increase convenience by serving vegetables/fruit ready to eat (washed, peeled, cut into pieces, and/or pre-portioned).	Transparent/ reflective	Restructuring the physical environment
"	"	"	Facilitate healthy choices by setting default options people receive unless they actively opt out.	Transparent/ automatic	Restructuring the physical environment
"	Size	Alter the size or shape of options or related objects.	Support healthy consumption by reducing the size of serving utensils, serving dishes, or portions of less healthy foods.	Non-transparent/ automatic	Restructuring the physical environment

Table 2 continues.

Table 2. (cont.) Choice architecture strategies for healthy eating or physical activity classified by existing typologies.

Mechanism[1]	Target/type[2]	Description[2]	Practical example[2]	Transparency /processing[3]	Behaviour change technique[4]
Affective	Presentation	Alter the visual, tactile, auditory, or olfactory properties of options or related objects or stimuli.	Increase attractiveness by presenting healthy options with appealing displays, descriptions, photos, or containers.	Transparent/ reflective	Restructuring the physical environment
Cognitive/ behavioural[5]	Availability	Add or remove options or related objects.	Enable healthy choices by introducing such options (absolute and relative availability).	Transparent/ reflective	Adding options to the environment
”	”	”	Facilitate healthy choices by increasing their proportion (volume or variety) in the selection (absolute and/or relative availability).	Transparent/ reflective	Adding options to the environment

Table 2 continues.

Table 2. (cont.) Choice architecture strategies for healthy eating or physical activity classified by existing typologies.

Mechanism[1]	Target/type[2]	Description[2]	Practical example[2]	Transparency /processing[3]	Behaviour change technique[4]
Cognitive/ behavioural[6]	Availability	Add or remove options or related objects.	Facilitate healthy choices by replacing less healthy options with healthier alternatives (relative availability).	Transparent or not/ reflective or automatic[6]	Adding options to the environment
Cognitive/ behavioural[5]	Position	Change the position or arrangement of options or related objects.	Increase the visibility, salience, proximity, and/or accessibility of healthy options by placing them first in line, in the front row, at the centre, or at eye level.	Non-transparent/ automatic	Restructuring the physical environment
Cognitive	Information	Add, remove, or change words, symbols, numbers, or pictures conveying information on options or their use.	Simplify the recognition of healthy options with point-of-choice nutrition labels that make nutritional quality visible and easy to understand.	Transparent/ reflective	Prompts/cues, Information about health consequences, Salience of consequences

Table 2 continues.

Table 2. (cont.) Choice architecture strategies for healthy eating or physical activity classified by existing typologies.

Mechanism[1]	Target/type[2]	Description[2]	Practical example[2]	Transparency /processing[3]	Behaviour change technique[4]
Cognitive	Information	Add, remove, or change words, symbols, numbers, or pictures conveying information on options or their use.	Prime for healthy choices before the point of choice with cues that facilitate the recognition of healthy options.	Transparent or not[7]/ automatic	Prompts/cues
″	″	″	Change perspective by reframing existing information to highlight different aspects or consequences of options.	Non-transparent/ reflective	Information about health consequences, Salience of consequences, and/or Information about social and environmental consequences
″	″	″	Leverage social norms by letting people know how other people (preferably valued individuals) think or act in favourable ways.	Transparent/ reflective	Demonstration of the behaviour, Social comparison, Information about others' approval, Credible source

Table 2 continues.

Table 2. (cont.) Choice architecture strategies for healthy eating or physical activity classified by existing typologies.

Mechanism[1]	Target/type[2]	Description[2]	Practical example[2]	Transparency /processing[3]	Behaviour change technique[4]
Cognitive	Information	Provide information on own behaviour.	Make own behaviour visible to the targeted individual with feedback.	Transparent/ reflective	Feedback on behaviour, Biofeedback, or Feedback on outcome(s) of behaviour
Cognitive/ affective	Self-regulation	Provide reminders.	Prompt healthy choices with encouraging messages or cues (without information on the option or its use).	Transparent/ reflective	Prompts/cues
Cognitive	”	Provide commitment devices.	Facilitate commitment with opportunities to sign in group/team activities related to healthy eating or physical activity.	Transparent/ reflective	Behavioural contract, Commitment

[1]Behavioural, affective, and cognitive strategies aim to change what people do, how people feel, and what people know (32). [2]Column content compiled from references: (32,39–41). [3]Transparent strategies are recognisable to target individuals, reflective strategies target deliberation (64). [4]Column content based on: (38). [5]Behavioural if the magnitude of modification is substantial and leads to considerable changes in required physical effort. [6]Behavioural, non-transparent, and automatic if the replacing option and the replaced option are perceptually identical. [7]Transparent if the intention of the priming message is evident.

2.3 IMPLEMENTATION OF INTERVENTIONS

2.3.1 Overview of implementation research

Developing effective interventions for identified public health problems is the first step towards improving people's health and wellbeing (66,67). Information on intervention effects is of little use, however, unless we know how to facilitate the jump from research to practice, meaning how to transfer promising innovations from experimental settings to the real world (66–68). Studying the implementation of health promotion interventions is thus necessary. Key elements of implementation research, which several intervention evaluation frameworks share, are fidelity and contextual factors, i.e., facilitators of and barriers to implementation (66,68–72). Evaluating these elements enables determining feasibility, identifying reasons for successes and failures, interpreting whether found effects or ineffectiveness results from the intended intervention or variations in its implementation, as well as developing improved interventions (68,73,74).

Fidelity—also referred to as adherence, compliance, integrity, reliability, and faithful replication (66,74)—refers to the methodological strategies used to monitor and enhance the reliability and validity of interventions (75). In health behaviour change research, the monitoring and enhancement of fidelity can target any phase of the intervention process from study design to implementer training, intervention delivery, intervention receipt (i.e., study subjects' understanding of provided information and ability to perform intervention-related activities), and the enactment of skills (i.e., the extent to which study subjects use learned skills as intended in relevant life situations) (75). Yet, the fidelity measures used in published implementation research have most commonly focused on the delivery domain (74). In the delivery phase, fidelity refers to the extent to which the core components of the intervention are delivered as intended (76). The fidelity of delivery can be assessed, for example, through dose and quality (77). The dose denotes how much of the

intervention was delivered and quality indicates how well diverse intervention components were implemented according to plan (66).

Contextual factors can be considered active and dynamic forces that may work for or against implementation efforts (72) and/or intervention effects (68), thus determining the intervention success. These forces have been classified into broad contextual domains, including the outer setting in which the implementation site exists (e.g., region), the inner setting in which the intervention is implemented (e.g., organisation), the intervention or "thing" being implemented, the individuals the implementation concerns (e.g., implementers, target audience), and the implementation process, meaning the activities and strategies used in the implementation (71,72).

2.3.2 Implementation of choice architecture interventions

Choice architecture interventions have been characterised as easy and inexpensive to implement (34,35), and feasible for changing behaviour at scale (78). Real-world evidence supporting this claim remains limited, however. Studies conducted in catering services such as worksite cafeterias have provided some insights into the implementation of various strategies, including changes to availability (79–82), position (82), presentation (81,82), functionality (defaults) (82,83), information (nutrition labelling, social norms) (81,84), and portion size (85). These studies have aimed at promoting healthier food consumption at one to eighteen implementation sites with durations ranging from one-time events to six months. The findings of these studies demonstrate that choice architecture interventions are not an exception to the rule that bridging research and practice can be challenging (66,67). The success of translating promising choice architecture interventions from controlled behavioural laboratories (86) or realistic living labs (87) to real-world operations is not guaranteed and may depend on the context and target audience (83,88,89). The feasibility, extent, and fidelity of implementation tends to vary across contexts and implementation sites, and numerous factors may hamper implementation (79–82,84,85), particularly in the beginning of the

intervention (84) or if the design and implementation process involves multiple parties (79).

2.4 ACCEPTABILITY OF INTERVENTIONS

2.4.1 Overview of acceptability evaluation

Within intervention research, acceptability has been defined as a multi-dimensional construct that reflects the extent to which intervention deliverers or receivers consider the intervention appropriate, based on anticipated (i.e., prospective) or experienced (i.e., concurrent or retrospective) cognitive and emotional responses to the intervention (90). Evaluating the acceptability of interventions reveals their approval among deliverers and receivers and enables detecting factors that influence implementation and effectiveness; thus supporting the interpretation of study outcomes and the development of improved interventions (90,91).

The Theoretical Framework of Acceptability (TFA) was developed for the assessment of acceptability of healthcare interventions (90). The framework specifies seven domains of acceptability: ethicality, affective attitude, burden, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy. Ethicality reflects the extent to which the intervention fits an individual's value system; affective attitude refers to how an individual feels about the intervention; burden reflects the perceived amount of effort that is required to participate in the intervention; intervention coherence means the extent to which an individual understands the intervention and how it works; opportunity costs reflect the extent to which benefits, profits, or values must be given up to engage in the intervention; while the perceived effectiveness reflects the extent to which the intervention is perceived as likely to achieve its purpose; and self-efficacy refers to the participant's confidence in their ability to perform the behaviours the intervention requires (90). The TFA has been applied to evaluate the acceptability of various health-promotion programmes (e.g., 92,93), but application within the choice architecture framework is still rare (94). Moreover, choice architecture studies are yet to

be conducted that evaluate acceptability according to the domains of the TFA. Applying the TFA in choice architecture research could yield a more comprehensive and nuanced understanding of the acceptability of choice architecture interventions.

2.4.2 Acceptability of choice architecture interventions

The core principle of the choice architecture framework is to help people act in ways that make them better off, as judged by themselves, simultaneously preserving people's liberty to choose and do what they like (31). However, the ethicality of the framework has sparked debate (64,95) because choice architecture interventions are subtle and able to change behaviour even if people are not aware of their presence or effect on behaviour (61). Assessing the acceptability of choice architecture interventions is thus particularly important.

The greatest body of evidence of the acceptability of choice architecture interventions for healthy eating or physical activity relies on observational studies that have surveyed the anticipated acceptance of various hypothetical interventions among the general population (89,96–108). In these studies, the portrayed sources behind interventions have most often been policymakers (96–102,105,108) and sometimes profit-making companies (96,102,106) or experts (102). On a few occasions, the portrayed source has been the employer (107) or a related actor such as a catering service (89,96,103) that could implement choice architecture interventions at the workplace to change the behaviour of employees.

The observational studies on anticipated acceptance have found overall support for choice architecture interventions (89,96–108). Yet, acceptance appears to depend on various factors, such as the intention, type, and perceived effectiveness of the intervention, and the characteristics of the participants. People tend to support interventions they perceive to have legitimate goals to promote their interests or values (98,99), for example, interventions intended to promote social good, such as health or sustainability (96,104). More transparent and less intrusive strategies that rely on the provision of information (e.g., nutrition labels) receive greater

support compared to less transparent and more intrusive strategies (e.g., reduced availability or portion size) (97–103,105,107,108). Furthermore, the perceived effectiveness predicts higher acceptance (96,97,100,101). Related to the participant characteristics, women appear more supportive of choice architecture interventions compared to men (97–99,101,102,105,108).

A smaller number of studies have evaluated the experienced acceptability of choice architecture interventions among the target audience after exposure to the intervention in a real-world setting (79,82,84,85,109–112). These studies have aimed at promoting healthier food consumption in catering services such as worksite cafeterias (79,82,84,85,112), in kiosks at train stations (109,110), or via online conference registration (111). The studies have had one to six implementation sites and durations ranging from one-time events to six months. The strategies applied in these studies have modified the availability (79,82), position (82,109,110), presentation (82), functionality (defaults) (82,111), information (nutrition labelling) (84), or portion size (85,112). In line with the observational studies, the experimental studies have found the participants to be supportive of or indifferent to the interventions.

Among the evaluations of experienced acceptability in real-world settings, a few studies have considered the perspective of the implementers as well (79,81,82,84,85). The implementer perspective is focal because the implementers determine whether and how interventions materialise. While reports of implementers' thoughts and experiences are still rare and represent the views of a small number of individuals, available reports have illustrated how the acceptability of specific choice architecture strategies can vary depending on the context. Contextual factors reported to influence acceptance have been related to burden (79,81,82,84,85), intervention coherence (84), opportunity costs (81,82,85), affective attitudes, or perceived effectiveness (81).

2.5 EFFECTIVENESS OF CHOICE ARCHITECTURE INTERVENTIONS

The potential of choice architecture interventions to change behaviour has been studied mainly with efficacy trials, often conducted in laboratory or artificial field settings (33). Efficacy trials test whether interventions do more good than harm under optimum conditions that typically include well-specified and standardised programmes delivered in a uniform fashion within harmonised and well-controlled experimental settings to specific target audiences (113). Once efficacy has been demonstrated, effectiveness trials can evaluate the implementation, acceptability, and effects of interventions when they are conducted in real-world conditions and delivered by individuals who are not part of the research staff (69,113).

A systematic literature review with meta-analysis searched for randomised controlled choice architecture experiments across seven behavioural domains: health, food, environment, finance, prosocial, and other behaviour (33). The search was completed in the summer of 2019 and identified 212 laboratory or field trials that reported 447 effect sizes. These effect sizes were included in the meta-analysis. The results suggested that across behavioural domains, choice architecture interventions promote behaviour change with a small to medium effect size. The standardised mean difference between intervention and control conditions, Cohen's d (0.2 = small, 0.5 = medium, 0.8 = large (114)), was estimated to be 0.43 (95% confidence interval CI 0.38 to 0.48). However, the effect sizes varied substantially between studies, and approximately 15% of interventions were estimated to backfire. The largest effects were observed in interventions using strategies that targeted the decision structure of the choice context (e.g., choice default) (40) and that typically reduced the physical effort required for the desired behaviour (d=0.54, 95% CI 0.46 to 0.62, number of effect sizes k=223). The behavioural domain most responsive to choice architecture interventions was eating behaviour (d=0.65, 95% CI 0.47 to 0.83, k=111). The authors considered whether this finding could be explained by the habitual nature of eating behaviour or its trivial perceived impact on personal life (33).

Another systematic review and meta-analysis of choice architecture interventions included 96 controlled or pre-post field experiments aimed at promoting healthy food choices or consumption (32). The studies were published up to January 2017, reported altogether 299 effect sizes, and had durations ranging from one week to 3.5 months. Congruent with the findings of the above-described meta-analysis (33), the interventions were estimated to promote behaviour change with a small effect size (d=0.23, standard error SE 0.04), and the largest effects were observed with behaviourally oriented strategies that reduced physical effort (e.g., convenience or size enhancements) (d=0.39, SE 0.05, k=82) (32).

Other systematic reviews and meta-analyses of choice architecture interventions for healthy eating have focused on availability or position (115), nutrition labelling (116), or size strategies (117,118). Meta-analyses of choice architecture interventions for daily physical activity have focused on strategies aimed at prompting stair use (119) or enhancing the availability of height-adjustable desks (18). These studies have produced effect size estimates which are largely comparable with the two above-portrayed meta-analyses (32,33).

The effect size estimates of available literature studies are probably overoptimistic, however, because evidence syntheses have found the choice architecture literature biased towards successful interventions with small sample sizes (33,120–122). This suggests that choice architecture interventions can be effective, but their effectiveness depends on the context in which they are implemented. While contexts which are conducive to effectiveness remain poorly understood (123), recent evidence indicates that effectiveness does not rely on transparency (i.e., the disclosure of intervention presence, purpose, or working mechanism), study subjects' mode of thinking (reflective vs. automatic), or attention to the intervention (95,124). Pre-existing preferences, however, may modify the effects (95,124).

In the workplace context, choice architecture interventions for healthy eating or daily physical activity have mainly targeted food choices at worksite cafeterias (17,125) or prompted stair use over the elevator (63,126). Few studies have targeted eating (127,128) or physical activity

(129) in other contexts at the workplace. Similarly, real-world interventions that have lasted longer than six months (130) or involved multiple implementation sites with broader target populations (79,80,84,85,131) remain rare. Moreover, while implementation has been shown to influence the effectiveness of health promotion interventions at workplaces (71) and other community settings (66), we lack choice architecture studies that integrate quantitative implementation measures with outcome data to explore the relationship between implementation and effects. Such analysis could support the interpretation of study outcomes (68) and explain some of the variability observed in intervention effects.

2.6 SUMMARY

Health behaviour can be determined by a wide array of factors, and behaviour change promoted in a multitude of ways. The choice architecture framework aims to support behaviour change with a focus on the contexts and environments in which behaviours and related decisions take place. The framework rests on scientific evidence of the capabilities and characteristics of processes that regulate attention, information processing, and behaviour. Efficacy trials have shown that choice architecture interventions can advance behaviour change, and early reports on implementation and acceptability seem promising (Table 3). Real-world evidence remains scarce, however, and interventions have been limited along several dimensions of scale-up, including target behaviours, intervention strategies, implementation settings, and duration. To increase the understanding of the potential of the choice architecture framework to promote public health and to facilitate its transfer from research to practice, we need wider-scale interventions with comprehensive evaluations of implementation, acceptability, and effectiveness in the real world.

Table 3. Summary of current evidence and knowledge gaps of choice architecture interventions for healthy lifestyles.

Evidence	Knowledge gap
Implementation • Feasible yet context-dependent **Acceptability** • Anticipated acceptance among the general population: positive • Experienced acceptance among intervention subjects: positive or neutral • Experienced acceptance among intervention implementers: context-dependent **Efficacy in laboratory and field settings** • Mean effect sizes small to medium • Behaviourally oriented strategies most potent	Implementation, acceptability, and effectiveness in heterogeneous real-world settings over longer periods

3 AIMS OF THE STUDY

The aim of this doctoral dissertation was to evaluate the implementation, acceptability, and effectiveness of a contextualised, multicomponent choice architecture intervention designed to promote healthy dietary choices and daily physical activity at diverse worksites. The aim was pursued with four empirical studies (I–IV), each focusing on one of the three areas of evaluation.

The specific aims of the dissertation were:

1. to evaluate the implementation of the intervention (Study I),
2. to evaluate the acceptability of the intervention among implementers and influenced employees (Study II),
3. to evaluate the effectiveness of the intervention on:
    a. employees' food consumption and daily physical activity patterns at work (Study III),
    b. employees' perceptions of and responses to the intervention (Study III), and
    c. customers' visual attention and food choices at a worksite cafeteria (Study IV).

The following chapters synthesise, summarise, and discuss the methods and results of the four studies according to the specific aims of the dissertation. The original publications of the studies can be found at the end of the dissertation.

4 SUBJECTS AND METHODS

The four studies of the dissertation were based on a large-scale worksite choice architecture intervention, StopDia at Work, and its sub-intervention at a worksite cafeteria. The studies were conducted under the umbrella of the research project StopDia (Stop Diabetes—Knowledge-Based Solutions). The StopDia project aimed to develop and test new approaches to prevent type 2 diabetes and other lifestyle-related non-communicable diseases at individual (132,133), environmental, and societal levels. The StopDia project targeted three regions of Finland (Northern Savo, South Karelia, and Päijät-Häme) and was conducted by three partner organisations: University of Eastern Finland, VTT Technical Research Centre of Finland, and THL Finnish Institute for Health and Welfare (formerly National Institute for Health and Welfare).

The research plan of the StopDia project was pre-registered (Trial registration: NCT03156478) and approved by the research ethics committee of the hospital district of Northern Savo (statement number: 467/2016). The protocol and analysis plan of the StopDia at Work-intervention were not registered separately. The studies of the dissertation were conducted according to the General Data Protection Regulation of the European Union (GDPR (EU) 2016/679), the Finnish code of conduct for research integrity, and the ethical principles of research with human participants as specified by the Finnish National Board on Research Integrity TENK.

The StopDia project received funding from the Strategic Research Council of the Academy of Finland between 2016 and 2019 (grant number: 303537). This dissertation was additionally funded by the Finnish Food Research Foundation, Juho Vainio Foundation (202100138), Yrjö Jahnsson Foundation (20207314), the North Savo Regional Fund of the Finnish Cultural Foundation (65221698), and the Finnish Diabetes Research Foundation (220016).

4.1 STUDY DESIGN AND SETTING

StopDia at Work was a one-year intervention study designed to promote healthy dietary choices and daily physical activity with subtle modifications to the worksite choice architecture. The intervention was rolled out between 2017 and 2019 in real-world settings at diverse worksites. The intervention was contextualised (i.e., adapted to local contexts) and integrated into the routine operations of the participating worksites. With an equal focus on implementation and effectiveness, the intervention represented a hybrid type 2 trial (134) whose effectiveness was examined in a quasi-experimental pre-post design.

The StopDia at Work sub-intervention was designed to promote nutritionally beneficial food choices at one worksite cafeteria and to more closely examine a subset of intervention strategies used in the main trial. The intervention was conducted between January and February 2018 in a quasi-experimental pre–post design that consisted of a 5-day control and a 5-day intervention condition with identical menus.

In each intervention, the specific aim or content of the intervention was not disclosed to the target audience. This non-disclosure resembled procedures followed in other choice architecture interventions (79,84,85). The purpose was to avoid prompting people to monitor their choice environment or their own behaviour, which could have altered their natural responses to the intervention.

4.2 INTERVENTION SITES AND PARTICIPANTS

For the StopDia at Work-intervention, medium to large organisations with physical worksites in the StopDia project's target regions were identified via web searches and local Centres for Economic Development, Transport, and the Environment. Identified organisations were contacted, invited to introductory workshops and interviews, and eventually to participate in the intervention. Sixteen organisations participated in the intervention with altogether 53 worksites that had in total approximately 5,100 employees. The organisations represented both public (n=6) and private (n=10) sector,

operated in various fields (industry, retail, education, municipality, farming, healthcare, and welfare), and had 1–20 intervention worksites (Table 4). Four organisations had on-site cafeterias that participated in the intervention. The median proportion of male employees per organisation was 35% (interquartile range IQR 21–71%, range 5–91%). In most organisations (n=12 and 10, respectively), the work ranged from sedentary to physical and at least a part of the employees worked in shifts. Fourteen organisations completed the full one-year intervention (46 sites, ~4,670 employees), whereas two organisations completed a shorter, six- to nine-month intervention (7 worksites, ~430 employees). The reasons for the shorter interventions involved moving to new facilities (5 sites) and the closure of the worksite (2 sites).

For the sub-intervention at the worksite cafeteria, the study cafeteria was identified within the recruitment process of the StopDia at Work-intervention, but the cafeteria did not participate in the main intervention. The cafeteria was located in a municipal office building in urban area and represented a typical Finnish workplace cafeteria where customers choose and compose their meals from a serving line. The participants were volunteer customers recruited at the cafeteria entrance (control condition: n=22, intervention condition: n=19). The mean age was 43 years (standard deviation SD 12, range 19–63) among the participants of the control condition and 46 years (SD 10, range 31–63) among the participants of the intervention condition. The proportion of men was 64% among the participants of the control condition and 53% among the participants of the intervention condition. During the intervention, customers could participate regardless of whether they had participated during the control condition. This resulted in partly overlapping study samples between the conditions. The participants of the intervention condition shared eight individuals with the participants of the control condition (mean age 44 years [SD 9, range 31–58], 75% male). The gender and age distribution of these individuals did not differ significantly from other participants of the intervention condition (mean age 47 years [SD 10, range 33–63], 36% male; Fisher's exact test for gender: p=0.170; t-test for age: t[17] = −0.770, p=0.452).

Table 4. Characteristics of organisations that participated in the StopDia at Work-intervention.

Sector	Field	Sites (n)	Employees[2]	Men[3]	Work[4]	Shifts[5]
Private	Education	University buildings (5)	370	34	S	No
Private	Farming	Farm (1)	140	35	SP	Yes
Private	Industry	Construction yards (4), office (1)	180	91	SP	No
Private	Industry	Factory (1)	600	80	SP	Yes
Private	Industry	Factory (1)	250	70	SP	Yes
Private	Industry	Factory (1) [1]	950	78	SP	Yes
Private	Industry	Factory (1) [1]	400	75	SP	Yes
Private	Retail	Groceries (5)	360	21	SP	Yes
Private	Retail	Groceries (3)	320	18	SP	Yes
Private	Retail	Groceries (3)	300	20	SP	Yes
Public	Healthcare	Hospital departments (20) [1]	490	46	SP	Yes
Public	Municipality	Bureau (1)	80	39	S	No
Public	Municipality	Bureau (1)	70	29	S	No
Public	Municipality	Bureaus (2), kindergarten (1)	250	32	SP	Yes
Public	Municipality	Bureau (1) [1]	300	20	S	No
Public	Welfare	Welfare services centre (1)	40	5	SP	No

[1]On-site cafeterias involved in the intervention. [2]Approximate number of employees exposed to the intervention. [3]Percentage of male employees in the organisation during the intervention year. [4]Type of work: S = sedentary, P = physical. [5]At least part of employees had shift work.

4.3 INTERVENTION CONTENT AND IMPLEMENTATION

Implementers of StopDia at Work

Each participating organisation had at least one member of their personnel involved in designing and delivering the intervention to their worksites. Designing involved planning the content and implementation of the intervention, whereas delivery included launching and sustaining selected intervention strategies. Additionally, some organisations had organisation-level coordinators who acted as contact persons between the researchers and individual intervention sites. The designers, deliverers, and coordinators together acted as the implementers of the intervention. The implementers represented various occupational groups, including human resources (HR), occupational wellbeing, and work ability personnel, health and safety representatives, management, assistants, and catering staff.

Content and contextualisation of StopDia at Work

The content and implementation of the intervention were tailored to local contexts in collaboration between the researchers and the implementers. Intervention strategies were selected individually for each site from the StopDia toolkit for creating health-promoting worksite environments (Supplementary Material 1 of Study I). The toolkit described 53 practical, evidence-based strategies for modifying the physical or social worksite environment to facilitate small healthy acts during daily work tasks. The strategies targeted healthy eating or daily physical activity and varied in their type and assumed behaviour change mechanism. The strategies could modify the availability of healthy and/or less healthy options at the worksite; alter the position, functionality, presentation, size, or information of available options; or remind of or facilitate commitment to beneficial actions. The toolkit advanced the implementation of nutrition (135,136) and physical activity (137,138) guidelines; built on the choice architecture framework (31,53,63), dual-process theories (45,51), and typologies of choice architecture interventions (39,56,139) with related empirical evidence; and considered the learnings of the introductory workshops and interviews conducted with organisations over the recruitment process.

Altogether 23 intervention strategies were selected for implementation: sixteen for healthy eating and seven for daily physical activity (Table 5). The strategies were mostly cognitively oriented (n=13 [57%]: availability, position, information, self-regulation) yet included also behaviourally oriented strategies (n=5 [22%]: functionality, size) and some hybrid strategies that combined properties of cognitively and affectively oriented strategies (n=4 [17%]: position, presentation, information, and/or self-regulation) or cognitively and behaviourally oriented strategies (n=1 [4%]: availability). Strategies for healthy eating were typically implemented in coffee rooms, worksite cafeterias, or meetings, and strategies for daily physical activity in various common spaces, such as coffee rooms, copy rooms, monitoring rooms, bathrooms, or stairwells. The three most common strategies were a packed lunch recipe strategy (Table 5: #15) and a movement prompt strategy (#20) that all 53 sites intended to implement, and a "fruit crew"-strategy (#16) that 37 sites intended to implement.

The research team judged ten of the selected intervention strategies as easy, nine as moderate, and four as demanding to implement based on the amount of knowledge and effort required to sustain the strategy after launch (Table 5). Easy strategies were defined as requiring little specialised knowledge and, besides occasional check-ups, no maintenance after launch (e.g., laying out posters or introducing new exercise equipment). Moderate strategies were defined as requiring some knowledge on correct implementation and light maintenance on a regular basis (e.g., keeping exercise equipment in pre-defined places or delivering packed lunch recipes weekly). Demanding strategies were defined as requiring more specialised knowledge and daily maintenance (e.g., the use of nutrition labels or the placement of healthy vs. less healthy foods in the worksite cafeteria).

Table 5. Intervention strategies selected for implementation in the StopDia at Work-intervention.

# Strategy	Mechanism | Type (subtype)	Setting	Ease[1]	n[2]
HEALTHY EATING 1. Enable healthy choice.	Cognitive | Availability (absolute and relative)	Meetings	Moderate	6 (6)
2. Modify selection/variety.	Cognitive | Availability (absolute and/or relative)	Cafeteria	Moderate	4 (4)
3. Replace with better alternatives.	Cognitive/Behavioural | Availability (relative)	Meetings	Moderate	1 (1)
4. Enhance placement.	Cognitive | Position (visibility, proximity)	Cafeteria	Demanding	4 (4)
5. Worsen placement.	Cognitive | Position (visibility, proximity)	Cafeteria	Demanding	4 (4)
6. Serve ready to eat.	Behavioural | Functionality (convenience)	Meetings	Demanding	1 (1)
7. Increase perceived variety (salad components in separate dishes).	Cognitive/Affective | Position (visibility), Presentation (attractiveness)	Cafeteria	Moderate	1 (1)
8. Decrease serving dish size.	Behavioural | Size	Cafeteria	Moderate	1 (1)
9. Decrease serving utensil size.	Behavioural | Size	Cafeteria	Moderate	1 (1)
10. Decrease serving size.	Behavioural | Size	Meetings	Moderate	1 (2)
11. One plate at lunch.	Behavioural | Functionality (default), Size	Cafeteria	Easy	1 (1)
12. Point-of-choice nutrition labels (the Heart Symbol).	Cognitive | Information (simplification, prompt)	Cafeteria	Demanding	4 (4)

Table 5 continues.

Table 5. (cont.) Intervention strategies selected for implementation in the StopDia at Work-intervention.

# Strategy	Mechanism | Type (subtype)	Setting	Ease[1]	n[2]
HEALTHY EATING 13. "Follow the heart"-posters cueing the nutrition labels of strategy #12.	Cognitive | Information (prime)	Cafeteria	Easy	4 (4)
14. Provide personal, reusable water bottles.	Cognitive | Availability (absolute and relative)	Personal workstation	Easy	2 (6)
15. Promote temptingly named, visually attractive packed lunch recipes that highlight appealing sensory properties or ease of preparation (one recipe for each week of the year).	Affective/Cognitive | Presentation (attractiveness), Information (prompt, social norm)	Coffee rooms, lobbies, info screens, intranet, newsletters	Moderate	16 (53)
16. Promote the "Fruit Crew"-starter set for forming fruit circles that organise fruit serving at work.	Cognitive | Self-regulation (commitment, reciprocity), Information (prompt, social norm)	Coffee rooms	Easy	9 (37)
DAILY PHYSICAL ACTIVITY 17. Enable active sitting (e.g., with balance cushions).	Cognitive | Availability (absolute and relative)	Common spaces	Easy	1 (1)
18. Encourage stair use with footprints leading to stairs.	Cognitive/Affective | Information (prompt), Self-regulation (reminder)	Stairwell	Easy	2 (2)

Table 5 continues.

Table 5. (cont.) Intervention strategies selected for implementation in the StopDia at Work-intervention.

# Strategy	Mechanism | Type (subtype)	Setting	Ease[1]	n[2]
DAILY PHYSICAL ACTIVITY 19. Encourage stair use with the StopDia logo (stop hand-sign with a heart on the palm) by the elevator.	Cognitive/Affective | Information (prompt), Self-regulation (reminder)	Elevator	Easy	3 (6)
20. Encourage movement with posters depicting simple exercises suitable to be performed within work tasks.	Cognitive | Information (prompt)	Common spaces	Easy	16 (53)
21. Enable movement with light exercise equipment.	Cognitive | Availability (absolute and relative)	Common spaces	Easy	7 (10)
22. Enhance exercise equipment placement.	Cognitive | Position (visibility, proximity)	Common spaces	Moderate	7 (14)
23. Encourage movement with a break exercise application.	Cognitive | Information (prompt), Self-regulation (reminder)	Personal workstation	Easy	1 (2)

Healthy food was defined as compliant with the nutrition criteria of the national nutrition recommendations (136) and the Heart Symbol—a nutrition labelling system of the Finnish Heart and Diabetes associations (140). For more details of the strategies and images of the intervention materials, see Table 2 and Supplementary Material 1, p. 7–8 of Study I. [1]Approximate ease of implementation (easy, moderate, demanding). [2]Number of organisations (sites) that intended to implement each strategy.

Tailoring the implementation of the selected intervention strategies concerned the choice options (e.g., specific food products or exercise equipment) and contexts (e.g., the worksite cafeteria or meetings) that each strategy targeted and the form (print vs. electronic) and delivery channel (e.g., coffee rooms vs. info screens) of the communication materials used. Site-specific plans also specified the actions and materials needed, people involved, schedules for the intervention launch, and tasks for keeping the intervention up. All adaptations maintained the essential elements of the strategies applied and were recorded carefully. The essential elements pertained to the concrete choice architectural modifications or intervention functions that were integral to each strategy (Supplementary Material 2 of Study I).

Participation in the study was free of charge for the intervention sites, and the study provided materials for strategies whose essential elements involved specific communication materials, such as posters, flyers, labels, or signage. The intervention sites procured any other materials needed for implementation, such as exercise equipment or food.

Implementation of StopDia at Work

The intervention sites received illustrated instructions on the implementation of the selected intervention strategies. The implementers launched the intervention independently (n=32, 60% sites) or with on-site assistance from the researchers (n=21, 40% sites). After the launch, the implementers sustained the intervention until the end of the study. For the packed lunch recipe strategy (Table 5: #15) that all sites intended to implement and that involved regular implementation tasks, the implementers were asked to keep records of completed tasks by filling out a provided form. Twelve (23%) sites additionally opted for text message reminders that assisted in remembering these tasks. Otherwise, the researchers supported the implementation in six-month follow-up visits and, as needed, via email or phone. The support involved assistance in solving emergent challenges and in enhancing displayed intervention materials, as well as encouragement to keep the intervention up. The instructions, records of completed tasks, reminders, follow-up visits, and

researchers' assistance and encouragement served as measures to both enhance and evaluate fidelity.

Sub-intervention at the worksite cafeteria

The StopDia at Work sub-intervention at the worksite cafeteria used three cognitively oriented intervention strategies that were employed in the main intervention. These strategies comprised priming health messages, point-of-choice nutrition labels, and an enhanced position. The used nutrition label was the Heart Symbol of the Finnish Heart Association and the Finnish Diabetes Association (140). The symbol builds on the national nutrition recommendations (136) and indicates nutritionally better choices that meet product category-specific nutrition criteria (fat quantity and quality, salt, sugar, and fibre). EU-Regulation (EC No. 1924/2006) acknowledges the symbol as a nutritional claim.

The priming strategy displayed posters (size A3–A4) saying "Follow the heart" or "A sign of good food" at the cafeteria entrance and on the serving line to facilitate noticing the Heart Symbols (Figure 3). The labelling strategy marked healthy foods (i.e., foods compliant with the Heart Symbol criteria) prominently with the Heart Symbol (size up to 10x10 cm) to facilitate their recognition at the point of choice. The primes and labels represented visual health cues that modified the health-related information available on provided foods. The placement strategy placed healthy foods first in line, in the front row, and/or at the eye level to increase visibility and proximity.

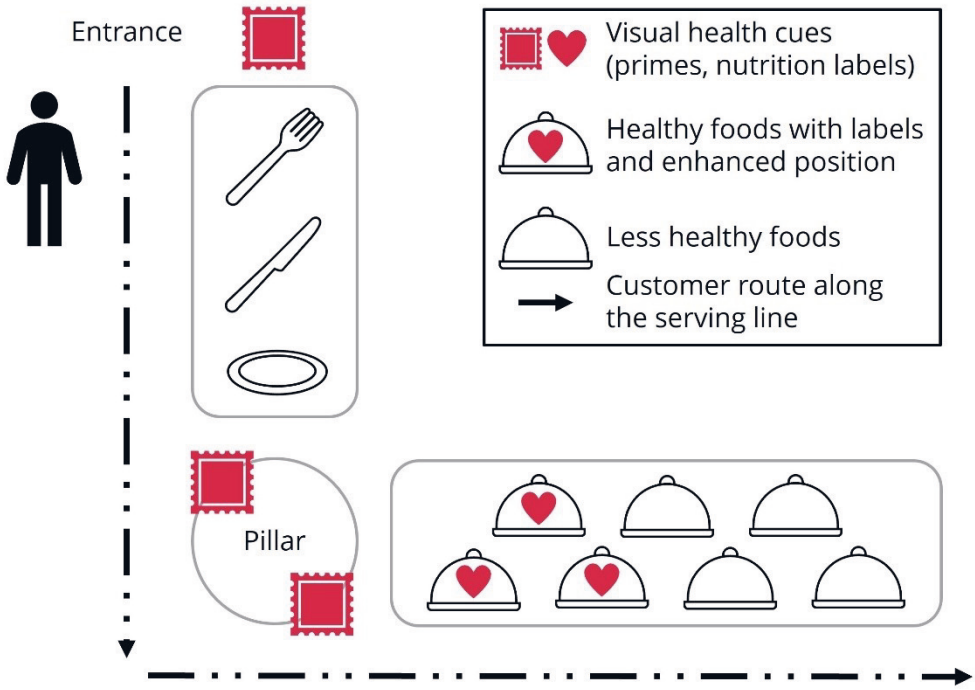


Figure 3. Strategies used in the sub-intervention at the worksite cafeteria.

4.4 DATA COLLECTION

In StopDia at Work, semi-structured implementer interviews and on-site observations halfway through and at the end of the intervention generated data for the evaluation of the implementation (Study I), its acceptability (Study II), and its effectiveness (Study III) (Figure 4). Photos from the intervention sites, written records of completed implementation tasks that the implementers returned, and additional communication with the implementers (emails, text messages, phone calls) complemented the data. Employee questionnaires pre and post intervention yielded data for the evaluation of acceptability (Study II), effectiveness regarding food consumption and daily physical activity patterns at work, and the perceptions of and responses to the intervention (Study III). Employees could complete the post-intervention questionnaire regardless of whether they had completed the pre-intervention questionnaire. This resulted in

two partly overlapping questionnaire datasets. Linking individuals across the datasets was not possible.

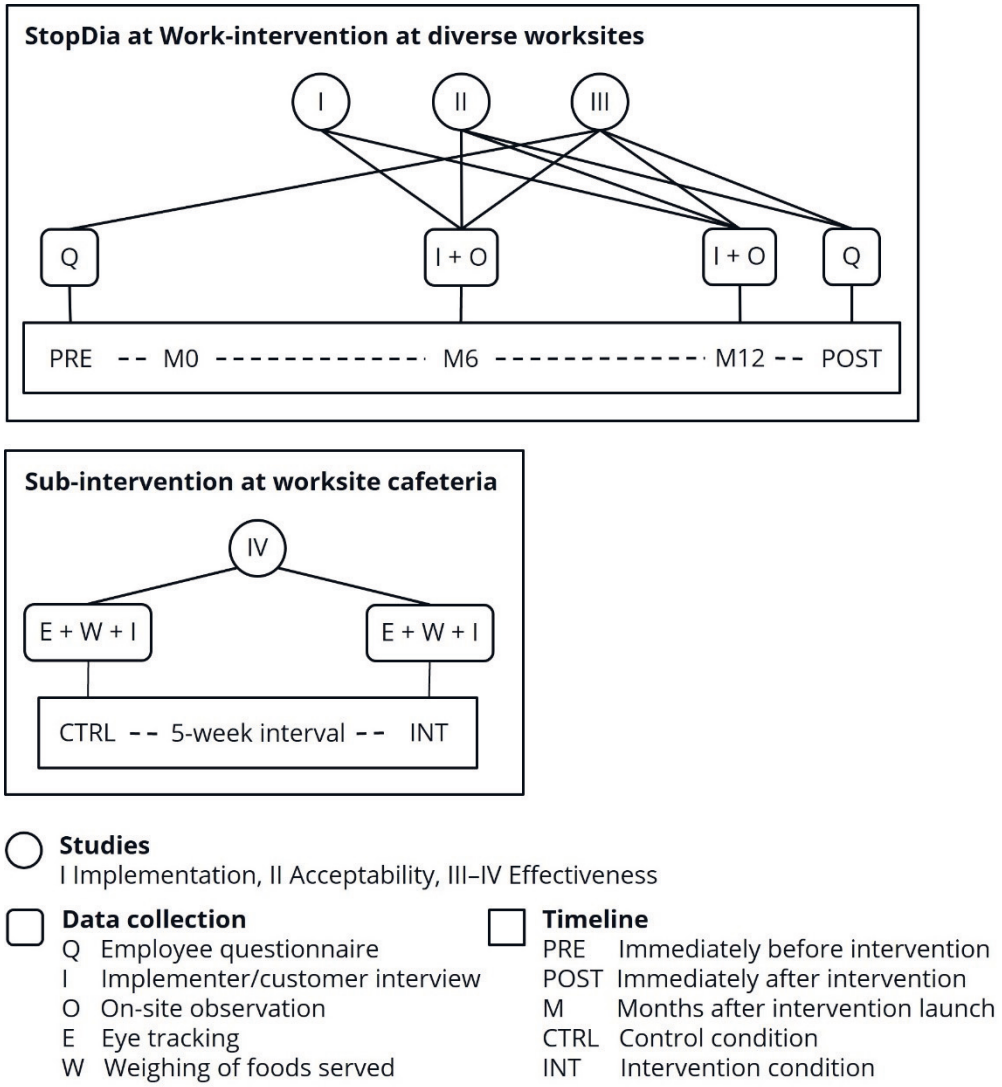


Figure 4. Data collection for studies I–IV.

In the sub-intervention at the worksite cafeteria, data were collected on five days (Monday to Friday over lunch time) during the control condition and on five days during the intervention condition (Figure 4). The data collection of the intervention condition started from the moment the

intervention was launched. Mobile eye tracking collected data on the participants' visual attention and food choices as they proceeded along the serving line and composed their meals. Eye tracking is an objective method to measure eye movements and to study visual attention and behaviour (141). Interviews collected data on factors the participants perceived to influence their food choices. Weighing the foods available on the serving line enabled estimating the cafeteria-level food consumption. The weighing covered foods available at the beginning of the lunch service, foods added during the service, and foods left over at the end of the service.

4.5 MEASURES AND OUTCOMES

Implementation (Study I)

The evaluation of the implementation focused on the fidelity of, facilitators for, and barriers to implementation (Table 6). Fidelity outcomes comprised the dose and quality of the implementation. These outcomes served the evaluation of effectiveness (Study III) as well. The dose was defined as the number of intervention strategies implemented per site. Quality was determined on a three-point scale (2 = successful, 1 = imperfect, 0 = failed) for individual, total, eating-related, and physical activity-related strategies implemented per site. Measures that collected data for the dose and quality assessment included on-site observations and interview questions concerning, inter alia, the intervention strategies implemented, ways of resolving difficulties, and adaptations made during the implementation (Appendix 1). The quality assessment additionally considered four factors related to the implementation: the ease of implementation of strategies implemented (easy, moderate, or demanding) (Table 5), researcher-assisted vs. independent launch, direct vs. coordinator-mediated contact between the researchers and the intervention sites, and reminders the implementers received for implementation tasks.

Table 6. Targets and main outcomes of the evaluations of studies I–IV.

Evaluation (study)	Target	Main outcomes
Implementation (I)	Fidelity	Dose and quality of implementation
”	Facilitators and barriers	Factors related to the organisation, intervention, worksite environment, and implementer[1]
Acceptability (II)	Implementer perspective	Ethicality, affective attitudes, burden, intervention coherence, opportunity costs, and perceived effectiveness[2]
”	Employee perspective	Acceptance of (i) the employer's attempts to influence the employees' health behaviour and (ii) eight specific intervention strategies employed in StopDia at Work
Effectiveness (III)	Food consumption and physical activity at work	Seven food consumption and three physical activity indicators
”	Intervention perception and response	Noticing of, interest in, and/or acting upon three specific intervention strategies used in StopDia at Work
Effectiveness (IV)	Visual attention at worksite cafeteria	% Fixations on visual health cues, healthy foods, and less healthy foods
”	Food choices at worksite cafeteria	Total (number), % healthy, and % less healthy food items chosen
”	Food consumption at worksite cafeteria	Total (grams), % healthy, and % less healthy food taken from the serving line
”	Perceived influences on food choices at worksite cafeteria	Factors perceived to influence own food choices

[1]Adapted from a framework of determinants of workplace health promotion (71,142). [2]Adapted from the Theoretical Framework of Acceptability (90).

The outcomes concerning facilitators for and barriers to the implementation were adapted from a framework of determinants of workplace health promotion interventions (71,142) and included factors related to the organisation, intervention, worksite environment, and implementer (Table 6). Measures included interview questions regarding the implementers' experiences and opinions of the implementation, for example, perceived successes, factors underlying the successes, and difficulties which emerged (Appendix 1).

Acceptability (Study II)

The evaluation of acceptability focused on the perspectives of the implementers and influenced employees (Table 6). Implementer-level acceptability outcomes were defined via six domains of the Theoretical Framework of Acceptability (TFA): ethicality, affective attitudes, burden, intervention coherence, opportunity costs, and perceived effectiveness (90). Measures included interview questions about the acceptability of the employer's attempts to influence the employees' health behaviour overall or with choice architecture interventions, questions about the perceived effects of the StopDia at Work-intervention, and questions used in the evaluation of implementation (Appendix 1), as relevant to the acceptability theme.

Employee-level acceptability outcomes were defined in nine questionnaire items (Table 6). One item asked about the acceptability of the employer's attempts to influence the employees' eating and physical activity patterns to promote the employees' wellbeing (acceptable/not acceptable). Eight items asked to rate the acceptability of specific intervention strategies the employer would implement at the workplace on a seven-point scale (completely disapprove—completely approve). These items were informed by measures used in other choice architecture studies (102,103,105) and adapted to fit the intervention strategies employed in the StopDia at Work-intervention. The rated strategies would: 1. distribute information or tips on healthy eating and physical activity (intervention type: information), 2. remind employees of wellbeing-promoting acts during working hours (self-regulation/information), 3.

increase the proportion of healthy options in the worksite cafeteria (availability), 4. enhance the visibility and accessibility of healthy options in the worksite cafeteria (position), 5. clearly mark healthy options in the worksite cafeteria (information), 6. increase the healthiness of foods and beverages available at the worksite (availability), 7. enable physical activity at the workplace, for example, with exercise equipment (availability), and 8. prompt stair use, for example, using encouraging illustrations or signage (self-regulation/information).

Effectiveness on food consumption and physical activity (Study III)

The evaluation of the effectiveness of the intervention on employees' food consumption and daily physical activity patterns at work involved seven eating- and three physical activity-related outcomes (Table 6). Food consumption was measured with six food frequency questions adapted from a validated questionnaire (143). The questions measured the consumption of vegetables and roots; fruit and berries; plain nuts, almonds, and seeds; sweet treats (e.g., confectionery, sweets); fast food (e.g., hamburger, pizza); and water during a typical work shift on a four-point scale (≥ 2 portions, 1 portion, < 1 portion, none). The seventh food consumption outcome was a diet quality score variable that was formed of individual food frequency questions. The scoring was based on a validated diet quality score (144).

Physical activity was measured with three questionnaire items constructed to match the physical activity-related intervention strategies implemented in the StopDia at Work-intervention. The items measured the performance of restorative movements such as stretching and the use of available exercise equipment (several times, once or twice, less than once, never), as well as stair use (always, frequently, seldom, never) during a typical work shift.

Effectiveness on intervention perception and response (Study III)

The evaluation of the effectiveness of the intervention on the employees' perceptions of and responses to the intervention had seven outcomes. Measures comprised questions about noticing, becoming interested in,

and/or acting upon the three most commonly applied intervention strategies in the StopDia at Work-intervention: packed lunch recipes, movement prompts, and the "fruit crew"-strategy (Table 5: #15, #20, and #16, respectively).

Effects on visual attention and food choices (Study IV)

In the worksite cafeteria, visual attention outcomes comprised the number and duration of the participants' fixations on three objects of interest: the visual health cues implemented (priming health messages, nutrition labels), healthy foods, and less healthy foods available on the serving line (Table 6). These outcomes were reported as the percentage of total fixations on the objects of interest before food choices. Fixations are eye movements that hold objects at the centre of the subjects' visual angle, enabling perception in detail (145,146). Fixations reflect exposure to visual stimuli (147) and serve as proxies for visual attention (141,147). Visual attention, in turn, often projects the focus of active processing (46).

Food choice outcomes included the total number of food items chosen per participant and the percentage of these items that were healthy and less healthy. Outcomes of the perceived influences on food choices comprised factors that the participants perceived to influence their choices. Measures included questions about factors the participants paid attention to on the serving line, factors that determined their choices on the participation day, and factors they usually considered important when choosing foods. Cafeteria-level food consumption outcomes included the total volume (weight in grams) of food taken from the serving line during each study condition, divided by the number of meals sold per condition, and the percentage of healthy and less healthy food within the total volume consumed.

4.6 ANALYSES

All analyses were discussed and decided upon within the multidisciplinary research team of each study. In studies II (acceptability) and III (effectiveness), the team included a statistician. All analyses were

performed by one researcher (ER) and peer-checked by the other research team members. The qualitative data were analysed using NVivo software versions R1 and R1.6 (QRS International). The quantitative data were analysed using IBM SPSS® Statistics versions 25, 28, and 29 (IBM Corp., Armonk, NY, USA); Microsoft Excel® 2016 (Redmond, WA, USA); and R version 4.2.1 (148) with the "Partiallyoverlapping" R-package version 2.0 (149). Eye-tracking data were analysed with SMI BeGaze™ 3.4 behavioural and gaze analysis software build 52, 2014© (150). The statistical significance was set at p-value < 0.05.

Implementation (Study I)

The implementation was evaluated at the level of the worksite. The fidelity outcomes—the dose and quality of implementation—were a result of a mixed-methods analysis that integrated qualitative and quantitative elements (151) (Table 7). The analysis built on qualitative data (interviews, observations) that were transformed into quantitative outcomes.

The dose was formed from the total number of intervention strategies implemented per site, excluding strategies whose implementation was evaluated failed (= 0 points) at both six- and twelve-month follow-up. In other words, the failed strategies did not increase the dose. The quality of implementation was evaluated by two researchers (ER, SV) who independently rated each intervention strategy that each site intended to implement at both follow-up timepoints. The evaluation built on an assessment framework that was developed in the study (Supplementary Material 2 of Study I). The framework defined the essential elements of each strategy and corresponding criteria for successful (= 2 points), imperfect (= 1 point), and failed (= 0 points) implementation. The framework also considered site-specific implementation plans, the continuity of implementation, and accessibility to all employees. The evaluators reached an interrater agreement of 89%; an acceptable result (≥ 85%) according to fidelity assessment guidelines (76). Disagreements were resolved through discussion, consulting a third evaluator (PA) as needed.

Table 7. Data and analyses used in the evaluations of studies I–IV.

Evaluation (study)	Target	Data	n Organisations[1]	n Informants[1]	Analysis
Implementation (I)	Fidelity Facilitators and barriers	I + O (M6 + M12) "	16 "	61 "	Mixed methods[2] Qualitative
Acceptability (II)	Implementer perspective Employee perspective	I (M6 + M12) Q (POST)	16 15	65 1124	Qualitative Quantitative
Effectiveness (III)	Food consumption/PA Intervention perception/response	Q (PRE + POST) Q (POST)	14 "	1126 + 943 943	Quantitative "
Effectiveness (IV)	Visual attention Food choices Perceived influences on choices Food consumption	E (CTRL + INT) E (CTRL + INT) I (CTRL + INT) W (CTRL + INT)	Not applicable " " "	17 + 17 22 + 19 22 + 19 556 + 589[3]	Mixed methods[2] Quantitative Qualitative Quantitative

I = implementer/customer interviews, O = observation, M = months after intervention launch, Q = employee questionnaire, POST = immediately after intervention, PA = physical activity, PRE = immediately before intervention, E = eye tracking, CTRL = control condition, INT = intervention condition, W = weight of food taken from the serving line. [1]Number of organisations/ individuals from whom valid data were available. The total number of participating organisations was 16. [2]Qualitative and quantitative integrated (151). [3]Meals sold at the worksite cafeteria.

Of all the cases evaluated (i.e., strategies per site and timepoint), 82% had sufficient data for a reliable quality assessment (n=337/412; month six: n=187/209, month twelve: n=150/203). These cases were included in the statistical analyses. "Sufficient data" meant that the documentation of the implementation enabled determining the quality of implementation based on the criteria defined in the assessment framework (Supplementary Material 2 of Study I). Mean quality scores were computed by averaging the six- and twelve-month quality ratings of the total, the eating-related, and the physical activity-related strategies that each site intended to implement. Kruskall–Wallis and Mann–Whitney U tests explored differences in the distributions of implementation quality across the categories of four implementation-related variables: ease of implementation (easy, moderate, or demanding), researcher-assisted (40% sites) vs. independent launch, direct contact (57% sites) vs. coordinator-mediated contact between the researchers and the intervention sites, and implementers receiving (i.e., opting for) reminders of the implementation tasks (23% sites) vs. not receiving (i.e., opting out of) the reminders. These tests were performed separately for each follow-up timepoint, pooling all quality ratings across intervention sites and strategies.

Facilitators for and barriers to the implementation were examined via a descriptive qualitative content analysis (152), using pooled data collected over the intervention year (Table 7). The analysis employed a data categorisation matrix adapted from a framework of determinants of workplace health promotion interventions (71,142). One researcher (ER) systematically coded the available data according to the matrix, and the coding was validated in a peer-checking process within the research team. The coding was not mutually exclusive, meaning that a piece of data could relate to multiple themes and thus could receive several codes.

Acceptability (Study II)

The implementer-level evaluation of acceptability was conducted at the level of the organisation, using interview data collected over the intervention year (Table 7). The evaluation applied a descriptive qualitative

content analysis with the protocol used in Study I and a data categorisation matrix based on the Theoretical Framework of Acceptability (TFA) (90).

The employee-level evaluation of acceptability used quantitative methods and post-intervention questionnaire data (Table 7). Valid data were available from 15/16 organisations (48/53 sites). In this sample, median response rate per site was 29% (IQR 23–55%, range 2–68%). A Friedman test with Dunn-Bonferroni post hoc analysis examined differences between the distributions of acceptance of the eight specific intervention strategies rated. An overall acceptance score was computed by averaging the ratings of individual strategies. A mixed-effects logistic regression model explored factors that could explain a low overall acceptance score (< 25th percentile). The model was specified with a site-level random intercept and five site-level predictors: the proportion of male employees, respondents with physical work, respondents with a habit of eating at the worksite cafeteria, and respondents who wished for support for healthy eating or physical activity.

Effectiveness on food consumption and physical activity (Study III)

The evaluation of the effectiveness of the intervention concerning the employees' food consumption and daily physical activity patterns at work was conducted at the level of the worksite, using quantitative methods and pre- and post-intervention questionnaire data (Table 7). Valid data were available from 14/16 organisations (43/53 sites). In this sample, the median response rate per site was 34% (IQR 19–44%, range 14–63%) pre intervention and 28% (IQR 23–58%, range 2–68%) post intervention.

The evaluation used linear mixed models with site-level random intercepts for continuous outcomes and multinomial logistic regression models for categorical outcomes. Each model included the main effect of time (post vs. pre intervention) and implementation (dose×quality), as well as their interaction. The interaction was interpreted as intervention effectiveness. The interaction parameters described how the log odds ratio of belonging to a certain outcome category post versus pre intervention changed depending on the level of implementation. These estimates were presented at exponentiated scale, i.e., as ratios of two odds ratios (ORR). In

multinomial models, the overall significance of the interaction was assessed with likelihood ratio test. The implementation term was formed of the site-specific dose and the mean quality of implementation relevant to each outcome (Table 2 and Supplementary Tables S3–S4 of Study III). The models were adjusted with the site-level proportions of male employees, respondents with physical work, and respondents with a habit of eating in the worksite cafeteria (in models related to food consumption).

Effectiveness on intervention perception and response (Study III)

The evaluation of the effectiveness of the intervention regarding the employees' perceptions of and responses to the intervention was cross-sectional, conducted at the level of the worksite, and based on the post-intervention questionnaire data (Table 7). The study sample was the same as the post-intervention sample in the above-described evaluation of the intervention effectiveness on food consumption and physical activity.

Mixed-effects logistic regression models with site-level random intercepts and logistic regression models without random intercepts examined the associations between implementation quality and the employees' perceptions of and responses to the three most common intervention strategies applied in the StopDia at Work-intervention (Table 5: #15, #20, and #16). Each model included the main effect of the quality of implementation corresponding to the outcome. The models were adjusted with the site-level proportions of male employees, respondents with physical work, respondents who wished for support in healthy eating or physical activity, and respondents who reported having completed the pre-intervention questionnaire.

Effects on visual attention and food choices (Study IV)

The analyses of visual attention, food choices, and food consumption in the worksite cafeteria covered a section of the serving line that provided main courses and snacks (e.g., sandwiches and yoghurt). The cafeteria provided four warm daily main course options (two fish/meat options, one vegetarian, and one soup) with relevant carbohydrate accompaniments

(rice and/or potatoes) and steamed vegetables, as well as a salad bar that served as a cold main course option.

Effects on visual attention and food choices were examined at the level of the individual, using mixed methods and eye tracking data (Table 7). The analysis of visual attention examined fixations that preceded food choices and fell on the defined objects of interest: visual health cues, healthy foods, or less healthy foods. The fixations were coded according to the objects of interest based on a visual inspection of eye-tracking recordings. The method is common in eye-tracking research (153,154). The coding was conducted by one researcher (ER) and validated in a peer-checking process within the research team. Between-condition differences in fixations and food choices were examined with statistical tests developed for comparing two partially overlapping samples that have both paired and independent observations (155). A partially overlapping samples t-test (T_{new1}) compared the means of normally distributed variables with equal variances (156,157). A corresponding non-parametric test (T_{RNK1}) examined the location shifts of non-normally distributed variables with equal variances (158).

The evaluation of the factors that participants perceived to influence their food choices employed a descriptive qualitative content analysis (152) with the protocol used in Study I. The analysis applied a data categorisation matrix that was based on the Food Choice Questionnaire, which has nine dimensions (health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, ethical concern) (159), and the NEO Personality Inventory dimension “openness to experience” (160), which predicts willingness to try new foods (161).

The cafeteria-level food consumption was determined by subtracting the pooled weight of leftover food available on the serving line at the end of the lunch service from the pooled weight of food placed on the serving line over the service. The total volume and the percentage of healthy and less healthy food consumed per study condition were computed.

5 RESULTS

5.1 IMPLEMENTATION OF CHOICE ARCHITECTURE MODIFICATION (STUDY I)

5.1.1 Fidelity

Dose

All but one intervention worksite of the StopDia at Work-intervention succeeded to implement at least one intervention strategy. The median number of strategies implemented per site was three (range 0–14); a median of two (range 0–9) for healthy eating and one (range 0–5) for daily physical activity (Figure 5).

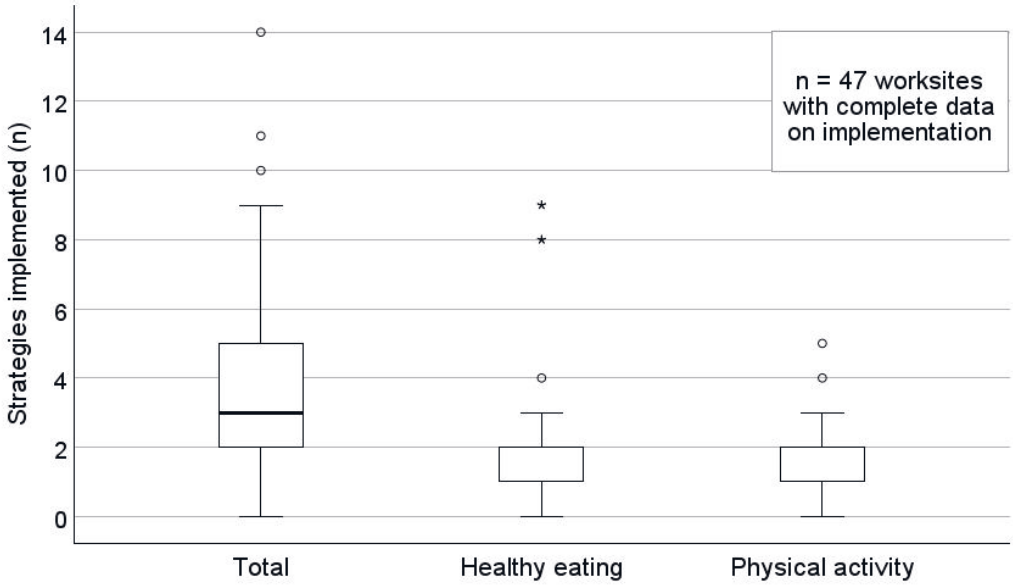


Figure 5. Intervention dose (i.e., number of strategies implemented) per worksite in total, for healthy eating, and for daily physical activity. Boxes extend from first to the third quartile, horizontal lines across the boxes represent medians, whisker endpoints indicate minimum and maximum values, and markers represent outliers (○) and extreme outliers (*).

At sites with on-site cafeterias that participated in the intervention (n=4), the dose was greater compared to sites without such cafeterias (n=43): median 10.5 vs. 3 strategies in total, 8.5 vs. 2 for healthy eating, and 2 vs. 1 for physical activity (Figure 6).

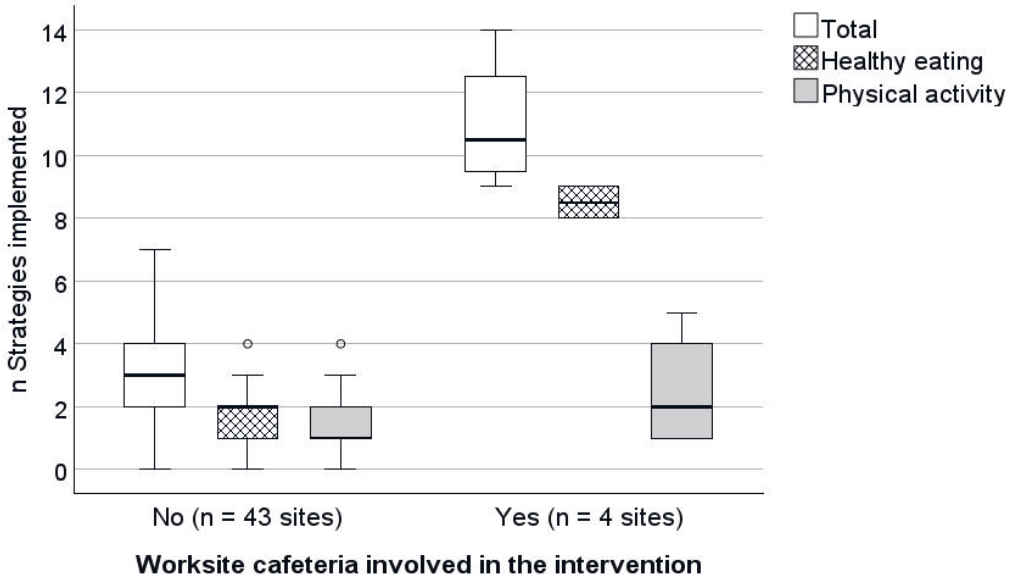


Figure 6. Intervention dose (i.e., number of strategies implemented) per worksite in total, for healthy eating, and for daily physical activity by the involvement of worksite cafeteria in the intervention. Boxes extend from first to the third quartile, horizontal lines across the boxes represent medians, whisker endpoints indicate minimum and maximum values, and markers (○) represent outliers.

Quality

The quality of implementation in the StopDia at Work-intervention was rated successful in 66%, imperfect in 25%, and failed in 9% of the cases assessed across sites and follow-up timepoints. A case referred to a given strategy assessed at a given site and timepoint. The median overall quality score per site was 1.7 (interquartile range IQR 1.3–1.8), representing 85% of the maximum score 2. The median score for eating-related strategies was

1.5 (IQR 1–2) and for physical activity-related strategies 2 (IQR 1.5–2), representing 75% and 100% of the maximum. The median quality ratings of researcher-assisted vs. independently launched strategies were the same at both follow-up timepoints (median 2, IQR 1–2), but according to a Mann-Whitney U test, the ratings of the researcher-assisted strategies ranked significantly higher at the first follow-up (U=4,594.5, p=0.021, n=63 vs. 124). The difference did not persist in the second follow-up, however (U=2,491.0, p=0.625, n=54 vs. 96). Similarly, the median quality ratings of strategies whose implementers had direct vs. coordinator-mediated contact to the researchers ranked significantly higher at the first follow-up (median 2 vs. 1.5, U=4,853.0, p<0.001, n=127 vs. 60) but not at the second (median 2 vs. 2, U=1,935.0, p=0.980, n=117 vs. 33). The distribution of quality ratings did not differ by the ease of implementation or reminders received for implementation tasks at either follow-up (p-values > 0.05).

5.1.2 Facilitators and barriers

The qualitative content analysis of implementer interviews and observations collected at the StopDia at Work-intervention sites identified facilitators for and barriers to implementation that were related to the organisation, intervention, worksite environment, and the implementer.

Facilitators

Organisational facilitators comprised careful planning and management engagement. Careful planning referred to clearly dividing implementation-related responsibilities within the organisation, communicating the intervention to employees, ensuring sufficient resources for designing and delivering the intervention, and integrating the intervention into existing health promotion activities. Management engagement meant supporting the implementers and encouraging employees to tap into provided opportunities.

Intervention-related facilitators included the perceived utility of the intervention to the implementer, the compatibility of the intervention with the mission of the worksite and the work of the implementer, the

perceived ease of implementation, perceived reach and effects, and support received from the researchers in the intervention design and delivery.

Facilitators related to the worksite environment included practical channels for distributing intervention materials, such as internal mail or info screens, and the existing worksite food supply that facilitated the implementation of strategies for healthy eating. The food supply could mean an onsite cafeteria, a food storage, or a custom to provide refreshments during meetings or in coffee rooms.

Implementer-related facilitators concerned the implementer's work and the implementer. Favourable characteristics of work comprised duties with regular tours round the premises of the worksite, workstations located at the intervention site, regular working hours, time available for the implementation, and a job substance related to the intervention. Favourable characteristics of the implementer included being committed, relatable to employees, motivated, motivational, sociable, organised, and tolerant to initial resistance to the intervention that could emerge.

Barriers

Organisational barriers included a lack of management support for the implementation, lack of time or personnel resources, organisational changes such as staff turnover, and poor flow of information between managers, implementers, and employees.

One intervention-related barrier that was also related to the poor flow of information within the organisation was suboptimal implementer training. This issue concerned particularly organisations with multiple intervention sites and/or implementers and situations in which the implementer changed. Another intervention-related barrier concerned intervention requirements, including efforts needed to keep the intervention up, a long duration, and costs of intensive implementation. Furthermore, perceived ineffectiveness frustrated some implementers and challenged implementation.

Barriers posed by the worksite environment involved limited possibilities for implementation and renovations that interrupted the

intervention. Limited possibilities for implementation referred to physical characteristics of the worksite facilities that restricted the type of strategies that could be implemented or the ways in which the strategies could be delivered. Such characteristics could mean an unmodifiable serving line at the worksite cafeteria or a lack of feasible places for displaying intervention materials.

Implementer-related barriers concerned the implementer's work and the implementer. Unfavourable characteristics of work comprised irregular working hours that did not allow regular completion of implementation tasks, a heavy workload, and a job substance unrelated to the intervention. Unfavourable characteristics of the implementer included forgetfulness, long absences from work, and negligence of intervention materials, which appeared in a failure to reintroduce removed materials. Further unfavourable characteristics included a lack of motivation, personal relevance, and understanding of the intervention. Many of the implementer-related barriers were related to a poor flow of information within the organisation and suboptimal implementer training.

Figure 7 summarises the findings of Study I on implementation.

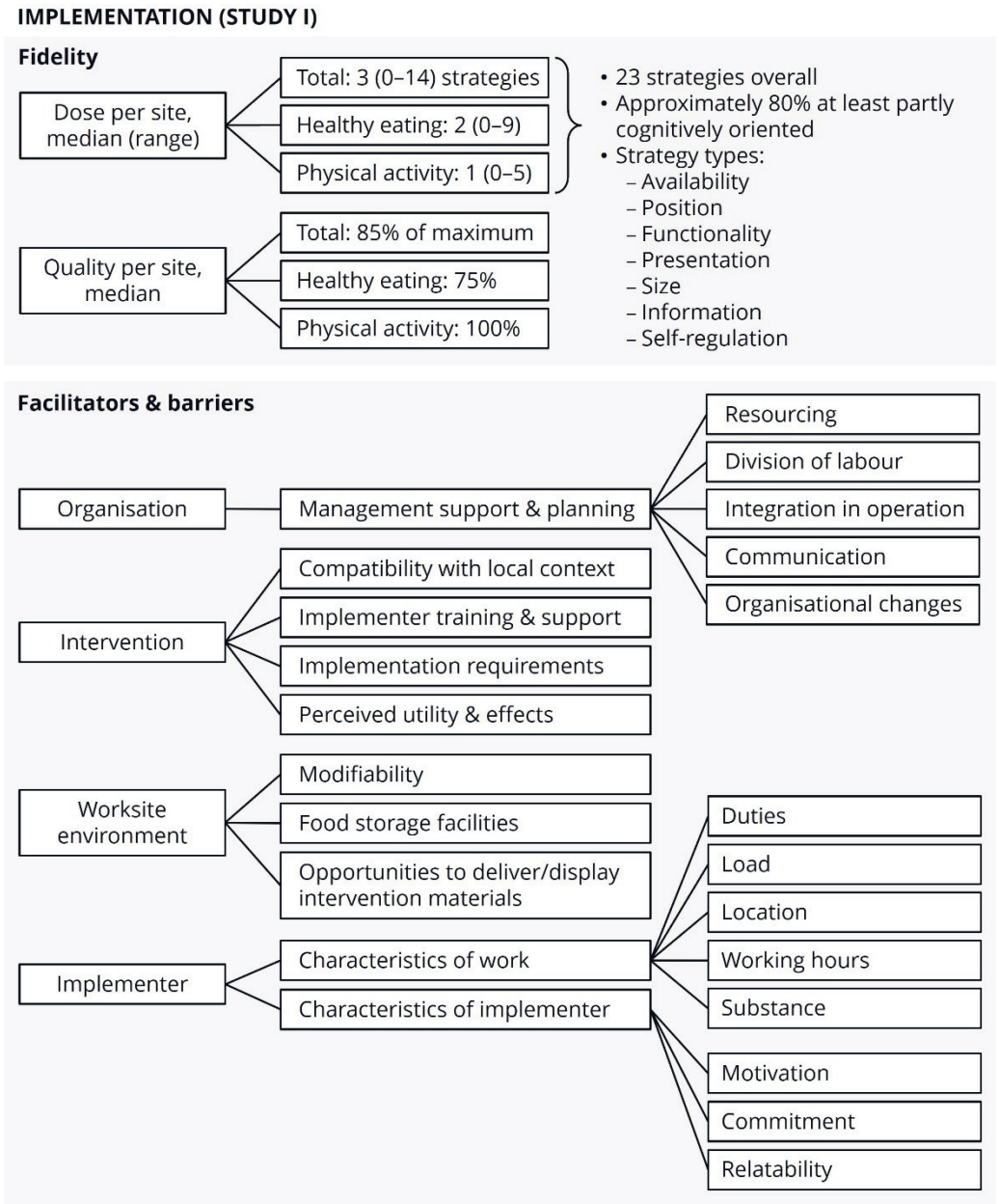


Figure 7. Summary of the findings concerning the evaluation of implementation.

5.2 ACCEPTABILITY OF CHOICE ARCHITECTURE MODIFICATION (STUDY II)

5.2.1 Perspective of implementers

The qualitative content analysis of interview data collected among the implementers of the StopDia at Work-intervention yielded findings related to six domains of the Theoretical Framework of Acceptability (90). These domains were: ethicality, affective attitudes, burden, intervention coherence, opportunity costs, and perceived effectiveness (Table 8).

The implementers considered choice architecture interventions an ethical approach to promote the employees' wellbeing and health (Table 8). They expressed mainly positive affective attitudes to the StopDia at Work-intervention and found its implementation mostly effortless. Reflecting intervention coherence, understanding the rationale of the intervention increased interest in the implementation. As such, intervention coherence appeared connected to affective attitudes towards the intervention. Lack of understanding, in turn, was proposed to explain poor implementation at sites where the implementers did not receive a proper introduction to the intervention. In terms of opportunity costs, perceived futility of the intervention was accompanied by the disapproval of the resources that were invested in its implementation. Moreover, cost acceptance varied along with the intensity of implementation. In one organisation, the costs of the "fruit crew"-strategy (Table 5: #16) proved too high when the employees were provided with unlimited amounts of fruit daily. The costs remained acceptable, however, when each employee received a piece of fruit twice per week.

Table 8. Summary of the findings of the implementer-level evaluation of acceptability.

Domain	Definition[1]	Topic of reports[2]	Main findings[2]
Ethicality	Extent to which the intervention fits the implementers' values	Workplace health promotion in general or with choice architecture interventions	• Workplace health promotion benefits everyone and is acceptable with voluntary, positive, and encouraging interventions. • Choice architecture interventions are an ethical, gentle, and freedom-preserving approach to encourage healthy choices.
Affective attitudes	Feelings about the intervention	Intervention content and implementation	• Attitudes to the choice architecture approach, implemented strategies, intervention materials, implementation, and the StopDia project were mainly positive. • Packed lunch recipes drew some criticism. • Perceived ineffectiveness reduced motivation for implementation.
Burden	Perceived amount of effort that participation requires	Implementation	• Once formed into a routine, implementation felt effortless.
Intervention coherence	Extent to which the implementers understand the intervention and how it works	Implementation	• Understanding increased interest in implementation.

Table 8 continues.

Table 8. (cont.) Summary of the findings of the implementer-level evaluation of acceptability.

Domain	Definition[1]	Topic of reports[2]	Main findings[2]
Opportunity costs	Extent to which benefits, profits, or values must be given up due to the intervention	Resources invested in intervention materials or implementation	• Perceived futility of the intervention and intensive implementations were accompanied by cost disapproval.
Perceived effectiveness	Extent to which the intervention is perceived as likely to achieve its purpose	Observed effects of the intervention	• Perceived effects were mostly positive or negligible. • Facilitators for effectiveness included an active implementer, supportive social and physical work environment, and the employer's support for implementation. • Proposed explanations for ineffectiveness included varying individual preferences, needs, and understanding of the intervention; and unsupportive circumstances at work.

[1]Adapted from the Theoretical Framework of Acceptability (90). [2] Unless otherwise specified, the topics of implementer reports and the main findings refer to the content, implementation, or perceived effectiveness of the StopDia at Work-intervention.

Perceived effects were mostly positive or negligible and rarely negative (Table 8). Positive perceived effects included increased availability and consumption of healthy foods at worksite cafeterias, meetings, or coffee rooms; employees' interest in and use of the packed lunch recipes; and increased movement or use of stairs or exercise equipment. Negative perceived effects included tearing down of materials or hoarding of fruit provided in coffee rooms. Sites solved such issues with enhanced implementation and communication with the employees.

Several factors were observed to accompany positive perceived effects (Table 8). One of the factors was an active implementer who presented or handed out intervention materials to employees personally. Another factor was a supportive social and physical work environment where colleagues showed a positive example and were used to organising common activities, or where worksite facilities supported the promoted behaviours. A third factor was the employer's support for implementation with money, working time, or facilities. Factors that implementers proposed to explain perceived ineffectiveness included the employees' individual preferences, needs, and understanding of the intervention, and unsupportive circumstances at work. The latter referred to large work communities or shift work that complicated the organisation of and engagement in common activities.

Critical or negative views the implementers expressed concerned mostly the packed lunch recipe strategy (Table 5: #15) that did not appeal to everyone and that some implementers found futile. For some, the weekly implementation tasks of this strategy felt unmotivating due to the perceived burden particularly at the beginning of the intervention or due to its perceived ineffectiveness. Thus, perceived burden and effectiveness appeared to influence affective attitudes to the intervention. Additionally, perceived ineffectiveness was accompanied by disapproval of opportunity costs.

The implementers who contributed to the acceptability evaluation included "designers" who had been involved in designing the content and implementation of the intervention on their sites (49% of informants); "health promoters" whose jobs were essentially focused on the promotion

of employee wellbeing and health (28%), for example, HR and occupational wellbeing personnel; and "other implementers" who were not designers nor health promoters (48%), for example, assistants and catering staff. Nearly all (89%) health promoters were also designers. All implementer groups expressed both positive and negative views of acceptability.

5.2.2 Perspective of influenced employees

Among the employees who completed the post-intervention questionnaire of the StopDia at Work-intervention, the proportion who considered it acceptable for the employer to seek to influence the employees' dietary and physical activity patterns to promote wellbeing was 95%. The median acceptance of each of the eight specific intervention strategies evaluated was 7 (IQRs 6–7 to 7–7; 1 = disapprove, 7 = approve) (Table 6 of Study II). Yet, a Friedman test observed statistically significant differences in the distributions of acceptance of specific strategies ($\chi^2(7) = 150.421$, $p<0.001$, n=977). The acceptance of a strategy that would improve the healthiness of foods and beverages available at the worksite—or in other words, replace less healthy options with healthier alternatives—ranked significantly lower compared to strategies that would provide information or tips on healthy eating and physical activity ($p<0.001$), increase the proportion of healthy options at the worksite cafeteria ($p<0.001$), enhance the visibility and accessibility of healthy options at the worksite cafeteria ($p=0.018$), clearly indicate healthy options at the worksite cafeteria ($p=0.005$), or increase opportunities for physical activity at the worksite ($p<0.001$).

The median overall acceptance score of the strategies evaluated was 7 (IQR 6.4–7). A greater proportion of male employees at the intervention site was significantly associated with a lower overall acceptance (OR 4.4, 95% CI 1.2 to 16.5). On the contrary, physical work, a habit of eating at the worksite cafeteria, and a wish for support for healthy eating or physical activity were not significantly associated with acceptance.

Figure 8 summarises the findings of Study II on acceptability.

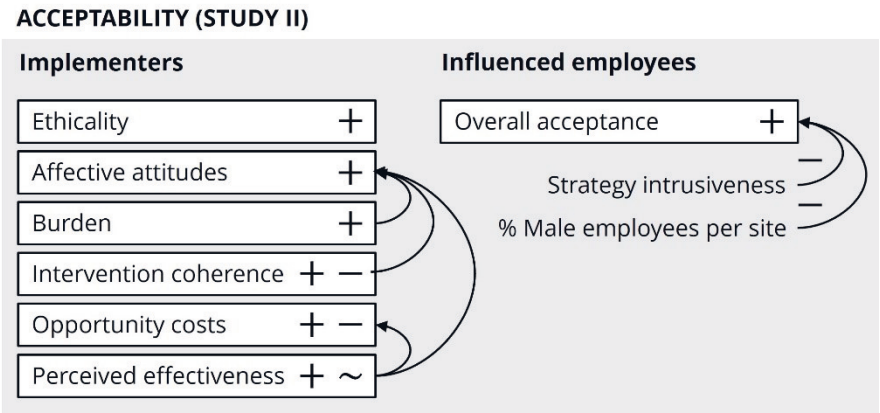


Figure 8. Summary of the findings concerning the evaluation of acceptability. (+ positive, ~ negligible, − negative).

5.3 EFFECTIVENESS OF CHOICE ARCHITECTURE MODIFICATION (STUDIES III–IV)

5.3.1 Food consumption and physical activity at work

Multinomial logistic regression models that estimated the interaction effect of time (post vs. pre intervention) and site-specific implementation (dose×quality) on employees' food consumption and physical activity patterns at work detected a statistically significant association between the StopDia at Work-intervention and a favourable change in employees' fruit and berry consumption (p=0.006) (Table 3 of Study III). The intervention was associated with an increase in the proportion of employees who consumed one portion (ORR 1.2, 95% CI 1.0 to 1.3) and the proportion who consumed two or more portions (ORR 1.2, 95% CI 1.0 to 1.4) of fruit and berries during a typical work shift compared to the proportion who consumed none. In addition, the models detected a significant association between the intervention and an unfavourable change in employees' sweet treat consumption (p=0.048). The intervention was associated with a decrease in the proportion of employees who consumed less than one portion (ORR 0.6, 95% CI 0.4 to 1.0) and the proportion who consumed zero portions (ORR 0.6, 95% CI 0.4 to 0.9) of sweet treats during a typical work shift compared to the proportion who consumed at least two portions. No

significant associations were observed between the intervention and changes in the diet quality score or in the consumption of vegetables and roots; nuts, almonds, and seeds; fast food; or water.

The models detected a statistically significant association between the intervention and a change in the frequency at which employees used available exercise equipment at work (p=0.040) (Table 3 of Study III). The intervention was associated with a decrease in the proportion of employees who used the equipment less than once (ORR 0.8, 95% CI 0.7 to 1.0) per work shift compared to the proportion who never used the equipment. Simultaneously, model estimates suggested the intervention was associated with an increase in the proportion of employees who used the equipment several times per work shift compared to the proportion who never used it, but this association was non-significant (ORR 1.8, 95% CI 0.9 to 3.4). No significant associations were observed between the intervention and changes in the performing of restorative movements or stair use. Both pre and post intervention, the most common reasons for never performing restorative movements or never using available exercise equipment were that the idea never crossed one's mind; forgetting; lack of time, space, or motivation; and embarrassment.

5.3.2 Perceptions of and responses to the intervention

At the end of the StopDia at Work-intervention, most questionnaire respondents reported having noticed the packed lunch recipes (70%), the "fruit crew"-materials (84%), and the movement prompts (76%) (Table 4 of Study III). Of these respondents, respectively, 67% had become interested in and 31% had tried at least one recipe, 28% had joined a fruit crew, and 50% had followed the movement prompts. Logistic regression models indicated that the quality of implementation was positively associated with the odds of noticing (OR 5.4, 95% CI 1.1 to 27.8) and trying (OR 2.3, 95% CI 1.2 to 4.5) the packed lunch recipes but unrelated to the odds of becoming interested in the recipes (OR 1.2, 95% CI 0.6 to 2.2). The quality of the implementation was negatively associated with the odds of noticing the "fruit crew"-materials (OR 0.4, 95% CI 0.2 to 0.8) but positively associated

with the odds of joining a fruit crew (OR 2.9, 95% CI 1.8 to 4.7). The implementation quality was not significantly associated with the odds of noticing (OR 5.3, 95% CI 0.9 to 32.4) or following (OR 1.1, 95% CI 0.6 to 2.2) the movement prompts. The proportion of respondents who wished that the employer would provide support for healthy eating was 37% and the proportion who wished for support for physical activity was 61%.

5.3.3 Visual attention and food choices at worksite cafeteria

In the sub-intervention at the worksite cafeteria, the participants' mean percentage of fixations on visual health cues (i.e., priming messages or nutrition labels) was approximately 13% during the intervention (Figure 9A, Table 3 of Study IV). This figure reflected the mean proportion of both total number and total duration of fixations that preceded food choices and fell on the defined objects of interest (i.e., visual health cues or foods). The finding implies that the cues captured visual attention, which was a prerequisite for the effectiveness of the intervention.

The mean percentage of visual fixations on healthy foods was approximately 61% during the control and 58% during the intervention condition, with no significant between-condition differences in the fixation number (T_{new1} = 0.387, p=0.702) or duration (T_{new1} = 0.406, p=0.688). Similarly, between-condition differences were non-significant for the number (T_{new1} = −0.706, p=0.486) and duration (T_{new1} = −0.726, p=0.474) of visual fixations on less healthy foods (Figure 9A, Table 3 of Study IV).

The participants chose a median of three (IQR 2–4) food items both during the control and the intervention condition with no significant difference between the conditions (T_{RNK1} = 0.075, p=0.941). The median percentage of healthy choices was 33% (IQR 0–79%) during the control and 67% (IQR 25–100%) during the intervention condition (Figure 9B, Table 4 of Study IV). The between-condition difference was non-significant (T_{RNK1} = −1.149, p=0.261). At the level of the cafeteria, the total volume of food consumed from the serving line, divided by the number of meals sold, was 15 g smaller during the intervention (389 g) compared to the control (404 g). The percentage of healthy foods consumed was approximately 45% and

the percentage of less healthy foods approximately 55% in both study conditions (Figure 9C, Figure 7 of Study IV).

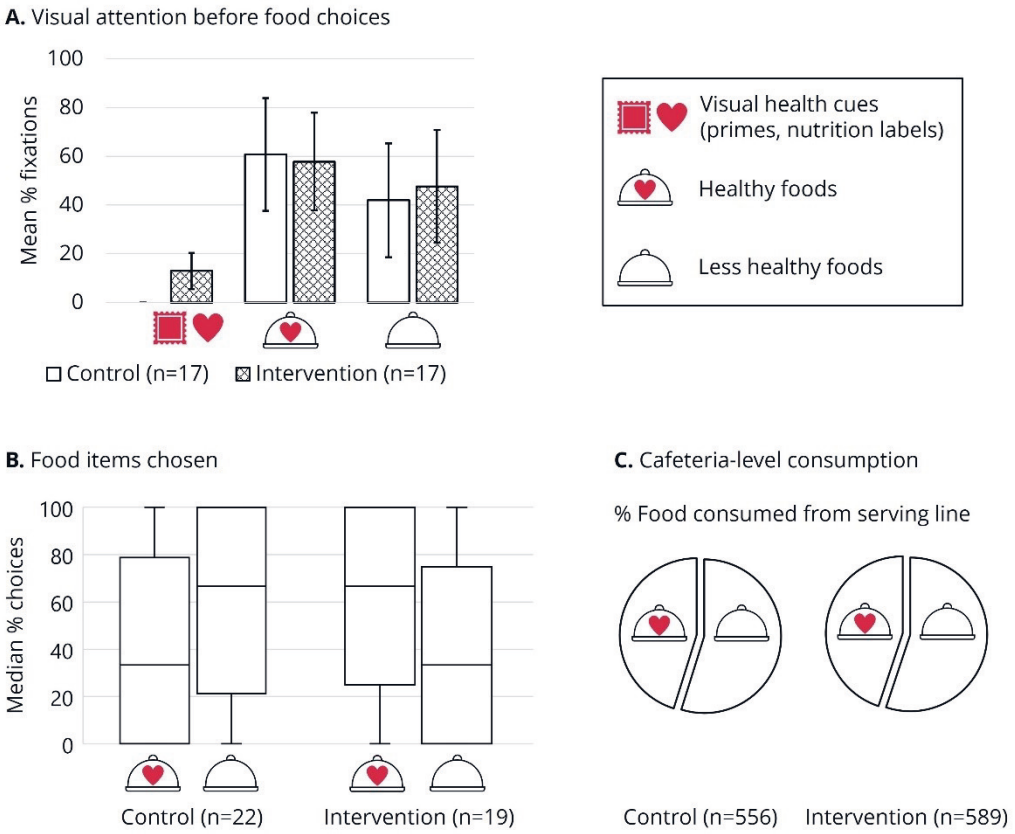


Figure 9. (A) Participants' visual attention to health cues, healthy foods, and less healthy foods. **(B)** Participants' healthy and less healthy food choices. **(C)** Cafeteria-level food consumption.

The qualitative content analysis of interview data collected from the participants identified 17 factors that the participants perceived to influence their food choices. The most frequently mentioned influence was sensory appeal (77% of control / 58% of intervention participants), such as the look, taste, or texture of food (Table 5 of Study IV). The next most frequently mentioned factors were healthiness (59%/47%) and familiarity (55%/42%). Familiarity included habitual choices. Reflecting habitualness, most participants (95%/84%) considered their choices on the participation

day to be typical or somewhat typical. Further influences were related to specific foods (e.g., vegetables), variation, weight control, menu, satiety, mood, special diet, food quality, convenience, price, season, social influence, natural content, or ethical concern. The participants often reported multiple influences, and the decisive influence could depend on the choice task. Sensory appeal, for example, could determine individual food choices, while healthiness guided the meal composition and portion size.

During the intervention, 11% of the participants reported having noticed changes in the cafeteria and correctly specified the changes as the Heart Symbol. No participant reported having noticed the primes or changes to the position of foods. Nearly all participants (89%) were familiar with the Heart Symbol, and all understood the label to indicate healthier foods.

Figure 10 summarises the findings of studies III–IV on effectiveness.

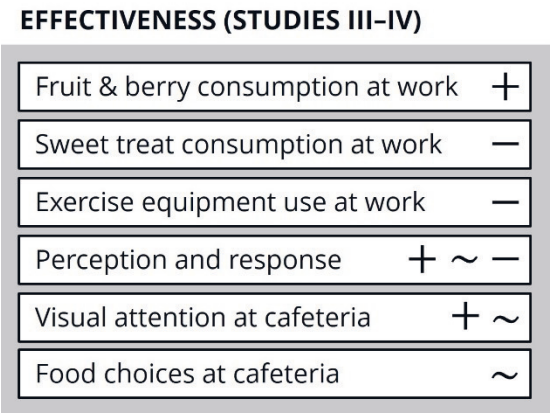


Figure 10. Summary of the findings concerning the evaluation of effectiveness. (+ positive, ~ non-significant, − negative).

6 DISCUSSION

This doctoral dissertation aimed to evaluate the implementation (Study I), acceptability (Study II), and effectiveness (Studies III–IV) of choice architecture modification for healthy eating and daily physical activity in real-world settings in heterogeneous worksites. The results suggest that choice architecture interventions are feasible for implementation in workplaces, well accepted among work communities, and capable of positively influencing health behaviour at work. However, the effects seem small and the success of the interventions depends on numerous interconnected factors that influence the implementation, acceptability, and effectiveness. Figure 11 synthesises the key findings of the dissertation and indicates connections between them. The following sections discuss the findings, the strengths and limitations of the work, and implications for research, practice, and policy.

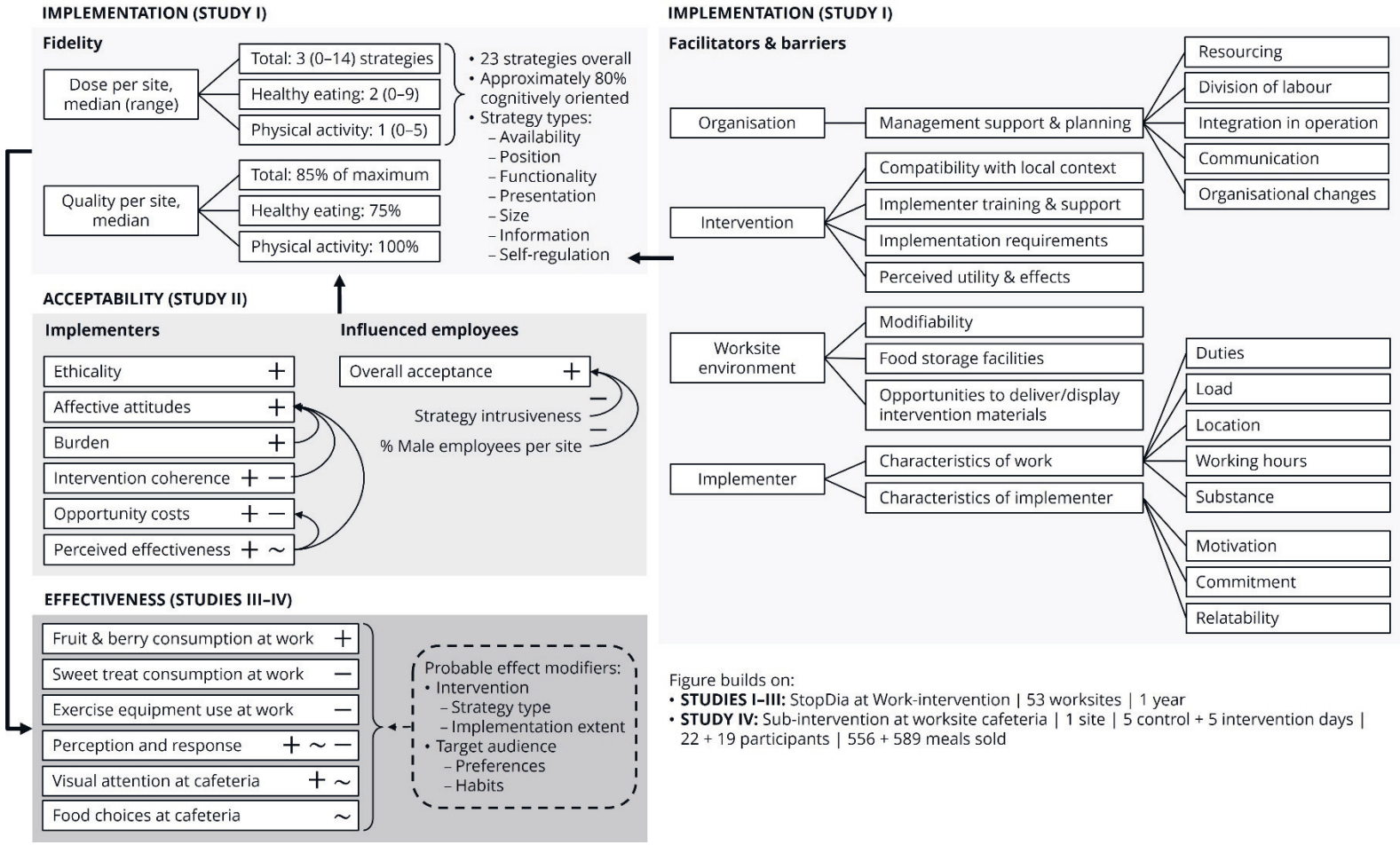


Figure 11. Synthesis of key findings (+ positive, ~ perceptibly negligible or statistically non-significant, − negative).

6.1 IMPLEMENTATION

6.1.1 Fidelity

Dose

In the StopDia at Work-intervention, all sites except one implemented at least one choice architecture strategy. The median intervention dose was three strategies per site, with a median of two strategies for healthy eating and one for physical activity. The dose varied substantially between sites, however. The variability was understandable considering the heterogeneity of the participating worksites and their resources. The dose was greatest at sites with onsite cafeterias that could readily apply a broad range of eating-related strategies. Relatedly, the overall variety of strategies implemented for healthy eating (n=16 across intervention sites) was greater compared to the variety of strategies implemented for physical activity (n=7).

The dominance of strategies for healthy eating mirrored the selection of the toolkit, from which the intervention sites chose strategies for implementation. The toolkit, in turn, was based on available scientific literature and reflected the current evidence base of lifestyle-related choice architecture interventions. Scoping reviews have identified a substantially greater proportion of interventions focused on eating behaviour compared to physical activity (63,162). Possible explanations for this imbalance in the literature are that compared to the physical activity domain, the eating behaviour domain provides a wider range of contexts and choice options which may be suitable for choice architectural modification, and that a larger variety of choice architecture strategies are easily applicable to these contexts and options (63). For example, abundant possibilities exist to modify the availability, position, portion size, or functionality (e.g., default choice or convenience) of healthy food options within micro-environments such as the workplace. In contrast, altering the availability, position, size, or functionality of opportunities for daily physical activity such as stair use may require more structural interventions that involve redesigning and renovating the built environment. A more comprehensive use of the choice architecture approach for physical activity would hence require that actors responsible for urban planning, traditional architecture, and related

regulation adopt the approach and apply it to designing living environments and buildings that facilitate staying active. A further factor that explains the relative scarcity of choice architecture strategies for physical activity in the present study is that the research team consisted predominantly of nutrition researchers for whom it was easier to develop strategies for healthy eating.

Another characteristic of the strategies selected for implementation in the StopDia at Work-intervention was that nearly 80% were at least partly cognitively oriented, i.e., aimed at facilitating the recognition of the promoted option and at boosting reflective processes that could lead to the desired behaviour. These strategies targeted the availability or position of behavioural options, modified behaviour-related information, or aimed at supporting self-regulation. In this respect too, the strategies reflected the scientific literature. Lifestyle-related choice architecture interventions have most frequently employed cognitively oriented strategies (32,63,162). The greater popularity of cognitively versus affectively or behaviourally oriented strategies may be explained by a greater variety of strategy types within the intervention category or by a higher applicability of the strategies to a broader range of contexts. Another potential explanation is the similarity of cognitively oriented strategies to more conventional, individual-level approaches to health promotion that rely on the provision of information (63). Additionally, commonly used cognitively oriented strategies, such as point-of-choice prompts and reminders count as the least intrusive choice architecture interventions because they are transparent to the target audience and aim at enhancing reflective processing (64). Hence, choice architects may be most familiar with and feel most comfortable using cognitively oriented strategies. Furthermore, a prevailing misconception about the relative effectiveness of diverse choice architecture strategies may favour the implementation of cognitively oriented ones. While empirical evidence indicates that behaviourally oriented strategies yield greater effects compared to cognitively oriented strategies (32,33), people have been found to believe that cognitively oriented strategies are the most effective (101).

Quality

Considering all intervention sites, strategies intended to implement, and follow-up timepoints, two thirds of the implementations in the StopDia at Work-intervention were rated as successful. The quality of implementation was independent of reminders and the ease of implementation of the applied strategies. The median overall quality score per site was 1.7 (85% of the maximum score 2), with a median score of 1.5 (75%) for strategies promoting healthy eating and 2 (100%) for strategies promoting physical activity.

The median overall quality scores may be somewhat overoptimistic, however, because 18% of the implementations across sites, strategies, and timepoints could not be rated due to incomplete data. The missing data concerned mostly sites that received no on-site assistance from the researchers and that communicated with the researchers via organisation-level coordinators. These factors proved relevant for implementation, as the researchers' assistance in intervention launch and direct communication with the intervention sites were significantly associated with a higher quality of implementation during the first half of the intervention. This finding received support from the qualitative analysis of the implementer interviews that identified the research team's support to facilitate intervention design and delivery. The findings also corroborate implementation research that emphasises the importance of an external support system (67) that provides the implementing organisations with technical assistance, such as support in problem solving, maintaining motivation, and staying committed (66).

Assuming the worst-case scenario that all the StopDia at Work implementations with incomplete data failed, the median overall quality score per site would drop from 1.7 to 1.3 (65% of maximum), the median score of eating-related strategies from 1.5 to 1 (50%), and the median score of physical activity strategies from 2 to 1.5 (75%). The reality likely lies somewhere between these estimates, as do the quality scores reported in other choice architecture interventions in real-world settings. A 12-week multicomponent choice architecture and social marketing intervention in worksite cafeterias observed that on average the intervention cafeterias

(n=14) implemented 77% of up to 14 eligible intervention strategies as intended (131). Comparably, a 6–12-month multicomponent choice architecture and pricing intervention that employed 11 intervention strategies in supermarkets (n=6) reported a median implementation fidelity of 72% (163). According to a literature review of implementation studies of health-related promotion and prevention interventions, studies have yielded positive outcomes with implementation levels around 60% of the optimal (66). Thus, the findings of the StopDia at Work-intervention suggest it is feasible for workplaces to implement choice architecture strategies with a quality sufficient to elicit positive outcomes, assuming the used intervention strategies are efficacious and work as intended.

6.1.2 Facilitators and barriers

Choice architecture interventions may be more straightforward, effortless, and inexpensive to implement than many conventional health promotion measures, such as education, counselling, or fiscal policies. Yet, successful choice architecture interventions do not invent, deliver, or sustain themselves. The present study demonstrated that a complex network of factors influence the implementation and feasibility of choice architecture interventions in real-world settings. Key factors operated at the levels of the organisation, intervention, worksite environment, and implementer. The findings support empirical evidence (66,71,76,164) and specific frameworks and theories of implementation science. These frameworks and theories include the Consolidated Framework of Implementation Research (CFIR) that collects determinants of implementation (72), the Normalisation Process Theory (NPT) (165,166) and the Diffusion of Innovations Theory (DIT) (167) that explain the adoption and embedding of new practices in social systems, as well as the Interactive Systems Framework for Dissemination and Implementation (ISF) that aims to support the bridging of research and practice (67). Moreover, many of the factors the present study identified to influence implementation appeared connected with each other and with specific domains of acceptability.

These interconnections are discussed in the following sections and illustrated in Figure 12.

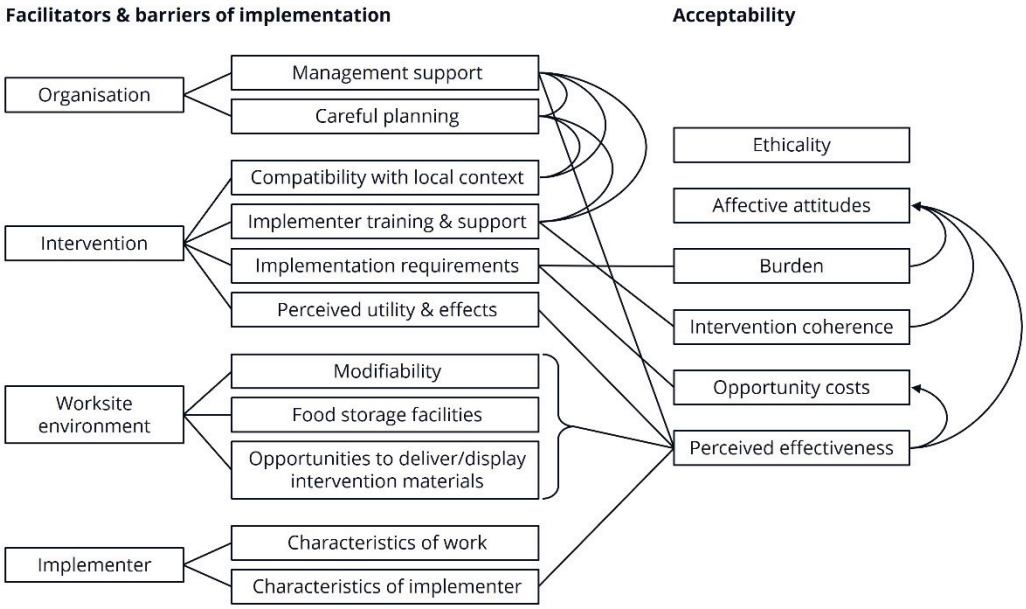


Figure 12. Connections between the facilitators for and barriers to implementation and the domains of acceptability.

Organisation

Major and often interconnected organisational factors that influenced the implementation of the StopDia at Work-intervention were management support and careful planning (Figure 12). These entailed adequate resourcing, division of labour, integration into ongoing activities, communication between different personnel groups, and dealing with organisational changes (Figure 11). These factors align with observations made in choice architecture interventions conducted in school cafeterias (81), supermarkets (168), and pharmacies (169), and with the findings of literature reviews of health promotion interventions in the workplace (71,164) and other settings (66,76). The factors largely relate to the "cognitive participation" construct of the NPT, which refers to the work people do to build and sustain a community of practice around a new intervention (166). Cognitive participation involves collective engagement

in defining and organising the work that drives the intervention forward; helps people buy in, contribute, and stay involved; and sustains the intervention (166). This work takes time, particularly in large organisations with multiple sites and individuals involved, and with multiple intervention strategies to be implemented. The work is crucial, however, and may determine the sustainability of the intervention. Hence, research teams and organisations that plan to implement choice architecture interventions should reserve sufficient time and personnel resources for the cognitive participation task.

Intervention

A central intervention-related factor that influenced the StopDia at Work-implementation was the compatibility between the intervention and the implementation setting. The compatibility concerned the mission of the worksite, available resources, and the work of the implementer; thus forming a link to the organisational factors observed (Figures 11–12). Compatibility has proven to be a key determinant of implementation also in other choice architecture (82) and workplace health promotion interventions (71,164). Moreover, compatibility is incorporated in the CFIR (72), NPT (165,166), and DIT (167). A literature review of factors that influenced the implementation process of health-related promotion and prevention interventions found two interconnected characteristics of interventions, compatibility and adaptability, to be consistently related to implementation (66). The review concluded that the success of integrating interventions into the routine operations of organisations depends on the extent to which the intervention can be modified to fit the organisation's mission, priorities, and practices, as well as the organisation's, the implementers', and the community's needs (66).

Another intervention-related factor that influenced the StopDia at Work-implementation was sufficient training and support for the implementers. This factor too was tied to the organisational factors observed, particularly management support and the flow of information within the organisation (Figure 12). Moreover, the factor relates to the acceptability domain of "intervention coherence". Sufficient implementer training should ensure

the implementers comprehend the purpose and assumed working mechanism of the intervention, as well as their own roles and duties in the implementation. Organising such training was challenging in organisations with multiple intervention sites and/or implementers and in situations in which the implementer changed. Implementer training and support are common themes in implementation science (66,71,72,75,76,164). Support from an external partner is recognised as a key facilitator for the design and delivery of interventions in choice architecture (81) and other real-world research (66,67). The external support can involve training and technical assistance, such as support for problem solving and for building and maintaining the motivation, commitment, and skills required for implementation (66,67). The challenges observed with multiple sites and (changing) implementers corroborate existing evidence of workplace health promotion (71) and choice architecture research (79,82). The involvement of multiple parties was found to complicate the design and implementation of a choice architecture intervention in worksite cafeterias (79). A high number of frequently changing implementers with constant need for instruction, in turn, hampered the implementation of a choice architecture intervention in football club canteens (82). Implementer training and support are related to the NPT construct of "coherence" (165,166). Coherence entails making sense of the intervention by building both individual and collective understanding of the intervention's distinct characteristics, aims, value, benefits, and importance, as well as the implementation tasks and responsibilities of everyone involved (166).

Further intervention-related factors that influenced the StopDia at Work-implementation were the perceived utility and effects of the intervention and implementation requirements. These factors relate to the acceptability domains of the "perceived effectiveness", "burden", and "opportunity costs" (Figure 12). Moreover, the factors support the DIT (167) and evidence of health promotion interventions in the workplace (71,164) and other settings (66,76). In choice architecture research, a relevant example was a multi-strategy intervention that modified the availability, functionality (default), and position of food options in football club canteens (82). The implementers of the intervention struggled to follow the intended protocol,

which resulted in varying delivery fidelity. The implementers considered the effort needed to sustain the intervention to be an important determinant of implementation and consequently effectiveness (82).

Worksite environment

In the StopDia at Work-implementation, the characteristics of the worksite environment influenced the type of choice architecture strategies that were feasible and the ways in which the strategies could be delivered. Such characteristics could refer to the modifiability of the serving line at the worksite cafeteria, possibilities to store food, or opportunities for displaying intervention materials. Similar experiences were also reported in a choice architecture intervention in school cafeterias in which the cafeteria space and layout limited the implementation of certain strategies (81). These findings underline the necessity to adapt intervention strategies to enhance compatibility with local contexts.

Implementer

Implementer-related factors that influenced the StopDia at Work-implementation were related to the characteristics of the implementer's work and the characteristics of the implementer. The characteristics of the work included duties, load, location, working hours, and substance (Figure 11). The characteristics of the implementers included being motivated, committed, motivational, and relatable to other members of the personnel. Similar factors are incorporated in the CFIR (72) and have been observed in workplace health promotion (71) and other interventions (66). The role and characteristics of the implementer are particularly emphasised in the DIT. The DIT characterises influential implementers who resemble other members of the community and have the respect and trust of them as champions or opinion leaders who can act as social models and assist in orchestrating implementations (66,167).

6.2 ACCEPTABILITY AMONG IMPLEMENTERS AND EMPLOYEES

The present study demonstrated that the Theoretical Framework of Acceptability (TFA) (90) is a feasible tool for assessing the acceptability of choice architecture interventions. A broad range of choice architecture strategies for healthy eating or daily physical activity were found to be well accepted at the worksites of the StopDia at Work-intervention. The findings provide a rich set of observations from diverse real-world settings and from the perspectives of both implementers and influenced individuals. Moreover, the findings suggest that many of the domains of the TFA are connected with each other and with various factors that influence the implementation (Figure 12). The study thus extends the scant existing evidence of the experienced acceptability of choice architecture interventions.

High acceptance among implementers and influenced employees

The high acceptance observed in the StopDia at Work-intervention is consistent with the results obtained in many observational studies on people's anticipated acceptance of imagined choice architecture interventions (89,96–108) and with the results of experimental studies on study subjects' experienced acceptance of real-world interventions (79,82,84,85,109–112). The acceptance observed in the StopDia at Work-intervention may be related to the intervention's intention to promote health and its reliance on strategies that were mostly transparent, non-intrusive, and aimed at enhancing reflective processing. People have supported choice architecture interventions that intend to promote social good such as health and that thus serve the interests of most receivers (96,98,99,104). On the other hand, transparent and less intrusive strategies have typically received greater support than less transparent and more intrusive strategies (97–103,105,107,108). This observation received further support from the employee-level data of the StopDia at Work-intervention that demonstrated more intrusive strategies (i.e., replacing unhealthy options with healthier alternatives) to be less well approved than less intrusive strategies (e.g., providing information or tips). In addition, the

employee-level data showed that a greater proportion of male employees per site predicted lower overall acceptance. This finding too agrees with prior research that has observed men to be less supportive of choice architecture interventions than women (97–99,101,102,105,108). However, the present study found no evidence of a relationship between employees' acceptance and their wish for support in healthy eating or physical activity. This observation contradicts the findings of an earlier survey that found such wishes to increase the anticipated acceptance of hypothetical choice architecture interventions that the employer would enact at the workplace (107).

Acceptance in the light of the Theoretical Framework of Acceptability

The implementers of the StopDia at Work-intervention considered the choice architecture approach to be ethical, expressed mostly positive affective attitudes towards the intervention, and perceived little burden due to the implementation. Several factors could reduce this acceptance, however, including any perceived burden of strategies with regular implementation tasks, perceived futility or ineffectiveness, poor understanding of the intervention, high costs, and personal preferences. The perceived burden could nevertheless disappear once the implementation began to roll, and costs could be managed by adjusting the intensity of the implementation to fit local resources—again highlighting the importance of compatibility. These findings receive support from other choice architecture studies. The perceived burden is a commonly reported theme that can change over time and determine both the implementation of the intervention and its acceptance among implementers (79,81,82,84,85). An illustrative example was a nutrition labelling intervention at worksite cafeterias in which site managers perceived the initial implementation of the intervention to be labour-intensive and time-consuming due to efforts needed to gather information and prepare the labels (84). Once the preparatory tasks were completed, however, the managers found the intervention easy to sustain (84). The perceived effectiveness, in turn, has correlated positively with anticipated acceptance in observational studies (96,97,100,101). Similarly, the

perceived effectiveness mirrored the implementers' acceptability ratings in a choice architecture intervention in school cafeterias (81). Acceptability evaluations of implementers have also indicated that understanding the intervention helps to approve it (84), that negative affective attitudes yield low acceptance ratings (81), and that decreased profits would be an unacceptable opportunity cost of health-promoting choice architecture interventions (82,85).

Critical views

Critical or negative views of the StopDia at Work-intervention were expressed in all implementer groups: the designers who were involved in intervention design, the health promoters who had jobs focused on employee wellbeing and health and who were often designers as well, and the other implementers who were not designers nor health promoters. The critique expressed by the designers and health promoters demonstrated that participation in intervention design does not mean a person will find the intervention fully acceptable once implemented. An intervention strategy may seem acceptable (e.g., effortless, inexpensive, and effective) in the design phase yet fail to fulfil expectations in the implementation phase. This observation underlined the importance of assessing not only anticipated but also experienced acceptability, as recommended by the TFA (90).

The critical attitudes and negative experiences expressed by the other implementers were understandable for at least three reasons. First, contrary to the designers and most health promoters, the other implementers had not had the opportunity to express their preferences, hopes, and needs when the intervention strategies were selected and the delivery was planned. Second, the other implementers may have had a poorer understanding of the purpose, rationale, and assumed working mechanism of the intervention compared to the designers and health promoters. Third, the other implementers may have been less interested in the promotion of healthy eating and physical activity compared to the health promoters. Together, the critique received from diverse

implementer groups demonstrated the difficulty (or impossibility even) of developing population-level interventions that appeal to everyone.

Acceptability and determinants of implementation interconnected

In the StopDia at Work-intervention, the TFA-domains of burden, intervention coherence, and perceived effectiveness appeared related to affective attitudes towards the intervention or its implementation (Figure 12). Additionally, perceived effectiveness appeared connected to the acceptance of opportunity costs. With respect to factors that could determine implementation, the TFA-domains of burden and opportunity costs were related to the intervention-related factor "implementation requirements", and intervention coherence was related to the intervention-related factor "implementer training and support". Reports of the perceived effectiveness suggested links to multiple determinants of implementation, including management support, worksite environment, and the characteristics of the implementer. The link between the perceived effects and factors influencing implementation is logical because better implementation has been proved to predict greater effectiveness (66,71). Finally, the implementers of the StopDia at Work-intervention proposed that perceived ineffectiveness could be explained by the characteristics of the target audience, for example, individual preferences. This proposition receives support from experimental studies that have found individual preferences to influence the effectiveness of choice architecture interventions (95,124). Future research is needed, however, to confirm or reject the connections the present study observed between acceptability domains and factors influencing implementation.

6.3 EFFECTIVENESS

6.3.1 Food consumption and physical activity

The effectiveness evaluation of the StopDia at Work-intervention found a significant association between the intervention and a favourable change in the employees' fruit and berry consumption and between the

intervention and an unfavourable change in sweet treat consumption at work over the one-year intervention. The association between the intervention and a change in the use of exercise equipment at work was also significant, but the meaning of this association was less straightforward to interpret. These findings were based on the interaction effect of time and the dose and quality of implementation. Furthermore, the quality of implementation appeared to be positively associated with the employees' response to the packed lunch recipes (i.e., trying the recipes) and the "fruit crew"-strategy (i.e., joining a fruit crew). Overall, the results indicate that implementation is an important determinant of effectiveness, confirming prior evidence from choice architecture studies (80,85) and health promotion interventions in the workplace (71) and other settings (66). The fact that the present study observed significant associations nearly exclusively between the intervention and eating-related outcomes could be related to the finding of a meta-analysis in which eating behaviour appeared to be a behavioural domain particularly responsive to choice architectural modifications (33).

Association with a favourable change in fruit and berry consumption

The evidence of an association between the StopDia at Work-intervention and a change in a behavioural outcome was strongest for the consumption of fruit and berries. Potential explanations include the type of intervention strategies used and the extent of their implementation. All intervention sites targeted fruit and berry consumption using up to six strategies of varying types: information, presentation, self-regulation, position, availability, and/or functionality (Table 2 of Study III). Sites with greater dose and quality of implementation applied not only cognitively or affectively oriented strategies but also behaviourally oriented strategies that reduced the physical effort required to choose and consume fruit or berries at work (availability and/or functionality; Supplementary Table S3 of Study III). Moreover, sites with greater dose and quality of implementation targeted multiple eating-related contexts at the worksite (i.e., coffee rooms plus cafeteria and/or meetings). At meetings and sometimes in coffee rooms as well, available fruit were additionally provided free of charge,

with costs covered by the employer. In these contexts, the intervention hence incorporated a minor financial incentive, potentially boosting its effectiveness.

Supporting these interpretations, meta-analyses have demonstrated that behaviourally oriented strategies yield larger effects compared to cognitively or affectively oriented strategies, which may be due to their lower demand regarding physical effort and information processing, and lower dependence on individual values and goals (32,33). Regarding the extent of implementation, an intervention study that reduced portion sizes at six worksite cafeterias observed the largest reductions in daily energy purchased at cafeterias that extended the intervention to the greatest number of available choice options (85). Related to the free availability of fruit at the workplace, a series of field experiments that targeted over 300 meetings across four worksites showed that employees can consume considerable portions of vegetables when they are available at meetings (128). Further explanations of the association the present study observed between the intervention and a favourable change in fruit and berry consumption may be the target behaviour and choice option. Increasing the consumption of healthy foods such as fruit may be easier than reducing the consumption of less healthy foods such as sweet treats. Relatedly, a multi-strategy randomised controlled trial at 30 worksite cafeterias found a combination of choice architecture strategies (availability, position, and presentation) and price incentives to cause desired changes in some food categories (e.g., fruit) but not in others (e.g., unhealthy snacks) (131).

Association with an unfavourable change in sweet treat consumption

Surprisingly, the StopDia at Work-intervention appeared to be associated with an unfavourable change in employees' sweet treat consumption. Sweet treats were targeted by slightly less than a quarter of the intervention sites that were included in the effectiveness evaluation. These sites used up to three strategies that altered the availability, position, or size (portion or serving dish) at cafeterias and/or in meetings (Table 2 of Study III). Several factors may have contributed to the observed

association. First, strategies that reduced the serving size of sweet treats or altered their availability by replacing sweet treats with nutritionally better alternatives may have increased the number of portions eaten. The number of portions, however, does not reveal potential changes in the volume or nutritional quality of the sweet treats consumed. Second, reports from the sites that targeted sweet treat consumption portrayed that the choice architectural modifications made were small in magnitude and only partially covered the contexts of the worksites that offered sweet temptations and only part of the sweet treat options available in these contexts. Third, it is possible that outside the contexts and options intervened, the variety and/or volume of sweet treats available at the worksites increased over the intervention year, leading to increased consumption.

In the choice architecture literature, availability and positional interventions at worksite cafeterias have failed to reduce the sales of unhealthy snacks such as candy and confectionery when snacks have simultaneously been sold in vending machines present at the worksite (131). Similarly, poor implementation of availability interventions have yielded negligible effects (79). Reviews on positional interventions also suggest that intervention effects are proportionate to the magnitude of modifications made (115,170). Regarding the implementation extent, a multicomponent supermarket intervention that promoted healthier purchases across a range of product categories by implementing choice architecture strategies (availability, position, and information) on 9% of the supermarket assortment and pricing strategies on 3% of the assortment proved insufficient to change customers' food purchases or diet quality (163).

As mentioned above, reducing sweet treat consumption may be more challenging than increasing healthy food consumption and might thus require substantial reductions to availability. Achieving such reductions can be challenging, however, if workplaces are used to providing unhealthy snacks and employees are used to consuming such snacks at work. Caterers, for example, may be reluctant to remove unhealthy foods from the selection for fear of negative customer feedback or loss of profit

(79,82,163). At one StopDia at Work-intervention site, a cafeteria worker also noted that the treats the cafeteria offers provide comfort for the employees when work does not go well and considered the provision of such comfort food a part of the cafeteria's "job description". Moreover, the employees at the StopDia at Work-intervention sites expressed least support for strategies that would replace the foods and beverages served at the worksite with healthier alternatives, for example, at meetings or coffee breaks. Nevertheless, the availability of indulgent foods that conflict with attempts to eat healthily challenges self-regulation (171) and can trigger reasoning processes that justify the indulgence, as portrayed by a phenomenon called the self-licensing effect (59,60). Furthermore, the so-called "office cake culture" that involves bringing sweet treats to work and enjoying them with colleagues can be an important tradition in the work community, whereby social norms prevent refusing the treats offered (171).

No clear associations with daily physical activity

The present study detected no clear associations between the StopDia at Work-intervention and changes in daily physical activity outcomes. The intervention sites aimed to encourage restorative physical movement and the use of exercise equipment and stairs with cognitively oriented strategies that targeted information (visual point-of-choice prompts), self-regulation (reminders), and/or the availability and position of light exercise equipment. Such strategies have been common in choice architecture interventions for physical activity, particularly stair use prompts that are the most frequently reported intervention type (63,162,172). The popularity of stair-use prompts is no wonder because many interventions have found such prompts to be effective in increasing stair use (119,126,172). With high stair-use at baseline, however, stair-use prompts can be unsuccessful and even lead to a decline in the use of stairs (173). In the pre-intervention questionnaire of StopDia at Work, almost 90% of the respondents with stairs available at work reported using them frequently or always (Table 3 of Study III). Room for improvement was thus limited.

On the other hand, compared to the improvement in dietary patterns, improving physical activity patterns may require stronger guidance and support from the social and organisational environment. In the present study, the proportion of employees who responded to the post-intervention questionnaire and wished that the employer would provide support for physical activity was substantially higher than the proportion of respondents who wished for support towards healthy eating. Common reasons for never performing restorative movements or using available exercise equipment at work included forgetting about it, lack of time or space, and embarrassment.

The importance of a supportive social environment was previously demonstrated in an intervention for increased walking at the workplace (129). In this intervention, a digital app that provided social support via team challenges proved effective at increasing the employees' daily step count, but motivational messages and point-of-choice prompts in the worksite environment failed to maintain the achieved effects (129). Similarly, an intervention that prompted physical activity with two to six daily push notifications from a smartphone app (feedback on step count, contextual prompts, and advice tailored to the participant's preferences) proved ineffective at increasing daily step count (163).

Preferences and habits blocking intervention effectiveness

The above discussion about the smaller effect sizes of cognitively versus behaviourally oriented strategies helps explain the results this study obtained at the worksite cafeteria. The intervention applied cognitively oriented strategies that modified information (priming health messages and point-of-choice nutrition labels) and position to facilitate the recognition of healthy options and to encourage their selection. While eye-tracking showed that participants saw the visual health cues (priming messages and labels), the intervention had no marked effect on the study participants' food choices or cafeteria-level food consumption.

Interviews about perceived influences on food choices revealed that the ineffectiveness was likely to be related to the participants' food choice motives. Healthiness was a factor that appeared in the reports of a

substantial proportion of participants, but health considerations were often challenged by various competing priorities, most frequently sensory appeal, or familiarity. Sensory appeal and healthiness have proven to drive people's food choices across cultures and populations (174,175). The importance of familiarity, which in the present study included habitual choices, may have been pronounced due to the habitual context the cafeteria was for most participants. Regarding competing priorities, sensory appeal can easily overcome health motives, because healthiness is commonly associated with poor taste—a lay belief known as the Unhealthy = Tasty Intuition (176,177). The results of this study thus suggest that cognitively oriented strategies that rely on visual health cues and visibility enhancements are insufficient to increase healthier choices in habitual food environments such as worksite cafeterias among individuals with varying motives regarding their food choices.

The outcomes obtained at the worksite cafeteria support the assumption that the effectiveness of cognitively oriented strategies depends on individual values and goals (33), and that hedonic eating goals work against the effectiveness of nutrition labels (178,179). These claims receive further support from emerging experimental evidence according to which preferences work as a boundary condition to the effectiveness of choice architecture interventions (95,124). A cognitively oriented intervention that aimed at cueing healthy snack choices in a supermarket with images of healthy foods on shopping baskets succeeded in increasing the healthiness of snack choices only among participants with strong health goals (124). On the other hand, a narrative review of as yet limited empirical evidence deduced that choice architecture interventions may be most effective when people hold no strong preferences for or against the promoted behaviour or when the target audience are uncertain, indifferent, or experiencing conflicting goals (95). According to this hypothesis, very strong preferences aligned with or against the promoted behaviour render choice architecture interventions futile because people will follow their preferences anyway (95). The portrayed evidence provides a plausible explanation as to why interventions similar to the present one have proven effective in hospitals (130,180,181) and military cafeterias

(182) where customers may be more focused on health and fitness. Together, the existing evidence indicates that choice architecture interventions work as they are supposed to work; promoting behaviours that individuals want to take but fail to choose due to specific features of the decision context (34).

Scholars have also contemplated the capability of choice architecture interventions to override habitual food choices (106). Some evidence suggests that habits may create barriers to the effectiveness of choice architecture interventions. A field experiment at a worksite cafeteria found a cognitively oriented information strategy (footsteps leading to the promoted choices) to elicit positive effects only for new employees and guests that had no established routines at the cafeteria (183). A nutrition labelling intervention at a university cafeteria, in turn, found label use more likely among individuals who were open to change and less bound to familiar meal choices (184). In the light of this evidence, the lack of effects the present study observed at the worksite cafeteria could partly be explained by the habitual context and the familiarity motive that determined the food choices of many participants.

6.3.2 Visual attention and perception

The present study yielded mixed results concerning the relationship between implementation quality and the self-reported perception of specific intervention strategies. The quality of implementation was positively associated with noticing the packed lunch recipe materials and negatively associated with noticing the "fruit crew"-materials. The estimate of the association between implementation quality and noticing the movement prompts was positive, but evidence remained insufficient to confirm the finding. Additionally, the implementation quality appeared to be unrelated with the odds of becoming interested in the packed lunch recipes. On the other hand, objective eye-tracking data indicated that prominently displayed and sizable visual cues (priming health messages and nutrition labels) were capable of capturing customers' visual attention at the worksite cafeteria, albeit few participants recalled having noticed the

cues. At the cafeteria, the researchers took care of and constantly monitored the implementation; thus ensuring acceptable fidelity.

Together, the findings suggest that high quality implementation can enhance the target audience's perception of cognitively or affectively oriented intervention strategies that aim to attract attention and prompt healthy behaviours with visual cues. However, this effect appears to vary according to the strategy and context and does not extend to changing the target audience's interest in the used cues. The findings support evidence that prominent displays, larger size, and distinctive colours enhance noticing visual cues (185–187) and that self-reports may yield less accurate estimates of visual attention than objective measures (153,188). While visual attention is a precondition for the effectiveness of interventions based on visual cues, a choice architecture intervention in a supermarket found that attention did not moderate the effects of such cues (124). Cognitively oriented choice architecture interventions thus seem to maintain people's freedom to choose according to their preferences, as stated by the core principle of the choice architecture framework (31).

6.4 STRENGTHS AND LIMITATIONS

6.4.1 Strengths

The StopDia at Work-intervention was a theory- and evidence-based, workplace-centred and -delivered implementation-effectiveness trial that was conducted under natural circumstances in heterogeneous real-world settings, with an intervention content and implementation which was adapted to fit local contexts. To promote local ownership, compatibility with the intervention setting, and sustainability, the participating worksites were given autonomy to determine the content of the intervention from a selection of evidence-based strategies. The sites could also determine the way in which the selected strategies were delivered. Yet, pre-defined essential elements of the applied intervention strategies were maintained and all adaptations were carefully recorded. With over fifty diverse worksites recruited, two lifestyle behaviours targeted (eating and daily

physical activity), over twenty distinct choice architecture strategies implemented across sites, and a year-long duration, the intervention may be the largest attempt thus far to translate the choice architecture approach from experimental research settings to the real world, and to evaluate and disseminate the approach in the service of public health. The StopDia at Work-intervention was complemented with a sub-intervention at one worksite cafeteria. The sub-intervention allowed a more detailed examination of three commonly used cognitively oriented choice architecture strategies in a real-world setting using a unique combination of objective and subjective data collection methods.

With multidimensional evaluations of implementation and acceptability, the present study yielded rich evidence on the feasibility—and contextual factors influencing the feasibility—of integrating various choice architecture strategies into the routine practices of diverse workplaces. Following recommendations provided in implementation research literature (74,75), implementation outcomes were integrated into the effectiveness evaluation of the intervention. This enabled assessing the relationship between the dose and quality of implementation and changes in behavioural outcomes over the intervention year, as well as the relationship between implementation quality and the perceptions of and responses to specific choice architecture strategies that relied on visual cues. The study also produced evidence supporting hypotheses that individual preferences and habits may influence the effectiveness of choice architecture interventions. Analyses employed varied qualitative and quantitative methods and involved method development that may serve future evaluations of real-world interventions. Together, the dissertation drew a nuanced picture of factors that may influence the implementation, acceptability, and effectiveness of choice architecture interventions in the real world, and how these factors relate to each other.

6.4.2 Limitations

The methodology used to conduct the interventions of this doctoral dissertation could have been improved in several domains, including study

design, data collection, and measurements. A more robust design such as a cluster randomised design and the collection of more versatile site- and individual-level data at a greater number of timepoints would have enhanced the internal validity of the study and enabled a more reliable, accurate, and nuanced evaluation of effectiveness. With the currently available data, the evaluation of the effectiveness of the StopDia at Work-intervention contains uncertainty due to the lack of control group and the partly overlapping samples with no possibility to link individuals in the pre and post intervention datasets.

However, randomising the participating organisations or worksites of the StopDia at Work-intervention into intervention and control arms would have halved the number of sites that implemented the intervention and hence would have reduced the richness of data available for the evaluation of the implementation and experienced acceptability. More extensive measurements, in turn, would have required greater resources for data collection and analysis and might have resulted in lower response rates in the employee questionnaires. While fairly low, the questionnaire response rates in this study (median 28–34% per site across datasets) were nevertheless higher than in several other studies conducted in similar contexts, such as worksite cafeterias or football club canteens (79,82,84,85).

Thus, the interventions conducted in the present work were compromises that resulted from balancing optimal methodology and real-world constraints, whereby large-scale implementation was prioritised. This choice was justified considering the relative scarcity of existing implementation versus efficacy trials. Investing in large-scale implementation also supported the assessment of the relationship between implementation and effectiveness. Overall, despite the methodological limitations, the study produced ample evidence and learnings that can prove valuable for future efforts to develop systematically designed, implemented, and evaluated trials in real-world settings.

The study could have adopted stronger measures to ensure the fidelity of implementation, following recommendations for enhancing fidelity (75).

Such measures could have included more standardised implementer training, better preparation for implementer turnover, and the prevention of "drift" (i.e., decay) in implementer skills and intervention delivery over the intervention year. Organising more standardised face-to-face or online training sessions or equivalent training videos could have increased the chance of all the implementers reaching a sufficient understanding of the intervention, how it was supposed to work, the implementation tasks they were expected to complete, and the importance of keeping the intervention up throughout the study period, regardless of perceived effectiveness. Ideally, this training would have reached each implementer at each site before the intervention launch or when they joined the implementation team, and as needed over the course of the intervention. Live or video-based training could have been more engaging than the illustrated instructions that the present study used and that in some cases formed the main introduction the implementers received.

While the intervention was designed in collaboration with the implementers and with the consent and approval of the management of the participating organisations and worksites, the design process did not involve representatives of the target audience, i.e., the employees of the intervention sites. This was an important limitation because implementation research has demonstrated that a shared decision-making practice that includes all relevant stakeholders—researchers, management, implementers, and employees—has consistently led to better implementation and predicts intervention sustainability (66). Our decision to exclude the employees from the design process was related to the decision not to disclose the specific aims of the intervention to the employees. This choice, in turn, resulted from the uncertainty of whether the target audience's awareness of the intervention would influence intervention effectiveness. Recently, choice architecture research has yielded some evidence that study subjects' awareness of the presence, purpose, or working mechanism of the intervention might not reduce the intervention's effectiveness (95). Future studies could hence enhance the implementation and sustainability, and probably also the acceptance and effectiveness of choice architecture interventions by including

representatives of the target audience in the intervention design process. This way the target audience's preferences could be better considered, which would give the intervention greater chances of yielding positive effects. Additionally, disclosing the intervention to the target audience would enhance open communication, which this study found to facilitate implementation.

The framework the present study developed and used for evaluating the quality of implementation could be improved with a more fine-grained rating scale and with additional dimensions of evaluation. New dimensions could consider the magnitude of modifications made to the choice architecture and the extent of implementation at the intervention site, considering the proportion of relevant contexts and choice options intervened. Additionally, besides considering the dose and quality of implementation, the assessment of the relationship between implementation and effectiveness could also consider the type or mechanism of intervention strategies applied, as these have been proven to influence effectiveness.

6.5 IMPLICATIONS FOR RESEARCH, PRACTICE, AND POLICY

The choice architecture framework is applicable to all actors with the power to influence the design and development of living environments related to health behaviour. Such actors include, inter alia, food services, groceries, town planners, architects, workplaces, universities, schools, kindergartens, and policymakers at the international, national, regional, and local level. Applying the framework, however, requires that all these actors understand and acknowledge the impact that choice environments have on people's behaviour and that they become aware of and learn how to use the tools the choice architecture framework provides for promoting healthy behaviours. The research community has an important role in disseminating available evidence of the choice architecture approach and in supporting various actors to translate the evidence into practice.

For researchers and practitioners considering the implementation of choice architecture interventions, the learnings of this study translate into

the following practical recommendations. The numbers in brackets indicate the chapters of the thesis that informed each recommendation.

1) Reserve time and adequate resources for the planning, preparation, and implementation of the intervention and for necessary data collection to allow comprehensive evaluation (5.1.2, 6.1.2, 6.4.2).
2) Involve all relevant stakeholders in the planning process, including representatives of the management, implementers, and target audience (6.4.2).
3) Tailor interventions and their implementation to local contexts and target audiences to the extent possible, considering their mission, culture, resources, practices, preferences, and needs (5.1.2, 5.2.1, 6.1.2, 6.2).
4) Ensure all implementers reach and maintain a sufficient understanding of the intervention and their responsibilities in its implementation, and that they possess the necessary capacity and resources to fulfil these responsibilities (5.1.2, 5.2.1, 6.1.2, 6.2, 6.4.2).
5) Be transparent by fostering open communication among all stakeholders and by communicating the purpose and presence of the intervention to the target audience (5.1.2, 6.1.2, 6.4.2).
6) Favour choice architecture strategies that reduce the physical effort required to engage in the desired behaviour and strive for extending implementation to all relevant behavioural contexts and choice options in the targeted environment (5.3.1, 6.3.1).
7) When designing strategies that aim at enhancing reflective processes and reducing the cognitive effort required to engage in the desired behaviour, make sure that the strategies match the target audience's preferences (5.3.2, 5.3.3, 6.3.1, 6.3.2).

A comprehensive evaluation of implementation, acceptability, and effectiveness of real-world interventions is time-consuming and resource intensive. The work is worth the trouble, however, as it helps to understand when and why interventions succeed and how to facilitate the integration of interventions into the practices of organisations or communities. To promote comprehensive evaluations of real-world interventions, research funders could demand them in funding calls and prepare to grant sufficient funding for their completion.

For decision-makers, the choice architecture framework provides a broad range of strategies that can and should be adopted as part of efforts to foster healthy lifestyles. While choice architecture interventions on average yield small effects, they hold potential to produce pervasive impacts on public health since they can be delivered to large audiences (44). For maximum impact, the choice architecture framework ought to be incorporated into a systemic approach to promote healthy lifestyles. This means using choice architecture strategies together with and/or as integral parts of other societal measures, such as fiscal policies, mass communication campaigns, limitations to the availability and marketing of harmful choices concerning diet and physical activity, public procurement criteria, and policies guiding the development of the built environment. To ensure a systematic adoption and effective and ethical use of the choice architecture approach across sectors and actors for the development of living environments conducive to healthy eating and physical activity, regulation may be required because voluntary measures tend to yield limited effects.

7 CONCLUSIONS

This doctoral dissertation evaluated the implementation, acceptability, and effectiveness of a contextualised, multicomponent choice architecture intervention for healthy eating and daily physical activity at the workplace. The work demonstrated that a broad range of choice architecture strategies that were selected in collaboration with local implementers and adapted to fit local contexts were feasible for implementation in diverse real-world settings over a one-year period. The strategies were well accepted within work communities and appeared capable of positively influencing health behaviour at work. Furthermore, the dissertation found evidence of a positive association between implementation quality and intervention perception and response. The findings suggest that the choice architecture framework could complement more conventional, individual-level approaches to health promotion. Intervention success depends on numerous contextual factors, however, that relate to the characteristics of the organisation, intervention setting, implementer, target audience, intervention, and implementation. These factors warrant careful consideration when designing future interventions.

The dissertation extended the scant existing evidence of the implementation, experienced acceptability among implementers and influenced individuals, and effectiveness of choice architecture interventions for healthy eating and daily physical activity in the real world. Moreover, the work produced novel information on the relationship between intervention implementation and effectiveness.

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APPENDICES

APPENDIX 1. INTERVIEW QUESTIONS USED TO COLLECT DATA FOR THE IMPLEMENTATION AND ACCEPTABILITY EVALUATION OF THE STOPDIA AT WORK-INTERVENTION

Questions translated from Finnish to English

Implementation

First interview halfway through the intervention:

What intervention strategies did you implement?

How did the launch of the intervention go?

How has sustaining the intervention gone?

What has worked well in the implementation? What factors have contributed to these successes?

Have there been difficulties in the implementation? If so, what kind of difficulties have there been and how have the difficulties been resolved?

How could the implementation be promoted at your workplace? What would it take?

What has motivated you in the implementation? Has something been unmotivating?

Have you presented the intervention materials to the employees or encouraged the employees to use the materials?

Are you the most appropriate person in your organisation to take care of the implementation, or would someone else be more appropriate?

Second interview at the end of the intervention:

Has anything changed in the implementation after the 6-month follow-up? For example, the schedule of completing implementation-related tasks, informing the employees of intervention materials, or promoting the materials to the employees.

Are you planning to continue implementation after the study? Which strategies are you planning to maintain?

Acceptability

Both interviews:

How has the intervention been received? Have the employees noticed or discussed the intervention? Have you heard any feedback?

What kinds of effects have you observed? Have the intervention materials been used? Have you noticed changes in the employees' behaviour?

First interview halfway through the intervention:

Do you find it acceptable that the employer attempts to influence the employees' health behaviour?

In your opinion, in what ways is the employer allowed to aim at influencing the employees' health behaviour?

Do you find choice architecture interventions an acceptable approach to promoting healthy dietary choices and physical activity among employees? Choice architecture interventions mean modifying the work environment in such a way that it gently guides employees to health-promoting habits.

ORIGINAL PUBLICATIONS (I–IV)

I

Choice Architecture Cueing to Healthier Dietary Choices and Physical Activity at the Workplace: Implementation and Feasibility Evaluation

Rantala E, Vanhatalo S, Tilles-Tirkkonen T, Kanerva M, Hansen P G, Kolehmainen M, Männikkö R, Lindström J, Pihlajamäki J, Poutanen K, Karhunen L, Absetz P

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Article

Choice Architecture Cueing to Healthier Dietary Choices and Physical Activity at the Workplace: Implementation and Feasibility Evaluation

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Abstract: Redesigning choice environments appears a promising approach to encourage healthier eating and physical activity, but little evidence exists of the feasibility of this approach in real-world settings. The aim of this paper is to portray the implementation and feasibility assessment of a 12-month mixed-methods intervention study, StopDia at Work, targeting the environment of 53 diverse worksites. The intervention was conducted within a type 2 diabetes prevention study, StopDia. We assessed feasibility through the fidelity, facilitators and barriers, and maintenance of implementation, building on implementer interviews (n = 61 informants) and observations of the worksites at six (t1) and twelve months (t2). We analysed quantitative data with Kruskall–Wallis and Mann–Whitney U tests and qualitative data with content analysis. Intervention sites altogether implemented 23 various choice architectural strategies (median 3, range 0–14 strategies/site), employing 21 behaviour change mechanisms. Quantitative analysis found implementation was successful in 66%, imperfect in 25%, and failed in 9% of evaluated cases. These ratings were independent of the ease of implementation of applied strategies and reminders that implementers received. Researchers' assistance in intervention launch ($p = 0.02$) and direct contact to intervention sites ($p < 0.001$) predicted higher fidelity at t1, but not at t2. Qualitative content analysis identified facilitators and barriers related to the organisation, intervention, worksite environment, implementer, and user. Contributors of successful implementation included apt implementers, sufficient implementer training, careful planning, integration into worksite values and activities, and management support. After the study, 49% of the worksites intended to maintain the implementation in some form. Overall, the choice architecture approach seems suitable for workplace health promotion, but a range of practicalities warrant consideration while designing real-world implementation.

Keywords: workplace; health promotion; prevention; type 2 diabetes; implementation research; behaviour change; choice architecture; nudge; diet; physical activity

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1. Introduction

Considering our susceptibility to external influences, changing behaviours requires targeting the contexts and environments in which behavioural decisions take place [1]. Workplaces provide an excellent setting for such interventions, as most adults spend a considerable share of waking hours at work. Workplace health promotion holds promise to benefit both employees and employers, for example, through improved employee wellbeing and productivity, reduced absenteeism and occupational health care costs, as well as enhanced corporate image and performance [2–4]. Societies, in turn, benefit through higher tax revenue and reduced social security costs because healthy workforces typically have better employment prospects, longer careers, and a higher income [5].

Health promotion has largely appealed to people's conscious reflection by using educational approaches to guide individuals towards healthier behaviours [6,7]. The impact of such interventions has proven modest, however [8,9]. Suggested explanations include the automatic nature of much of human behaviour [10,11], and the imperfect rate at which beliefs and intentions convert into action [8,12]—particularly if the environment fails to support these intentions. Educational approaches also tend to favour socioeconomically advantaged individuals; hence bearing a risk of increasing health inequalities [13–15].

Environmental interventions that cue healthy behaviours primarily via automatic mental processes could yield effects with less cognitive effort, and independent of individuals' socio-economic background and self-regulatory capacities [16,17]. Such interventions are closely tied with the concepts of nudge and choice architecture. Nudges encourage better choices by exploiting the known boundaries, biases, and routines of cognitive processes [18], the very features often preventing people from behaving rationally in ways that promote their own interests. In practice, nudges attempt to influence behaviour by modifying the surrounding choice architecture—i.e., the way that available choice options are presented in decision-making contexts—in ways that work independently of limiting the freedom of choice, substantially changing incentives, or relying on education [18,19]. Nudges typically work by reducing effort and cognitive load, increasing salience and attractiveness, or leveraging social norms [20]. Over a decade of intensive research [21], choice architecture interventions have proved effective in guiding food choices, for example, by altering food availability, position, order, and portion size [22–25], as well as by prompting healthier choices at the point of choice [26,27]. Physical activity, in turn, has increased through enhanced movement opportunities and contextual prompts [28,29].

Implementing choice architecture interventions is considered less resource-intensive compared to individual-level interventions [20,30]. Hence, scaling up to population level could be feasible [31]. Some evidence speaks for the feasibility of implementing prompting and proximity strategies in grocery shops to encourage healthy purchases [32], and digital decision-support systems in pharmacies to increase vaccination rates [33]. By contrast, in food service settings, scaling up a default type "dish of the day" strategy for promoting plant-based meals appeared challenging and yielded mixed results that depended on the context and target population [34–37]. However, overall evidence remains scarce on the implementation and feasibility of choice architecture interventions in real-world settings [20,38], including workplaces [39,40].

Impactful interventions are of little use, unless we know how to implement them effectively [41]. Studying implementation is thus necessary. Important elements of implementation process evaluation include the fidelity, barriers and facilitators, and maintenance of implementation [42,43]. Fidelity reflects the extent to which implementation follows plans [44], and reveals the likelihood with which interventions can and will be implemented successfully [45]. Besides projecting feasibility, assessing fidelity also supports accurate interpretation of study outcomes [39,46], as it enables determining whether the found effects—or lack of them—are due to the intended intervention or variations in its implementation [47,48]. Knowledge on fidelity also strengthens understanding of why interventions succeed or fail; thus, informing intervention development and optimisation [49,50]. The same rationale applies to studying contextual factors that may facilitate or

hamper implementation and hence influence intervention effects [43,49]. Maintenance, in turn, refers to the extent to which implementation sustains over time [42] and serves as an important indicator of the overall feasibility and success of implementation.

In summary, restructuring the choice architecture appears an effective and equitable approach to support the adoption of healthy behaviours. However, research has nearly exclusively focused on impact assessment, leaving unanswered questions on implementation and feasibility. The current paper portrays the real-world implementation and feasibility evaluation of a choice architectural intervention designed to promote healthier dietary choices and physical activity at the workplace. The feasibility evaluation focuses on the fidelity, facilitators and barriers, and maintenance of implementation. In addition, items that are considered include the applicability to diverse worksites, ease of implementation, and required purchases of applied choice architectural strategies.

2. Materials and Methods

2.1. Study Design

We conducted a 12-month quasi-experimental pretest–posttest intervention, StopDia at Work, in natural settings at workplaces in three regions of Finland. The intervention took place between 2017 and 2019 within a larger type 2 diabetes prevention study, Stop Diabetes (StopDia) (Trial registration: NCT03156478) [51]. This study had the approval of the research ethics committee of the hospital district of Northern Savo.

The aim of the StopDia at Work intervention was to promote healthy dietary choices and daily physical activity at the workplace, with subtle modifications to the worksite environment, including common working spaces, personal workstations, recreation rooms, stairwells, elevators, and cafeterias. The employees of intervention sites received general information on the StopDia study and the collaboration between their workplace and the study. However, the employees were not disclosed the specific aim of the StopDia at Work intervention, that it is to alter workplace choice architectures to promote healthy behaviours mainly via automatic cognitive processes. This non-disclosure was to ensure the intervention would not inadvertently enhance employee self-awareness, prompt monitoring of the worksite environment, and stimulate a deliberate reflection of behavioural choices; hence interfering with employees' natural responses to the intervention.

2.2. Recruitment of Participating Organisations

Through web searches and by consulting local ELY centres (Centres for Economic Development, Transport, and the Environment), we identified major public and private sector organisations operating in three regions of Finland. The three regions—Northern Savo, Southern Karelia, and Päijät-Häme—were the target areas of the StopDia study. The focus was on organisations with at least 100 employees and physical working environments suitable for the intervention. We contacted the management and/or human resources (HR) of potentially eligible workplaces (n = 86) via email and/or telephone, and arranged workshops (n = 4) for those initially interested in the study (Figure 1). Representatives of 31 organisations attended the workshops. In the workshops, these representatives discussed measures that workplaces had taken to promote employee health, as well as the potential facilitators and barriers of workplace health promotion. The representatives also received information on the choice architecture approach and brainstormed how to apply this approach to the workplace. After the workshops, we had additional one-to-one discussions with 23 volunteer workshop participants to further discuss the themes covered in the workshops. Workshop participants (n = 27) that expressed interest in the study, and organisations that had shown initial interest but were unable to send representatives to the workshops (n = 14), received an invitation to participate in the StopDia at Work intervention and a leaflet of the *StopDia Toolkit for Creating Healthy Working Environments* (Section 2.3). The leaflet introduced the choice architecture approach and a selection of practical strategies that had potential for implementation in the intervention.

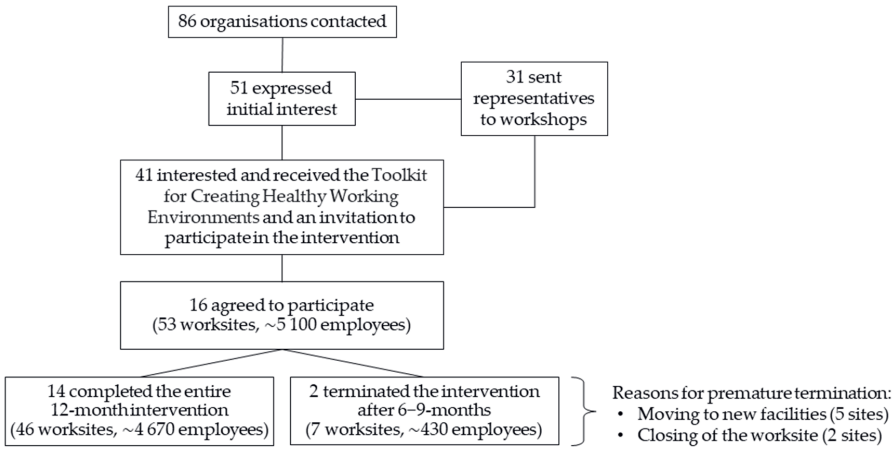

Figure 1. Flow chart of the recruitment and participation of organisations. Numbers refer to organisations, unless otherwise specified.

Sixteen organisations with altogether 53 worksites decided to participate in the intervention (Figure 1). Each organisation chose one or more members of their personnel as implementers. These implementers were in charge of maintaining the intervention after the launch. In addition, the sites could have organisation-level coordinators that acted as contact persons between the research team and the intervention sites. Regarding 30 (57%) sites, our primary contact persons worked at the intervention sites, and the research team members visited the sites at least once during the intervention process. In the remaining sites, we communicated with organisation-level coordinators without actually visiting the sites. The coordinators and implementers typically represented HR or middle- or operational-level management, yet involved employees and cafeteria personnel as well.

2.3. Intervention Development and Content

As the basis of the StopDia at Work intervention, we developed the StopDia Toolkit for creating healthy working environments (Supplementary Materials Table S1). This hands-on instrument is based on a comprehensive literature review and describes 53 practical strategies targeting generic workplace choice architectures, such as cafeterias, coffee rooms, and stairs. The strategies aim to facilitate healthier choices for diet and physical activity. The strategies were designed to be adaptable to diverse worksite environments, capable of reaching numerous employees within the workplace, and relatively effortless and inexpensive to implement. The toolkit applies both scientific literature and empirical knowledge to foster the adoption of dietary [52,53] and physical activity [54] guidelines for promoting health and preventing the development of type 2 diabetes and other lifestyle-related non-communicable diseases. Informed by the dual process theories that specify distinct reflective and automatic cognitive processes [10], we based the intervention mainly on automatic processes and applied the choice architecture approach [18,19,55]. We defined the toolkit strategies using three frameworks for applying behavioural insights: TIPPME [56], MINDSPACE [57], and EAST [58]. At an empirical level, the toolkit considers the needs and challenges of workplace health promotion identified through the recruitment phase discussions with contacted organisations (Section 2.2). Supplementary Materials Table S1 details the development and theoretical background and presents the full version of the toolkit.

Section 3.2 presents the toolkit strategies selected for implementation in the intervention, and details the applied behaviour change mechanisms, ease of implementation, and required purchases. We defined ease of implementation as the amount of knowledge and effort required to maintain a strategy after its launch. Easy strategies require little specialised

knowledge, and besides occasional check-ups, no maintenance after launch. Moderate strategies require some knowledge on correct implementation and light maintenance on a regular basis, whereas demanding strategies require more specialised knowledge and daily maintenance. Required purchases suggestively indicate the extent to which implementation requires the procurement of new materials or services. Strategies with no purchases require no procuring, or in the case of this intervention, the study provided and delivered needed materials. Minor and substantial purchases refer to relatively inexpensive and relatively expensive goods, respectively.

2.4. Implementation Process

Preparations for implementation proceeded in collaboration with the coordinators and/or implementers and with the consent of the management of participating worksites. Thus, we consider that the researchers, implementers, and coordinators together acted as the choice architects of the study.

We became acquainted with the worksites through discussions with the coordinators and/or implementers, and visited sites accessible to us (n = 30) to map out opportunities for choice architectural modifications. Based on these discussions and visits, the research team and the coordinators and/or implementers selected intervention strategies from the toolkit (Section 2.3) individually for each site, and tailored the implementation of selected strategies to local contexts. Such contextualisation was justified, since the worksites (Section 3.1) were highly heterogeneous in terms of facilities, resources, and employees' needs concerning diet and physical activity. The contextualisation involved planning of schedules, people involved, actions and materials needed, as well as physical spots to be adapted in the worksite environment. To maintain fidelity, we carefully recorded all adaptations and ensured the adaptations maintained the essential elements of the intervention [41,49]. These elements included, for example, using the same materials and placement principles, although targeted worksite environments and the form and delivery channels (print vs. electronic) of intervention materials varied across sites. Participation was free of charge for the organisations, and the study provided intervention sites with print intervention materials, such as posters and signs. However, should the sites choose to implement strategies that require the procurement of other materials, such as water bottles, height-adjustable desks, or gymnastic balls, the sites were responsible for the acquisition.

Intervention sites received illustrated instructions on the implementation of selected strategies. In 21 (40%) sites, researchers assisted the implementers and/or coordinators to launch the intervention. In the remaining 32 (60%) sites, the sites launched the intervention independently. The coordinators and implementers were asked to inform employees about the collaboration with the StopDia study and about provided intervention materials, as well as to encourage employees to use these materials. The employees were not, however, disclosed the specific aim of the intervention to alter workplace choice architectures to promote healthy behaviours predominantly via automatic cognitive processes.

After intervention launch, the sites independently maintained the implemented strategies over 12 months. Regarding one strategy that required weekly maintenance (#15, Section 3.2) and that all intervention sites intended to implement, implementers received checklists that they should sign each time they completed the maintenance. This procedure aimed to enhance implementation fidelity and to support fidelity assessment. In the Northern Savo region, implementers also received weekly text message reminders for this strategy, if they wished so. Implementers of 12 (33%) sites in this region opted for the reminders.

Where feasible, researchers or coordinators made follow-up visits to the intervention sites at month six (n = 41 sites; 77%) and month twelve (n = 18 sites; 34%). When visiting the sites was not possible, researchers conducted the follow-ups by phone. Besides supporting data collection and fidelity assessment, the follow-up sessions provided opportunities to enhance implementation. We answered implementers' questions, encouraged imple-

menters to maintain the intervention, and if needed and possible, helped to enhance the displayed intervention materials.

2.5. Data Collection

We collected data with several methods. Our primary data collection means were semi-structured interviews and observation. As complementary data, we collected photos from intervention sites, checklists returned by implementers (n = 21), and email and text messages exchanged with the coordinators and implementers. Post intervention, we requested additional information from sites with incomplete data via email and/or phone. In this paper, we refer to individual organisations with the capital letter O and identification numbers 1–16 (e.g., O1). Small letters following the organisation identifier indicate the worksites within the organisations (e.g., O1a).

2.5.1. Interviews

The first two authors (E.R., S.V.) conducted the interviews over the follow-up visits and/or phone calls at months 6 and 12 (Section 2.4). These authors had a major role in the recruitment, intervention development, and implementation phases (Sections 2.2–2.4), and they had thus become acquainted with the worksites as well as established rapport with the contact persons. The median durations of the first and second follow-up sessions were 60 min (range 20–180) and 30 min (range 20–120), respectively.

One organisation (O5) completed the intervention after six months, because its sites moved to new premises (Figure 1). Regarding this organisation, the first interview serves as the primary data on implementation. In another organisation (O11), two sites (O11b–c) completed the intervention after nine months because the sites, being construction yards, were closed (Figure 1). At these sites, the second interview took place shortly before the closing of the sites. At one site (O10a), the implementer was not available at month 6, and so the two interviews were merged and conducted at month 12. Sites O12c–q were not accessible to externals, and hence the organisation-level coordinator visited these sites after six months to check their implementation status.

At the follow-up visits, informants were interviewed in person, often at their personal workstations, and sometimes while they were performing their work tasks. In open and shared workspaces, personnel not involved in the implementation could be present as well. When visiting the intervention sites was not feasible, we conducted the interviews on the phone. The interviews ranged from individual to group interviews, depending on the number and availability of persons involved in the implementation. The researchers made notes during the interviews and typed the notes up as soon as possible after the interviews, while the discussions were still fresh in their minds.

The interviews involved altogether 61 informants, the majority of whom were females (n = 44). The informants represented predominantly implementers (n = 40) and coordinators (n = 11). However, some information was received from other informants (n = 10) as well. The informants represented professionals from numerous fields and both employees (n = 34) and managers (n = 19) of the participating organisations. Among the informants were, for example, HR personnel, occupational health and safety representatives, shop stewards, site managers, assistants, and cafeteria personnel. Two informants were external stakeholders of one participating organisation (O3), and the job titles of six informants remained unknown. Most informants (64%) had become acquainted with the interviewers over the planning and/or launch of the intervention, and were aware of the main purpose of the intervention.

The first interview covered questions on strategies that had been implemented, perceived success in launching and maintaining implemented strategies, if and how employees had been informed of and encouraged to tap into implemented strategies, possible difficulties encountered and ways of solving these difficulties, as well as perceived facilitators for and barriers to maintaining the intervention. In addition, we enquired about factors that motivate and do not motivate the implementers to maintain the intervention, and

about persons most suitable for the implementer's role. The second interview asked about changes in the implementation since the first interview and enquired about whether the sites intended to maintain the intervention after the study.

2.5.2. Observation

When feasible, we made quality assurance tours in the worksite environments during the follow-up visits. The purpose of these tours was to record observations on the quality of implementation and thus to complement data collected with interviews. The tours covered altogether 39 (74%) worksites (t1: n = 37 (70%), t2: n = 13 (25%)), representing the majority of intervention sites. Such a well-selected sample is considered capable of providing sufficient insight on implementation [43]. The first two authors (E.R., S.V.) conducted the tours and recorded observations as field notes and/or photos. The only exceptions were sites O12c–q that were not accessible to externals and that were toured by the organisation-level coordinator.

2.6. Analyses

We used NVivo R1 (QRS International) to manage and analyse qualitative data, and Microsoft Excel® 2016 (Redmond, WA, USA) and IBM SPSS® Statistics 25 (Armonk, NY, USA) for quantitative data.

2.6.1. Fidelity

We assessed fidelity both qualitatively and quantitatively, focusing on the dose delivered and the quality of implementation. We measured dose as the number of practical strategies implemented per site and evaluated implementation quality against an assessment framework (Supplementary Materials Table S2) and site-specific implementation plans. The quality assessment framework was developed in this study and comprises the essential elements of and a tripartite assessment scale (2 = successful, 1 = imperfect, and 0 = failed) for each implemented practical strategy. Evaluating the quality of implementation categorically has also been common in prior implementation research [41].

Qualitative analysis: We compiled all available data on implementation at intervention sites and organised the data according to the site, strategy, and follow-up time point (t1 = month 6, t2 = month 12). We performed the implementation quality assessment individually for each strategy at each site and at each time point, and refer to this unit of analysis as "case". Two authors (E.R., S.V.) independently rated the quality of all cases, discussed and agreed on differing ratings, and consulted a third author (P.A.) in uncertain cases. The assessment process comprised several rating and discussion rounds, along which we refined the assessment framework and the definitions of implemented strategies as well as requested further details from sites with incomplete data. Across all assessment rounds, the mean interrater agreement was 89%. Cases with too little data available for reliable quality assessment received a code N/A. The assessment focused on toolkit strategies launched during the intervention and excluded strategies that the participating worksites had adopted already before the intervention.

Quantitative analysis: Pooling all intervention sites, implemented strategies, and follow-up measurements, our dataset comprised 412 individual cases (t1 = 209, t2 = 203). Within this sample, 75 cases (t1 = 22, t2 = 53) were coded N/A due to incomplete data. Thus, 337 cases (t1 = 187, t2 = 150) received implementation quality ratings and were included in statistical analyses. The rated cases covered 82% (t1 = 90%, t2 = 74%) of the full sample. Of the cases coded N/A, 95% (t1 = 82%, t2 = 100%) concerned sites to which we had no direct contact and 100% represented strategies that the sites implemented independently without researchers' assistance. In addition, all N/A cases represented sites that received no text message reminders (Section 2.4) for strategy #15 (Section 3.2).

Using the cases that received implementation quality ratings, we examined whether these ratings were dependent on four independent variables: (1) the ease of implementation of applied strategies, (2) researchers' assistance in intervention launch, (3) direct contact to

intervention sites, and (4) sending text message reminders to implementers. We assessed these associations separately for ratings at six (t1) and twelve months (t2). Statistical tests of normality, Shapiro–Wilk and Kolmogorov–Smirnov, indicated that across the four independent variables and at both time points, the implementation quality ratings did not follow a normal distribution ($p < 0.05$). Hence, we employed nonparametric statistical tests [59], defining p-values < 0.05 as statistically significant and reporting all p-values as two-tailed. Independent samples Kruskall–Wallis test assessed the difference in implementation quality ratings between the three levels of implementation ease: easy, moderate, and demanding. Independent samples Mann–Whitney U test assessed the difference in implementation quality ratings between cases that received and cases that did not receive researcher's assistance, direct contact, or reminders.

2.6.2. Facilitators and Barriers of Implementation

We explored the facilitators and barriers of implementation with descriptive qualitative content analysis [60]. We performed the analysis from a factual perspective, assuming that our informants had answered the interview questions to the best of their knowledge, and that the data they had shared reflected reality more or less truthfully [61]. Due to the practical orientation of this work, the analysis focused on the visible and obvious content of collected data (i.e., *manifest content*), instead of interpreting underlying meanings hidden between the lines (i.e., *latent content*) [62]. We adopted a deductive approach in that we employed a framework proposed for grouping facilitators and barriers of workplace health promotion interventions [39,42]. This framework comprises five domains that distinguish between the characteristics of (1) the socio-political context, (2) the organisation, (3) the implementer, (4) the intervention, and (5) the participant, referring to the subjects of the intervention [39,42]. Since our analysis identified no facilitators nor barriers related to the socio-political context, we excluded this domain from the framework. Instead, we identified facilitators and barriers related to the worksite environment and included an additional domain: "physical and digital environment". To avoid confusion with participating worksites, we labelled the domain "participant" as "user". Hence, our final categorisation matrix involved the following domains: (1) organisation, (2) intervention, (3) physical and digital environment, (4) implementer, and (5) user; user referring to the employees of intervention sites who became exposed to the intervention. We systematically coded the data according to these domains, and within each domain, generated categories freely following the principles of inductive qualitative content analysis [60].

The first author (E.R.) immersed herself in the data through reading and rereading, simultaneously coding the data and organising similar codes under higher-order headings or categories. The validity and reliability of the coding was ensured through a peer-checking process, common in qualitative research [63,64]. This meant that the first author iteratively reviewed a sample of codes and their corresponding raw text with three other authors (S.V., P.A., and L.K.), and the four authors refined and agreed on the codes and their grouping into categories and domains.

2.6.3. Maintenance

We measured maintenance as the proportion of intervention sites that intended to maintain at least one implemented strategy after the study. By participating in the study, the intervention sites agreed to sustain implemented strategies over 12 months. Continuing implementation longer than this was thus not expected. In the 12-month follow-up interview (Section 2.5.1), we nevertheless enquired whether the sites intended to continue implementation. In addition, while requesting additional information from sites with incomplete data on intervention delivery over the 12-month study, we received some information on post-study maintenance as well.

3. Results

3.1. Participating Organisations

Table 1 presents the characteristics of the 16 participating organisations. Three of the organisations operated in the region of Southern Karelia, four in Päijät-Häme, and nine in Northern Savo. The organisations represented both private (n = 10) and public sector (n = 6), and various fields of operation. From each organisation, 1−20 (mean 3.3) distinct worksites or departments were involved in the intervention, forming the study sample of altogether 53 intervention sites. Among these worksites were grocery shops, factories, a university of applied sciences, bureaus, a farm, a kindergarten, construction yards, hospital departments, and a welfare services centre. Nine organisations had worksite cafeterias on intervention sites, and four of these organisations involved the cafeterias in the intervention. Over 5000 employees in total worked at the intervention sites (Figure 1), and the proportion of male employees within organisations ranged from 5 to 91% (mean 43%). In 12 organisations, the work ranged from sedentary to physical, whereas in four organisations the work was predominantly sedentary. In ten organisations, at least part of the employees worked in shifts.

Table 1. Characteristics of participating organisations.

Organisation	Sector	Field of Operation	*n* Sites	*n* Employees [1]	% Men	Type of Work	Shift Work
O1	Private	Retail	5	360	21	Mixed [2]	Yes
O2	Private	Metal industry	1	600	80	Mixed [2]	Yes
O3	Private	Forest industry	1	950	78	Mixed [2]	Yes
O4	Private	Retail	3	300	20	Mixed [2]	Yes
O5	Private	Higher education	5	370	34	Sedentary	No
O6	Public	Municipality	1	70	29	Sedentary	No
O7	Private	Chemical industry	1	400	75	Mixed [2]	Yes
O8	Private	Farming	1	140	35	Mixed [2]	Yes
O9	Public	Municipality	1	80	39	Sedentary	No
O10	Public	Municipality	3	250	32	Mixed [2]	Yes
O11	Private	Construction industry	5	180	91	Mixed [2]	No
O12	Public	Health care	20	490	46	Mixed [2]	Yes
O13	Private	Food industry	1	250	70	Mixed [2]	Yes
O14	Private	Retail	3	320	18	Mixed [2]	Yes
O15	Public	Municipality	1	300	20	Sedentary	No
O16	Public	Welfare services	1	40	5	Mixed [2]	No

[1] Approximate number of employees exposed to the intervention, [2] a mixture of physical and sedentary work.

3.2. Characteristics of Implemented Strategies

3.2.1. Descriptions, Mechanisms, and Settings

Table 2 portrays the characteristics of the practical strategies implemented in the intervention. In total, 23 strategies were launched by at least one intervention site, representing 43% of the strategies included in the toolkit (Supplementary Materials Table S1). Of these strategies, 16 promoted nutrition and seven physical activity. Overall, the implemented strategies applied 21 diverse behavioural change mechanisms. Implementation settings comprised coffee rooms, cafeterias, meetings, personal workstations, common environments, stairs, and elevators.

Table 2. Characteristics of strategies implemented and the number (*n*) of intervention sites that implemented each strategy. The total number of sites was 53.

Target		Practical Strategy	Description	Behaviour Change Mechanism [3]	Ease of Implementation [4]	Required Purchases [4]	Setting	*n*
				Food provision				
Nutrition	1.	Enable healthy choices	Healthy [1] food and beverage choices, such as fruit and smoothies made available.	Product availability ↑ [T]	Moderate	Minor	Meetings	6
Nutrition	2.	Widen selection	Greater variety of healthy [1] food and beverage options available.	Product availability ↑ [T] Attractive (salience ↑) [M, E]	Moderate	Minor	Cafeteria	4
Nutrition	3.	Replace with better alternatives	Energy dense and nutritionally poor options replaced with similar but nutritionally better alternatives.	Product availability ↑ [T] Easy (substitution, default) [E]	Moderate	Minor	Meetings	1
Nutrition	4.	Increase visibility and proximity	Healthy [1] options placed: (a) in visible spots, (b) at the beginning of the buffet, (c) closer to the chooser (e.g., in front row), and/or (d) in the middle of the tray, shelf, or showcase.	Product position [T] Easy (friction costs ↓) [E] Attractive (salience ↑) [M, E]	Demanding	None	Cafeteria	4
Nutrition	5.	Decrease visibility and proximity	Less healthy options placed: (a) in less visible spots, (b) at the end of the buffet, (c) further away from the chooser (e.g., in back row), and/or (d) on the edge of the tray, shelf, or showcase.	Product position [T] Less easy (friction costs ↑) [E] Less attractive (salience ↓) [M, E]	Demanding	None	Cafeteria	4
Nutrition	6.	Increase convenience	Fruit and vegetable served ready to eat, i.e., washed, peeled if needed, and cut into pieces.	Product functionality [T] Easy (friction costs ↓) [E]	Demanding	None	Meetings	1
Nutrition	7.	Increase perceived variety	Salad components served from separate serving dishes to encourage greater consumption.	Product presentation [T] Attractive (salience ↑) [M, E]	Moderate	None	Cafeteria	1
Nutrition	8.	Use smaller serving dishes	Less healthy foods served from smaller serving dishes.	Product size [T] Easy (default) [M, E]	Moderate	None	Cafeteria	1

Table 2. *Cont.*

Target		Practical Strategy	Description	Behaviour Change Mechanism [3]	Ease of Implementation [4]	Required Purchases [4]	Setting	*n*
				Food provision				
Nutrition	9.	Use smaller serving utensils	Less healthy foods served with smaller tongs and spoons.	Product size [T] Less easy (default) [M, E]	Moderate	None	Cafeteria	1
Nutrition	10.	Use smaller serving sizes	Less healthy options served in smaller sizes.	Product size [T] Easy (default) [M, E]	Moderate	None	Meetings	2
Nutrition	11.	One plate-policy	Separate bread and salad plates moved out of sight to guide employees to choose one large plate; thus facilitating the composition of the meal according to the plate model (i.e., 1/2 vegetable, 1/4 protein, and 1/4 carbohydrates). For the strategy to be effective, salads should be placed first in the buffet line.	Product size [T] Easy (default) [M, E]	Easy	None	Cafeteria	1
Nutrition	12.	Point-of-choice prompts	Healthy [1] options indicated with the Heart Symbol [2] on menus and at the point of choice.	Information on related objects [T] Attractive (salience ↑) [M, E] Timely (prompting) [E] Easy (simplification) [E]	Demanding	None [5]	Cafeteria	4
Nutrition	13.	Prime for better choices	Follow the heart posters [2] at restaurant entrance and/or at the beginning of the buffet to guide customers to notice and choose options labelled with the Heart Symbol [2].	Information within the wider environment [T] Attractive (salience ↑) [M, E] Timely (priming) [M, E]	Easy	None [5]	Cafeteria	4
				Drinking water				
Nutrition	14.	Facilitate and remind of drinking water	Personal, reusable water bottles provided for employees.	Related object availability ↑ [T] Easy (friction costs ↓) [E]	Easy	Minor	Personal workstation	6

Table 2. *Cont.*

Target		Practical Strategy	Description	Behaviour Change Mechanism [3]	Ease of Implementation [4]	Required Purchases [4]	Setting	*n*
Packed lunches and snacks								
Nutrition	15.	Encourage smart packed lunches	Temptingly named, visually attractive, and seasonal StopDia packed lunch of the week recipes [2] promoted and provided at workplace coffee rooms and/or via electronic channels, such as info-screens, company intranet, and newsletters. The campaign comprises one recipe for each week of the year, and all recipes meet the nutritional criteria of the Heart Symbol [1].	Easy (friction costs ↓, chunking) [E] Attractive (salience ↑) [M, E] Social (descriptive norm) [M, E] Timely (priming) [M, E] Affect [M]	Moderate	None [5]	Coffee rooms	48
Nutrition	16.	Encourage provision of fruit at work	The promotion and provision of the fruit crew starting kit [2] that facilitates colleagues to found a fruit circle and consequently have fresh fruit available at the workplace.	Social (network nudge, commitment contracts, descriptive norm, reciprocity) [M, E] Attractive (gamification, salience ↑) [M, E] Timely (implementation intentions) [E]	Easy	None [5]	Coffee rooms	17
Time spent sitting								
Physical activity	17.	Enable active sitting	Introduction of alternative seats, such as wobble chairs or balance cushions.	Product availability [T] Easy (friction costs ↓) [E]	Easy	Substantial	Common environments	1
Stair use								
Physical activity	18.	Enhance stairwell visibility	Footprints attached on the floor to lead to stairs from the point of choice between the stairs and the elevator.	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M, E] Timely (prompting) [E]	Easy	None [5]	Elevator, stairs	2
Physical activity	19.	Prompt choosing the stairs	StopDia logo (a stop hand sign with a heart on the palm) [2] placed on elevator doors, next to elevator call buttons, or in their immediacy.	Timely (prompting) [E]	Easy	None [5]	Elevator	6

Table 2. *Cont.*

Target		Practical Strategy	Description	Behaviour Change Mechanism [3]	Ease of Implementation [4]	Required Purchases [4]	Setting	*n*
				Movement breaks				
Physical activity	20.	Prompt context-specific movement	StopDia Flex! movement posters [2] placed on salient spots where employees typically pause for a moment and have the opportunity to perform movements. Such spots can be, for example, by copy machines, microwaves, kettles, coffee makers, and bathrooms.	Timely (prompting) [E] Attractive (salience ↑) [M, E] Easy (chunking) [E]	Easy	None [5]	Common environments	43
Physical activity	21.	Enable movement with exercise equipment	Light exercise equipment made available, for example, gym sticks, balance boards, or hanging bars.	Product availability [T] Easy (friction costs ↓) [E]	Easy	Minor	Common environments	9
Physical activity	22.	Prompt movement with exercise equipment	Available exercise equipment placed on salient spots where employees typically pause for a moment, and an opportunity for a short exercise break occurs, for example, by copy machines, micros, kettles, or coffee makers.	Timely (prompting) [E] Attractive (salience ↑) [M, E]	Moderate	None	Common environments	13
Physical activity	23.	Prompt movement with automatic reminders	An application that prompts to take short exercise breaks at pre-set intervals provided for employees.	Timely (prompting) [E]	Easy	Minor	Personal workstation	2

[1] Food products, meals, and recipes that meet the product category-specific nutritional criteria of the Heart Symbol (https://www.sydanmerkki.fi/en/ (accessed on 12 October 2021)), as well as energy-free beverages; [2] for images of the materials, see Supplementary Materials Table S1; [3] behaviour change mechanisms: [T] = TIPPME [56], [M] = MINDSPACE [57], [E] = EAST [58], ↑ = increase, ↓ = decrease; [4] for definitions of categories, see Supplementary Materials Table S1; [5] the study treated and delivered needed materials.

The three most often implemented strategies were #*15 encourage smart packed lunches*, #*20 prompt context-specific movement*, and #*16 encourage provision of fruit at work* (Table 2). These strategies were implemented at 48 (91%), 43 (81%), and 17 (32%) sites, respectively. At 31 (58%) sites, the entire intervention consisted of one or more of these three strategies. Strategy #15 comprised a year-long packed lunch of the week recipe campaign that primed the preparation of nutritionally high-quality packed lunches. This strategy aimed to cultivate descriptive social norms of what packed lunches could be, and to break up the complex behaviour of healthy eating into more manageable and attractive tasks. Strategy #20 aimed to prompt context-specific movement with a series of Flex! movement posters depicting simple movements suitable to be performed within daily work tasks. Strategy #16 provided a starting kit for forming fruit crews, i.e., social circles in which the members take turns to organise fruit provision at work. This strategy aimed to tap into social networks and people's inclination for reciprocity, to encourage commitment contracts, and to cultivate the social norm of offering healthier food at the workplace. In two grocery shops (O14a–b), the implementation of this strategy was adapted so that the employer provided the fruit and the workers of the fruit and vegetable section arranged regular fruit offerings in staff coffee rooms. For images of the materials of these three strategies, see Supplementary Materials Table S1.

Fifteen (65%) strategies were each launched by less than five intervention sites (Table 2). Of these strategies, 12 were related to nutrition and required some sort of food offering at the intervention site. These twelve strategies were implemented at sites (n = 6 in total) that had on-site cafeterias involved in the intervention and/or that often organised meetings with food and beverage provision.

Intervention sites mainly kept to their implementation plans and enacted strategies that were selected in the designing phase (Section 2.4). Eight sites, however, ended up implementing one or two additional strategies from the toolkit alongside their originally planned strategies. These so-called spin-off strategies are included in Table 2, and concerned strategies #1, 10, 17, 21, 22, and 23.

3.2.2. Ease of Implementation

According to our definition (Section 2.3), ten (43%) of the implemented strategies were categorised as easy to maintain, nine (39%) moderate, and four (17%) demanding (Table 2). The three most often implemented strategies (#15, 20, and 16) were easy to moderate to maintain. Easy strategies mainly increased the availability of opportunities that enable healthy behaviours, and used contextual cues that encourage such behaviours. The availability increased through providing employees reusable water bottles, fruit, light exercise equipment, a break exercise application, and/or wobble chairs. The contextual cues, in turn, prompted movement and/or stair use or primed healthy food choices.

The moderate to demanding strategies focused largely on nutrition and were delivered in cafeterias and meetings. These strategies altered the availability, salience, accessibility, convenience, and/or size of food options, as well as prompted choosing healthier options. Maintaining these strategies typically required knowledge on the nutritional quality of foods and constant maintenance because the food choice architecture keeps changing as people choose and consume foods.

3.2.3. Required Purchases

Sixteen (70%) of the applied strategies required no purchases, six (26%) required minor, and one (4%) substantial purchases (Table 2). For the three most often implemented strategies (#15, 20, and 16), the study provided required materials. Minor purchases comprised food products procured to cafeterias or meetings, as well as reusable water bottles, light exercise equipment, and a break exercise application provided for employees. Substantial purchases involved wobble chairs acquired for common work environments.

3.3. Fidelity

3.3.1. Dose Delivered

Except for one site, all intervention sites implemented at least one strategy. The median number of implemented strategies was three (range 0–14), with a median of two strategies (range 0–9) promoting nutrition, and one strategy (range 0–5) promoting physical activity. The number of implemented strategies differed, however, between sites that had on-site cafeterias involved in the intervention and sites that had no participating cafeterias. At sites with cafeterias (n = 4), the median number of implemented strategies was 10.5 (range 9–14), with a median of 8.5 (range 8–9) strategies related to nutrition and two (range 1–5) strategies related to physical activity. In contrast, sites with no cafeterias (n = 43) implemented a median of three (range 0–7) strategies; two (range 0–4) focusing on nutrition and one (range 0–4) on physical activity.

3.3.2. Quality of Implementation

Implementation quality was rated for 187 cases at month 6 (t1) and for 150 cases at month 12 (t2). *A case refers to a given strategy implemented at a given worksite at a given follow-up time point*. Figure 2 presents the distribution of implementation quality ratings by implemented strategy and follow-up time point. Overall, implementation was successful in an average of 66% (t1: 64%; t2: 69%), imperfect in 25% (t1: 26%, t2: 23%), and failed in 9% (t1: 11%, t2: 7%) of the rated cases.

We examined the association of implementation quality with the ease of implementation (Section 2.3), researchers' assistance in intervention launch, mode of contact to the intervention sites, and text message reminders (Section 2.4) received (Table 3). Ease of implementation was not statistically significantly associated with the quality of implementation at either time point (t1: p = 0.54, t2: p = 0.19). Researchers' assistance (p = 0.02) and direct contact to intervention sites (p < 0.001) were associated with higher implementation quality at t1, but the associations disappeared at t2 (p = 0.63 and p = 0.98, respectively). Receiving reminders had no statistically significant association with implementation quality at either time point (t1: p = 0.10, t2: p = 0.29).

Table 3. The associations of implementation quality (0 = failed, 1 = imperfect, 2 = successful) at month 6 (t1) and month 12 (t2), with the ease of implementation of applied strategies and the three diverse modes of support that the research team could provide.

Independent Variable	t1				t2			
	n Cases	Mean	95% CI for Mean	*p* [1]	*n* Cases	Mean	95% CI for Mean	*p* [1]
Ease of implementation								
Easy	100	1.47	1.32–1.62	0.535 [2]	68	1.65	1.49–1.81	0.187 [2]
Moderate	74	1.62	1.49–1.75		69	1.64	1.50–1.77	
Demanding	13	1.46	1.06–1.86		13	1.38	0.99–1.78	
Researcher assisted intervention launch								
Yes	63	1.71	1.59–1.84	0.021 [3]	54	1.59	1.42–1.76	0.625 [3]
No	124	1.44	1.30–1.57		96	1.64	1.51–1.76	
Direct contact to intervention site								
Yes	127	1.68	1.59–1.77	0.000 [3]	117	1.64	1.54–1.74	0.980 [3]
No	60	1.22	0.99–1.44		33	1.55	1.26–1.83	
SMS reminders for strategy 15								
Yes	12	1.83	1.59–2.08	0.100 [3]	12	1.75	1.46–2.04	0.290 [3]
No	38	1.50	1.29–1.71		32	1.47	1.23–1.71	

[1] p-values < 0.05 statistically significant; [2] Kruskall–Wallis test; [3] Mann–Whitney U test.

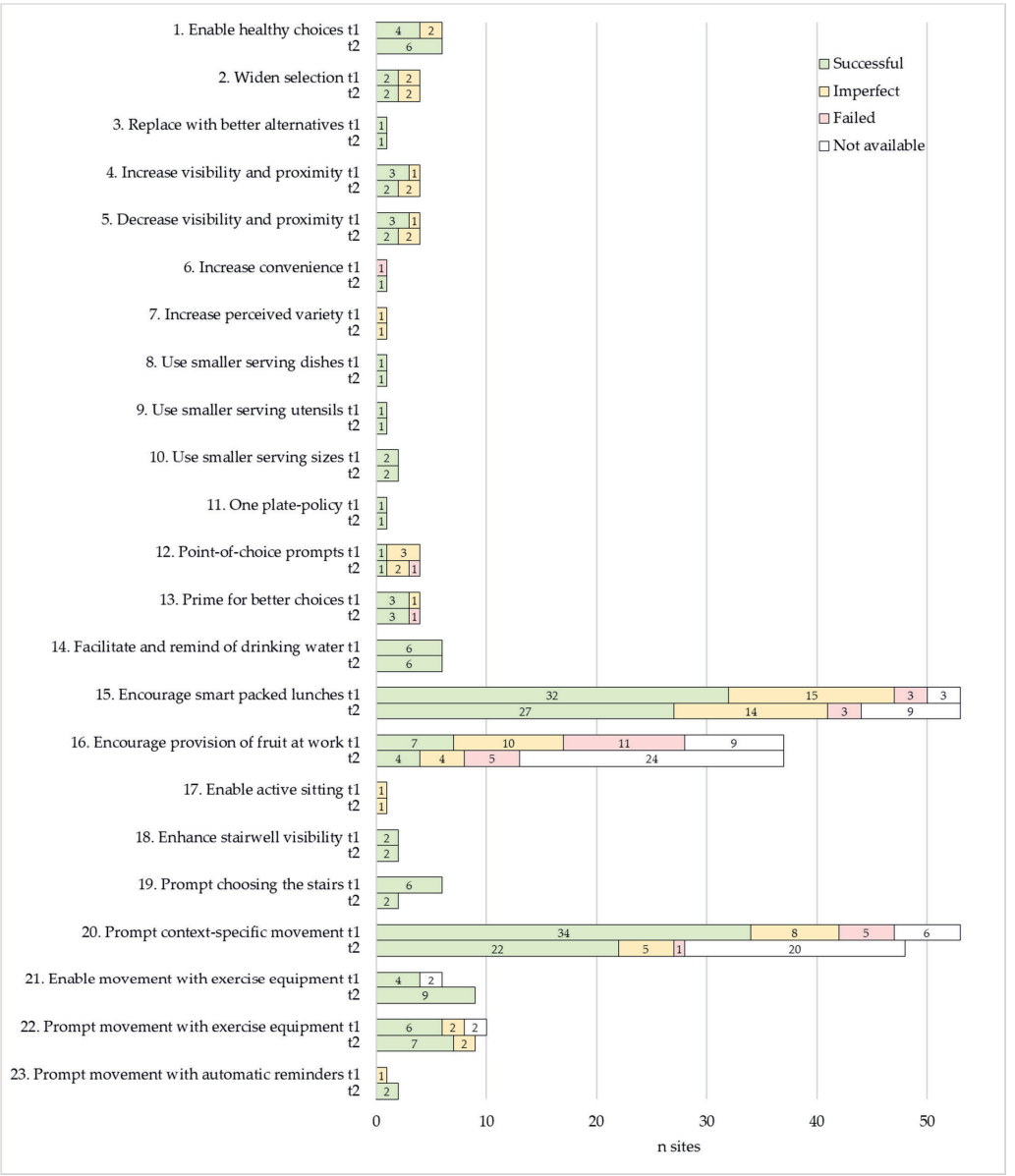

Figure 2. Implementation quality ratings by practical strategy at month 6 (t1) and month 12 (t2).

The majority of rated cases were categorised as easy to implement (t1: 53%, t2: 45%), followed by cases that were moderate (t1: 40%, t2: 46%), and demanding (t1: 7%, t2: 9%). In slightly over one third of the rated cases (t1: 34%, t2: 36%), researchers had assisted intervention launch, and in nearly three thirds of the cases (t1: 68%, t2: 78%), communication to the intervention sites had been direct. Weekly text message reminders for strategy #15 (Table 2) were received at slightly over one third of the rated cases (t1: 32%, t2: 38%).

3.4. Facilitators and Barriers of Implementation

Across the five domains of the used categorisation matrix (Section 2.6.2), our qualitative content analysis identified 11 main categories of facilitators and 12 main categories of barriers (Figure 3). Both facilitators and barriers included categories related to the characteristics of the organisation, intervention, physical and digital environment, and implementer. Barriers also comprised one category related to the user.

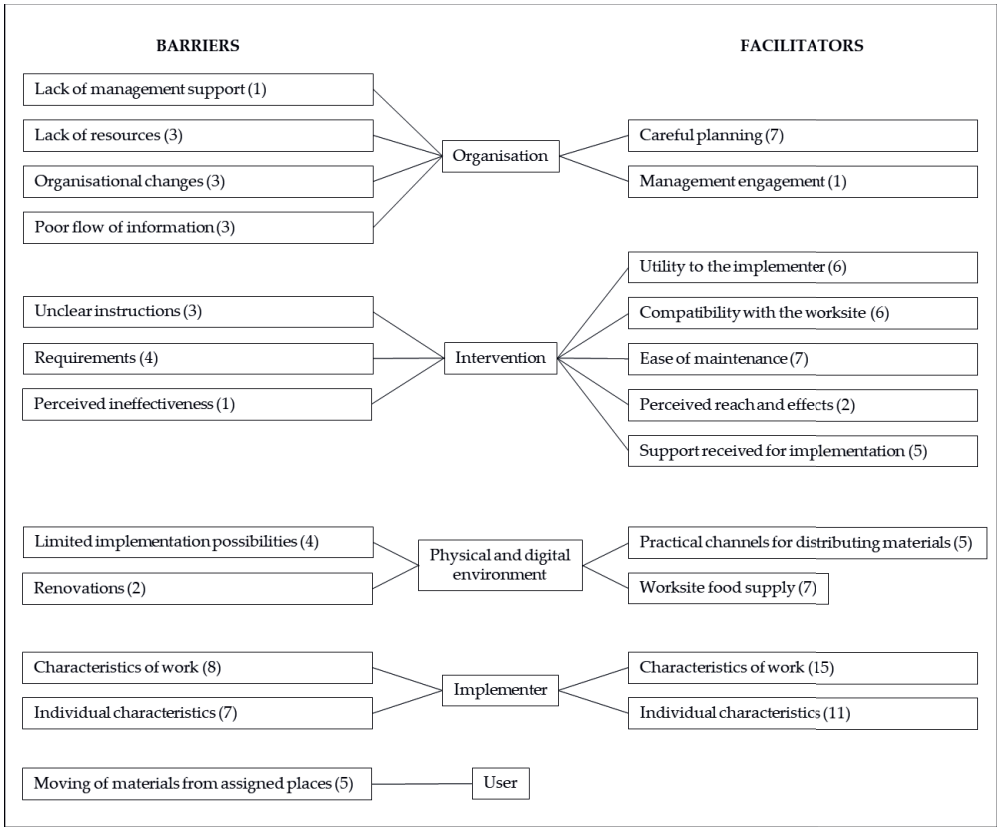

Figure 3. Main categories of the facilitators and barriers of implementation identified through qualitative content analysis. Numbers refer to organisations associated with each category.

3.4.1. Facilitators

Characteristics of the Organisation

Careful planning was a major organisational facilitator that involved clear division of responsibilities, communication, sufficient resourcing, and integration into existing health promotion activities. Several informants highlighted the importance of dividing responsibilities clearly (O3, O10b, O13, and O14a–b), and the implementation rolled out smoothly at sites that explicitly defined who should do what (O10b, O13, O14a–b). As for communication, informants (O3, O11e) considered it recommendable to formulate a communication plan and inform employees of the intervention. One implementer (O11e) thought it would be helpful if employees were aware of implemented strategies and the reason for, for example, changed food provision in meetings, "*So they wouldn't think the changes were from me*". Informants also stressed the necessity of ensuring sufficient resources, including enough time for planning the launch and maintenance of intervention strategies

(O3, O2). The significance of integrating the intervention into existing operations was crystallised by one coordinator (O1): "*Chances for success are higher when linked with the organisational context. If the initiative is not connected to the main activities, it easily remains undone*". Another coordinator (O13) provided a successful example of how this integration materialised: "*The launch of the intervention occurred at a good time, because an ongoing wellbeing initiative had discussed, inter alia, nutrition and sleep, so the strategies served as good support measures for the ongoing initiative*".

Another organisational facilitator was management engagement. The management can support implementers by participating in the implementation and encouraging employees to tap into provided opportunities (O11e).

Characteristics of the Intervention

The intervention afforded utility to the implementer, manifested in opportunities for breaks and physical activity (O7, O8, and O11c), as well as in food for thought (O5c, O10a, and O12b). As for breaks, one implementer (O11c) said: "*Changing the recipes (#15) breaks the workday and you get to stretch the legs*". Regarding food for thought, one implementer (O12b) portrayed how understanding of the rationale behind the intervention sparked motivation for implementation: "*The study woke me to think of type 2 diabetes and that I wouldn't want to get it. That raised my interest in nudging as well*".

Compatibility with the worksite denotes that the intervention fits the mission of the worksite and the work of the implementer. This theme relates to the organisational facilitator "careful planning", whereby the organisation can adjust and integrate the intervention into the organisational context. Reflecting fit with the worksite mission, the head of one cafeteria (O12a) said: "*Serving health promoting food is the responsibility and the value of the cafeteria*". Indicating fit with implementers' work, informants from several sites (O1, O11b, O12a, O13, O15, and O16) reported that the implementation could be integrated into the duties of the implementer. One coordinator (O13) portrayed how the maintenance of the recipe campaign (#15, Table 2) fits the work of their occupational health and safety (OHS) representative: "*The duties of the representative include a weekly tour in the working environments, and changing the recipe cards could be integrated into this tour*". At another site (O15), the same strategy supported the OHS representative to perform the representative's role: "*Visits to coffee rooms enable meeting the personnel in person, discussing the recipes or other matters, and meeting new employees. The recipes provide a reason to visit the workstations*".

Reflecting the ease of maintenance, a number of informants described the intervention as easy, simple, natural, and/or effortless to maintain (O1b, O5a, O5c, O6, O10b–c, O11c, O11e, O12a–b, and O16). One implementer (O12b) also discovered that when displayed successfully, intervention materials per se remind them of their maintenance. Indicating perceived reach and effects, implementers found it motivating to observe how the intervention reaches employees (O5) and starts to take effect (O7). Finally, implementers were satisfied with the support received from the research team. This support involved co-design of implementation (O5b), fluent delivery (O5b, O13) and clear packaging of provided materials (O11c, O12b), as well as reminders sent for strategy #15 (Table 2) (O11c, O11e, and O14c).

Characteristics of the Physical and Digital Environment

Practical channels for distributing intervention materials within the worksite included internal mail (O2, O10b), info screens, email, and intranet (O11c, O13, and O15). Compared to delivering print materials, digital delivery was considered more effortless for the implementer, yet potentially inferior in reaching employees. One implementer (O15) justified this viewpoint as follows: "*Digital delivery would facilitate the dissemination of the recipes, but uploading the recipes on the intranet, for example, would require employees to go and get the recipes from there. In that case, it's likely fewer would find them*". Existing worksite food supply facilitated the implementation of many eating-related strategies. For example, sites with cafeterias and/or a custom to provide refreshments in meetings (O3, O7, O8, O11e, O12a,

and O15) successfully applied a variety of strategies. In grocery shops (O14a–b), in turn, fruit stocks enabled arranging regular fruit provision in coffee rooms.

Characteristics of the Implementer

Characteristics of work that facilitated implementation comprised duties that involve regular touring of worksite premises (O2, O7, and O13), location at the intervention site (O1, O4, O6, and O10b–c), regular working hours (O12a), and time available for the implementation (O10c). Besides these practical aspects, many informants considered it also natural if the substance of implementers' work relates to the intervention (O1, O3, O5, O6, O8, O9, O11e, O12a–b, O13, O14a–b, and O15). In our study, these criteria applied to HR personnel (O9), occupational health and safety representatives (O13), communication specialists (O3), cafeteria personnel (O12a), and workers of the fruit and vegetable section of grocery shops (O14a). According to informants, the implementer's role suits both managers (O1, O8, O11a, O11d, O11e, O12a, and O14a) and employees (O6, O10a, and O12a).

Individual characteristics attributed to persons suitable for maintaining the intervention involved committed, motivated and motivational, relatable to employees, sociable, organised, and tolerant to employees' initial resistance to change. Commitment manifested itself in the way that implementers conscientiously maintained the intervention regardless of their personal attitudes towards this task. For example, one implementer (O11c) said: "*The firm pays for working, and maintaining the intervention is part of the duties. I wouldn't change the recipes for fun during free time*". A coordinator (O14b) expressed similar thoughts: "*When you have involved yourself in the project and committed to the maintenance, you will do it*". This coordinator pondered, however, that it would be beneficial to find an implementer who is motivated and motivational as well: "*The work community needs ambassadors that show the way with their own behaviour and inspire and encourage other employees to try out new things and change their behaviour*". Furthermore, other informants mentioned the importance of motivation and interest in the intervention (O4, O7, O10c, O11a, O12b, O14a, O15, and O16). Related to being motivational, informants considered it beneficial if the implementer is close, or relatable, to employees (O4), and sociable (O11c).

Being organised appeared in the way that implementers created and used reminders for strategies that require active maintenance (O5, O9, O10b–c, O11b–c, and O16), integrated the maintenance into existing routines at the workplace (O9, O14c, O16), and performed maintenance tasks regularly. Consequently, several informants reported that the implementation became a routine (O10b, O11a, O11e, O13) that needs no reminding (O11a, O12b). Implementers demonstrated organisation also by enhancing the display of intervention materials (O10a, O13, and O15) and by arranging stand-ins (O9, O12o) if need be.

The ability to maintain the intervention despite negative feedback from employees was the key to success in one cafeteria (O7), where employees' initial response to new arrangements (strategies 4–5 and 11; Table 2) was undesirable. Over time, however, the employees understood the purpose of the strategies to facilitate healthier food choices and portion sizes, and agreed with the changes. This occurrence links to the organisational facilitator "careful planning" and the finding that communicating the intervention to employees could facilitate implementation.

3.4.2. Barriers

Characteristics of the Organisation

Lack of management support was a rare problem, concerning only one site (O11e). At this site, however, the issue bothered the implementer throughout the study, making them feel left alone with the implementation. Lack of resources manifested as a lack of time and personnel (O3, O4a–c, and O7). Typically, this issue was due to busyness with competing priorities, as one coordinator portrayed (O7): "*We are growing with a huge speed and are pretty much tied with the recruitment and orientation of new employees*". Regarding organisational changes, one coordinator (O5) noted how "*all shifts and distractions*

in the routines of the organisation complicate implementation". A common example was staff turnover. When the implementer changed jobs, the implementation easily ceased (O5a–e, O11c–d) or the implementer's role could pass on to the next implementer with deficient instructions (O10a). This issue of poor knowledge transfer links to the final organisational barrier, poor flow of information, which manifested at a few sites (O3, O4a–c, and O11e). Information flowed poorly from coordinators to implementers (O4a–c) or from coordinators and/or worksite management to employees (O3, O11e). Reasons for failed communication included scattered organisation structure (O4a–c) and the above-mentioned barrier: lack of management support (O11e).

Characteristics of the Intervention

Unclear implementer instruction is an issue that concerns both the intervention—and hence the researchers—and the organisation, and that relates to the organisational barrier of "poor flow of information". Ensuring that everyone involved in the implementation receives sufficient information is crucial to fidelity, but it proved challenging, particularly in organisations with multiple intervention sites and/or implementers (O5), and in situations where the implementer changed (O10a). Suboptimal knowledge transfer bothered two implementers (O5b, O11e) that remained unsure of what was expected from them.

Intervention requirements that challenged implementation involved efforts, duration, and costs. Remembering to perform implementation tasks and to remind other implementers to perform theirs appeared challenging at first, but the burden of remembering reduced over time as the implementation "*fell into a routine*" (O10b). Maintaining the packed lunch recipe strategy (#15, Table 2) felt too burdening for one implementer (O1), and the 12-month duration too long for another (O2). Costs proved a barrier to sustained implementation at one site (O14b) that had chosen to implement the fruit crew strategy (#16, Table 2) by treating employees with unlimited fruit on every workday. In contrast, another site of the same organisation (O14a) found this strategy feasible by providing one fruit per employee twice a week. This example illustrates how intervention intensity can be adapted, and how adapting intensity allows adjusting costs.

The final intervention-related barrier, perceived ineffectiveness, terminated the maintenance at one site (O14a), where the implementer lacked motivation to maintain the recipe strategy (#15, Table 2) because "*the recipes did not seem to interest the employees*".

Characteristics of the Physical and Digital Environment

Physical worksite environments limited implementation possibilities at a few sites. Finding feasible places and ways to display print intervention materials challenged implementation at two sites (O10a, O13). In cafeterias, fixed serving lines in which the arrangement of and space for various foods are unchangeable restricted the number of strategies that could be implemented and the way in which selected strategies could be delivered. The head of one cafeteria (O12a) reflected that "*a new serving line with separate salad bar and more room could promote healthy food choices*", but at the time, such a substantial procurement was not on the agenda. Regarding digital environments, the delayed introduction of company's internal social media platform prevented the digital delivery of intervention materials that had been planned at one site (O14a). Renovations, in turn, required the removal of all intervention materials and interrupted the implementation for several months at two sites (O10a, O15).

Characteristics of the Implementer

Characteristics of work that challenged implementation comprised irregular working hours, heavy workload, and a job substance unrelated to the intervention. Irregular working hours were problematic with strategies requiring regular maintenance (O10a, O12a), such as the packed lunch recipe campaign (#15, Table 2), because "*work days vary in shift work, and changing the recipes is not always possible on the same weekday*" (O12a). Irregular maintenance, in turn, complicates remembering and forming a habit of the implementation.

Heavy workload manifested itself in the lack of time (O1, O10a, O11b, O11e, O12e, O14a, and O15) and in the declined coping of the implementer (O3). This issue links with the organisational barrier of "lack of resources". A job substance not related to the intervention bothered two assistants (O5a-b), one of whom thought the implementation "*didn't feel natural*" within their job (O5a).

Individual factors that hampered the implementation involved forgetting, absenteeism, and negligence of intervention materials, as well as the lack of motivation, personal relevance, and understanding of the intervention. As a minor problem, implementers reported occasional forgetting of maintenance tasks (O1b, O11a, and O12a). A major problem, in turn, was implementers' long absences, which could cease the implementation over longer periods (O1, O14b). In such cases, arranging stand-ins was beneficial, as long as the stand-ins received sufficient instructions. Otherwise, the fidelity might decline, as happened at one site (O15a). The negligence of intervention materials manifested at two sites (O10a, O15), where the implementers failed to reintroduce materials removed due to renovations. The lack of motivation, personal relevance, and understanding of the intervention were barriers identified in one organisation (O4). The coordinator of this organisation portrayed how their implementers—the site managers—were "*very competitive and young, and might not find diabetes a personally relevant subject*", and pondered that "*the managers might not see the connection between health promotion activities, diabetes, and, for example, absence from work*". In this organisation, the implementers received minimal introduction to the intervention and little support for implementation, as the coordinator assigned the implementation responsibility via email. The above examples of insufficient stand-in introduction, negligence of intervention materials, and lack of understanding relate to the organisational barrier of poor flow of information and the intervention-related barrier unclear implementer instruction.

Characteristics of the User

The users of intervention materials challenged implementation, because they moved materials away from their assigned places. Materials disappeared (O7, O9, O10a), were thrown away over cleaning (O1PA), or were moved out of the way and hidden in cupboards (O10a). Exercise equipment travelled to employees' personal workstations and under or behind furniture (O9, 15). On one hand, the moving of materials was a positive sign, indicating the materials were noted and used. On the other hand, mobility increased implementer burden, requiring implementers to collect and bring the materials back to where they belong.

3.5. Maintenance

As the final indicator of feasibility, we surveyed the maintenance of implemented strategies post study. Overall, we obtained maintenance information from 32 sites (60%). Of these sites, 26 (81%) kept maintaining, considered reintroducing, or planned to apply in a modified way at least one strategy. This continuation involved nutrition-related strategies implemented at cafeterias and meetings, the packed lunch recipe campaign (#15, Table 2), the fruit crew strategy (#16), and several strategies for physical activity (#17–22). Known reasons for discontinuation included the implementer leaving the site, the site being closed, the disposal of materials, and high implementation costs.

4. Discussion

Choice architecture—the variety, arrangement, properties, and presentation of choice options—can have a powerful, often unnoticeable influence on behaviour. The main emphasis of choice architecture research has been on effectiveness, while implementation and feasibility have remained less studied. We portrayed the implementation and feasibility evaluation of a 12-month choice architecture intervention at diverse worksites. The intervention employed a broad range of choice architectural strategies related to nutrition and physical activity. Implemented strategies were selected and contextualised individually

for each site via bilateral dialogues between the research team and the worksites. Semi-structured interviews and observations indicated that implementation was successful at two thirds of evaluated cases, and prospects for maintaining implementation post study emerged at a substantial proportion of worksites. Implementation quality was independent of reminders and the ease of implementation of applied strategies, but researchers' assistance in intervention launch and direct communication with implementers seemed beneficial within the first six months. Furthermore, an array of contextual factors influenced implementation.

4.1. Implementation and Feasibility Evaluation

4.1.1. Applicability to Worksites, Ease of Implementation, and Required Purchases

All participating worksites found strategies suitable for their settings from the StopDia Toolkit for Creating Healthy Working Environments, the pool of strategies from which the ones implemented were selected. This indicates that the toolkit and choice architectural strategies in general serve diverse workplaces. The applicability of several nutrition-related strategies, however, was limited at worksites without cafeterias, vending machines, or other pre-existing food provision. At such sites, feasible nutrition strategies were restricted to the packed lunch of the week recipe campaign (#15) and the fruit crew-strategy (#16). These strategies encourage healthier food choices by increasing the salience and social acceptability of healthy foods, as well as by facilitating the availability of such foods. These strategies do not provide the encouraged foods there and then, however. For wider application of nutrition-related choice architectural strategies and to further reduce the amount of individual resources—or "agency" [7]—required for making healthy food choices during working hours, workplaces should make health-promoting foods available for their staff. Increasing availability would be justified, because the use of worksite catering services has proved to predict healthier dietary patterns among the working population [65–67]. Motivating workplaces to improve healthy food availability might require government policy actions, such as tax incentives or standards for food procurement [68–72]. In Denmark, for example, the government-launched Organic Action Plan 2020 has increased the procurement and hence availability of organic foods in public kitchens [73].

Choice architecture interventions are considered relatively effortless to implement [30,74]. Supporting this claim, we scored the majority of strategies implemented in this study and the majority of strategies in the StopDia Toolkit easy or moderate to implement, defined as requiring little specialised knowledge and light or no maintenance after launch. In line with this scoring, a number of implementers found the intervention effortless to maintain alongside work duties. Nevertheless, the choice architecture approach features also more challenging strategies, particularly within the nutrition domain. Yet, our results indicate that workplaces can successfully implement demanding strategies as well (#4–6 and 12), and that implementation quality is independent of how demanding a strategy is. Considering that our implementers represented diverse occupational groups without earlier experience in the choice architecture approach, learning the implementation seemed possible with the support that the research team provided. This support comprised the co-design of the intervention, illustrated instructions and on-site assistance for intervention launch, as well as follow-up visits to support sustained implementation.

Besides being effortless, choice architecture interventions are considered relatively inexpensive [6,20]. Our findings support this assumption in that the delivery of nearly all implemented strategies and the majority of strategies in the toolkit require no or minor purchases. Unsurprisingly, implementation sites also seemed to prefer these less expensive strategies, since only one site chose to implement a strategy that required a substantial purchase. Implementation costs are not restricted to purchases, however, but include implementer training too. Estimating the full costs of implementing choice architecture interventions, including training, fell out of the scope of the current paper, yet would be an important topic for future research.

4.1.2. Fidelity

With a median of three implemented strategies per site and with two thirds of implementations evaluated as successful and one fourth partially successful, we consider the overall fidelity in this study satisfactory. According to a literature review on implementation studies, expecting perfect or near-perfect implementation is unrealistic and unnecessary because few interventions have reached implementation levels closer than 80% of optimal, and studies have yielded positive results with levels around 60% [41].

A few matters warrant consideration, however, while interpreting our fidelity findings. First, we were unable to rate the fidelity of 18% of all cases due to incomplete data, and decided to exclude these cases from statistical analyses. Importantly, the non-rated cases nearly exclusively represent sites that missed the three support measures that the research team could offer: direct communication, on-site assistance in intervention launch, and reminders. In addition, the number of excluded cases was substantially higher at twelve versus six months. These factors may have influenced the observations that direct contact and assistance predicted higher fidelity at six but not at twelve months, and that reminders had no significant association with fidelity. According to earlier research, technical assistance, such as efforts to support implementers to solve problems and maintain motivation and commitment is essential for effective implementation [41].

Two other remarks on our fidelity results concern the used assessment framework. First, since the framework comprises only three grades (successful, imperfect, and failed), it is rather insensitive to variations in implementation intensity, particularly at the higher end of the assessment scale. Hence, sites may have received equal grades with various levels of implementation intensity. For example, the packed lunch recipe campaign (#15) was rated as successfully delivered both at sites that distributed the materials through one channel (e.g., info screens), and at sites that used multiple channels (e.g., print materials in coffee rooms and digital distribution through info screens and email). In these examples, both delivery modes met our minimum criteria for successful implementation, although the multi-channel approach, which equals a higher dose, might prove more effective in reaching employees and influencing their behaviour [39]. Second, our fidelity ratings reflect both absolute implementation performance and performance relative to the site-specific implementation plans. This entails that equal performance sites with ambitious plans (e.g., several new products to worksite cafeterias) could receive poorer grades than sites with less ambitious plans (e.g., few new products to cafeterias).

4.1.3. Facilitators and Barriers of Implementation

Our qualitative analysis indicated that successful implementation requires adjusting and integrating the intervention into the values, ongoing activities, and resources of the organisation; careful planning and resourcing; as well as a management that supports and actively engages in the implementation. These findings cohere with the results of prior workplace health promotion interventions [39,75], choice architecture studies in pharmacy [33] and retail settings [32], and intervention studies from other fields [41]. In addition, the results reflect the normalisation process theory (NPT) [76,77] and the diffusion of innovations theory (DIT) [78], which support understanding of how new practices become adopted and routinely embedded in social systems. According to both these theories, the compatibility of the intervention with the values, goals, and operations of the organisation is crucial for adoption [76,78]. This entails that while targeting generic choice architectures, such as workplace cafeterias or coffee rooms, and while employing strategies generally relevant for and applicable to these choice architectures, some level of contextualisation is often necessary for effective implementation. Fortunately, literature suggests that contextualisation and fidelity can coexist, given that interventions preserve their essential elements [41,49].

Related to our findings on careful planning, resourcing, and management support, NPT highlights the willingness and commitment of actors involved in the implementation to invest efforts in defining, organising, resourcing, and enacting needed procedures

through *cognitive participation* and *collective action* [76,77]. We attempted to support such involvement by designing the intervention in collaboration with the participating worksites. Research suggests that shared decision making, which involves non-hierarchical relationships, mutual trust, and open communication between involved partners, is associated with superior and sustained implementation [39,41]. Shared decision making also reflects the interactive systems framework for dissemination and implementation (ISF), which emphasises the need for collaboration and two-way interaction between stakeholders involved in bridging research and practice [79].

Regarding the intervention, we found key facilitators to involve the perceived utility of the intervention to the implementer, as well as perceived ease of maintenance, reach, and effects. These facilitators align with DIT, which postulates that a rapid adoption requires perceiving the practice as relatively advantageous, easy to implement, and effective [78]. Similarly, literature reviews on implementation research have identified perceived benefits, ease, and effects to facilitate implementation [39,75]. Our results indicated, however, that strategies requiring regular maintenance might feel burdensome in the beginning—even with relatively effortless to implement strategies. This finding is unsurprising because remembering new tasks demands conscious effort [80–82]. Paradoxically, achieving choice architectures that guide healthy behaviours automatically requires the choice architects to learn new implementation-related routines and hence change their own behaviour deliberately. Providing stronger support for the implementers in the early phases of the intervention might thus be beneficial to enhance implementers' action-control skills needed for intervention maintenance [82]. In following what some of our implementers intuitively did and what research around implementation intentions and habit formation suggest [81–86], implementers could be guided to make detailed plans on integrating implementation tasks into existing routines at the workplace, and to create contextual cues—or choice architectures—that automatically guide them to perform these tasks. Additionally, to further promote habit formation, implementers could be encouraged to perform implementation tasks consistently and regularly [82,84].

Besides providing guidance for forming the implementation into a routine, our data speak for the necessity of a more comprehensive implementer training. The training should ensure everyone involved—including individuals that join the process later—understands the rationale, purpose, and significance of the intervention, how the intervention is assumed to work, and the tasks each implementer is expected to complete. As for the significance, the training should help implementers see the relevance of the intervention for themselves, their work community, and the organisation. Evidence suggests that increased understanding can strengthen motivation [82] and result in improved implementation [41]. Otherwise, implementers may find the intervention personally insignificant, as occurred at some of our intervention sites. Regarding the logic behind expected effects, training implementers—or choice architects—should emphasise the importance of timely and accurate delivery. Choice architecture interventions play with details, and slightly wrong timing or non-optimal placement may make otherwise effective strategies lose their power to guide peoples' choices for the better [19]. This entails that choice architects need to learn to observe and enhance the choice environment to achieve and maintain a set-up that is capable of triggering healthier behaviours. In terms of implementation tasks, our data pointed out that the training should encourage implementers not to give up if they fail to observe immediate effects. Effects might remain undetected if the intervention works for certain individuals during certain time periods or in specific contexts [87], or if the effects manifest with some delay, as typically happens with priming [88,89]. Overall, the above remarks on knowledge-building reflect the NPT construct coherence, which involves building a shared understanding of the aims, value, importance, and benefits of a new practice, as well as the tasks and responsibilities of everyone involved [76,77]. Similarly, prior implementation research stresses the importance of implementer capacity [39,41], and notes that besides information, implementer training should involve practical on-site coaching [79].

In terms of the implementer, our results suggest that implementation benefits from committed, motivated, inspirational, and organised implementers with job substance, duties, and schedules to which the implementation fits. Similarly, DIT acknowledges the role of influential implementers, or opinion leaders, that resemble other members of the community and act as social models [78]. Such "champions" have the respect of the personnel and can help orchestrate interventions from their adoption to maintenance [41]. The characteristic of being organised relates to the above-discussed skills to reinforce habit formation [82]. Compatibility with work, in turn, replicates results of earlier studies [39].

Our findings indicate that informing personnel of the intervention could facilitate implementation through enhanced employee acceptance. This finding aligns with the results of an interview study on consumer acceptance of nudging, which concluded that increasing consumer awareness and comprehension of nudged decision-making contexts predicts higher acceptability [90]. Fortunately, emerging evidence suggests such informing might not compromise intervention effectiveness [91]. Linking back to the above remarks on the importance of shared decision making and collaboration among all involved parties, this finding on openness raises the question, who do we think the choice architects are, and who should they be? In this work, the researchers and the coordinators and implementers of intervention sites acted as choice architects. Future studies could nevertheless consider broadening this perspective. Besides informing employees of implemented strategies, studies could involve employees in designing these strategies. Such an inclusive approach could enhance the ownership, commitment to, and acceptance of interventions on all levels of organisations; thus facilitating improved and sustained implementation. The shared ownership and understanding of implemented strategies could also enable a shared responsibility of maintaining the commonly constructed choice architecture, further supporting fidelity and maintenance.

4.2. Strenghts and Limitations

The strengths of this work include the way that the study bridges theory, scientific evidence, and empirical experiences from stakeholders in the field to a practical, adaptable, and workplace-centred intervention approach for real-world circumstances. In collaboration with participating worksites, intervention content and implementation were contextualised and integrated into the activities of each site, aiming to cause minimal disruption to site operations. This co-creative and contextualised approach was expected to improve implementation quality and reflect better long-term maintenance, as literature [20,39,41,49], the normalisation process theory [76,77], the diffusion of innovations theory [78], and the interactive systems framework [79] suggest. Further strengths include the large and heterogeneous study sample, as well as the systematic, mixed-methods analysis of implementation. This analysis enables us to examine the association between implementation and intervention effectiveness [43], variables that prior research has found to be positively correlated [39,41].

The study has its limitations as well. First, the majority of implemented practical strategies were launched by few intervention sites only. The feasibility evaluation of these strategies is thus limited to a small number of cases, reducing the representativeness of observed findings. Second, although our fidelity evaluation excluded cases with too little data for reliable assessment, some ratings nevertheless build on relatively limited data on intervention delivery. Such less comprehensive data pertain particularly to sites to which we had no direct contact. Consequently, the results warrant cautious interpretation. Third, our implementation and feasibility evaluation were limited to select indicators: applicability to diverse worksites, ease of implementation, required purchases, dose delivered, quality of implementation, and maintenance. Intervention evaluation frameworks, however, feature other elements as well, including intervention adoption [42,92]; design, protocol, and implementer training [44,45,47]; intervention reach [42,92], as well as receipt and participant enactment [44,47]. We omitted the evaluation of intervention design, protocol, adoption (i.e., proportion of sites adopting the intervention), and implementer training

due to limited resources and space. Yet, we have reported on and discussed these domains in the manuscript. Intervention receipt, which reflects the extent to which study subjects demonstrate knowledge and skills acquired in the intervention [47], was excluded from the analysis because choice architectural interventions do not rely on education and knowledge acquisition [18,30]. Reach refers to the proportion of the target audience that is aware of the intervention [39], and participant enactment implies whether study subjects apply skills learned in the intervention in their daily lives [47]. We consider these dimensions to reflect intervention effects, which we will report elsewhere.

4.3. Implications for Practice and Research

The choice architecture of living environments substantially influences dietary behaviour and physical activity. Efforts are hence needed to develop choice architectures that are conducive to healthier behaviours. Workplaces provide one suitable setting for such efforts. The hands-on instrument developed in this study, the StopDia Toolkit for Creating Healthy Working Environments, portrays a broad selection of practical, evidence-based, fairly effortless, and inexpensive choice architectural strategies for several generic settings in the workplace. For effective implementation, we recommend adapting the strategies to local contexts and considering the facilitators and barriers detailed in this paper. To build necessary capacity for implementation, organisations typically need support from external partners [41,79], such as the research team in the current study. In future, occupational wellbeing and health service providers or other organisations working for occupational and public health could be apt partners for providing the support. Moreover, although this study focused on workplaces, its contribution could benefit other real-world settings as well, such as schools, grocery shops, and catering services. Future research is needed to confirm our findings and to increase understanding of, inter alia, the following topics: (1) the effects, (2) the association between implementation and effects, (3) the acceptance, (4) the full implementation costs, and (5) the relationship between costs and effects of choice architecture interventions implemented in real-world settings.

5. Conclusions

Our findings suggest that a broad range of choice architectural strategies for healthier dietary choices and physical activity are applicable to diverse workplaces. These strategies fit generic workplace choice architectures, but tailoring to local contexts, i.e., contextualisation, improves their feasibility and implementation. Collaboration with intervention sites is thus recommended when designing real-world implementation; considering the characteristics of the organisation, intervention, worksite environment, and implementer. Sufficient training and support for implementers, as well as management support appear important for sustained and high-quality implementation.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/nu13103592/s1, Table S1: Toolkit for Creating Healthy Working Environments, Table S2: Implementation quality assessment framework.

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Supplementary material 1.

Toolkit for Creating Healthy Working Environments

This supplementary material portrays 1) the aims and evidence base and 2) the structure and content of the *StopDia Toolkit for Creating Healthy Working Environments*.

1. Aims and evidence base

The Toolkit comprises practical strategies for modifying physical and social working environments to facilitate healthier choices and the performance of small, healthy acts at the workplace within daily work tasks. The Toolkit applies dietary and physical activity recommendations, scientific literature, empirical knowledge from workplaces, and practical considerations relevant for the workplace setting.

The aim of the Toolkit is to support dietary and physical activity patterns recommended for promoting health and preventing non-communicable diseases and related risk factors [1–4] (**Table 1**).

Table 1. Aims of the Toolkit.

Higher level aim	Lower level aim
Healthy food choices ↑	Consumption of vegetables, fruit, berries, plain nuts, almonds, seeds ↑
	Drinking water ↑
	Drinking sugary beverages ↓
Regular meal pattern ↑	Having lunch or other main meal during a work shift ↑
	Having healthy snacks ↑
Physical activity ↑	Time spent sitting ↓
Sedentary behaviour ↓	Time spent standing ↑
	Amount of steps taken ↑
	Use of stairs ↑
	Short exercise bursts ↑
Recovery from work ↑	Taking breaks ↑

↑ = increases/strengthens, ↓ = decreases

The strategies of the Toolkit, their core components, and/or the mechanisms whereby they affect behaviour have proved effective in earlier scientific research. On a theoretical level, the Toolkit relies on the dual process theories of cognition, which assume that two types of cognitive processes, automatic and reflective, regulate decision-making and behaviour [5,6]. Striving to promote healthy behaviours, the Toolkit applies the nudge [7,8] and choice architecture [7,9] approaches. The idea of these approaches is to alter the choice architecture, i.e. the placement, presentation, arrangement, and properties of available choice options in the context or environment in which choices are made and the target behaviour takes place [7–9]. The core aim of nudge and choice architecture interventions is to facilitate choices and behaviours that serve the chooser's best interest, without limiting freedom of choice, significantly changing financial or other incentives, and relying on the provision of factual information or rational argumentation [7,8].

The Toolkit strategies employ numerous behaviour change mechanisms known to influence behaviour predominantly through automatic cognitive processes. The strategies were defined following three frameworks that support the application of these behavioural insights: TIPPME [10], MINDSPACE [11], and EAST [12]. The TIPPME Typology of Interventions in Proximal Physical Micro-Environments defines six intervention types and three spatial intervention foci; forming altogether 18 intervention categories [10]. The TIPPME interventions alter the placement (i.e. availability or position) or properties (i.e. functionality, presentation, size, or information) of objects and stimuli within small-scale micro-environments, targeting either products, product-related objects, or the wider environment [10]. The MINDSPACE [11] and EAST [12] frameworks serve as mnemonics and comprise nine and four behavioural approaches, respectively. The approaches of MINDSPACE are messenger, incentives, norms, defaults, salience, priming, affect, commitment, and ego. The approaches of EAST are easy, attractive, social, and timely.

Besides scientific literature, the strategies of the Toolkit consider interventions already executed at workplaces as well as the needs for and the challenges of workplace health promotion. These empirical data were collected during the development phase of the StopDia at Work intervention in stakeholder workshops (n = 4) and individual interviews (n = 23) involving representatives from 31 organisations. Finally, regarding

practical considerations, the strategies included in the Toolkit ought to be relevant for the workplace setting, applicable to various worksite environments, accessible to all employees of a workplace, and inexpensive and effortless as possible to implement and maintain.

2. Structure and content

Table 2 presents the practical strategies of the Toolkit, including suitable settings, ease of implementation, required purchases, applied behaviour change mechanisms, expected effects, and references to supporting evidence. The following paragraphs define the key concepts of the Toolkit.

2.1 Ease of implementation

Ease of implementation reflects the amount of knowledge and/or effort required to maintain a strategy after its launch on a tripartite scale: easy, moderate, and demanding. Easy-to-implement strategies require little specialised knowledge and besides occasional check-ups no maintenance after launch. Examples of such strategies are laying out posters and introducing new equipment or furniture. Moderate-to-implement strategies require some knowledge on correct implementation and light maintenance on a regular basis. Examples of such strategies are maintaining exercise equipment in pre-defined places, running a campaign that requires regular delivery of materials, and creating a social norm by reminding of a new, commonly agreed practice. Demanding-to-implement strategies require more specialised knowledge on correct implementation and daily maintenance. Examples of such strategies are the use of nutritional labels and placement of healthier foods in workplace cafeterias.

2.2 Required purchases

Required purchases suggestively indicate the extent to which implementation requires the procurement of new materials, goods, or services on a tripartite scale: none, minor, and substantial. None refers to strategies that require no procuring. Minor purchases refer to relatively inexpensive goods, such as gym sticks or water bottles, and substantial purchases to relatively expensive goods such as new furniture. Costs of purchases depend, however, on the price category of procured items and intervention dose delivered; for example, whether height-adjustable desks are provided for all employees or to common work environments only, or whether employees are provided fresh fruit every day or only once a week.

2.3 Behaviour change mechanisms

Behaviour change mechanisms portray how the Toolkit strategies can trigger changes in behaviour, and follow the above-described frameworks of TIPPME [10], MINDSPACE [11], and EAST [12].

2.4 Expected effects

Expected effects illustrate rough estimates of effect sizes on a tripartite scale: small, medium, and large. These estimates follow the findings and categorisation of a recent meta-analysis [13] that grouped nutrition-related nudge interventions into three categories: cognitively, affectively, and behaviourally oriented interventions. Cognitively oriented strategies influence primarily what people know, affectively oriented strategies how people feel, and behaviourally oriented strategies what people do. The meta-analysis found affectively oriented interventions more effective than cognitively oriented interventions, and behaviourally oriented interventions more effective than cognitively and affectively oriented interventions [13].

2.5 Healthy options

In this work, healthy options refer to food products, meals, and recipes that meet the nutritional criteria of the Heart Symbol*, the nutritional labelling system of the Finnish Heart Association and the Finnish Diabetes Association (https://www.sydanmerkki.fi/en/). Energy-free beverages, such as water, coffee, and tea count as healthy as well. The Heart Symbol is a nutritional claim according to EU regulation on nutrition and health claims made on foods (EC N° 1924/2006). A Heart Symbol-product represents nutritionally better a choice within its product category and meets category-specific criteria regarding fat (quantity and quality), salt, sugar, and fibre. These criteria build on the Finnish nutrition recommendations [2].

* The Heart Symbol. Image reproduced and used with the permission of The Finnish Heart Association.

Table 2. The StopDia Toolkit for Creating Healthy Working Environments.

Target		Practical strategy	Workplace setting	Ease of implementation	Required purchases	Behaviour change mechanism [1]	Expected effect	Reference
Nutrition		*Food provision*						
	1.	Enable healthy food and beverage choices by making them available at the workplace.	Cafeteria, vending machines, coffee rooms, events	Moderate	Minor	Product availability ↑ [T]	Small	[14]
	2.	Widen the selection and proportion of healthy food and beverage options available at the workplace.	Cafeteria, vending machines, events	Moderate	Minor	Product availability ↑ [T] Attractive (salience ↑) [M,E]	Small	[14–19]
	3.	Replace energy dense and nutritionally poor food and beverage options with similar but nutritionally better alternatives.	Cafeteria, vending machines, coffee rooms, events	Moderate	Minor	Product availability ↑[T] Easy (substitution, default) [E]	Large	[14]
	4.	Introduce snack spots in which healthy snacks and beverages are available for employees.	Common work environments	Moderate	Minor	Product availability ↑ [T]	Small	[14,15,20,21]
	5.	Place healthy options according to the following principles: a.) on visible, easily noticeable spots b.) at the beginning of the buffet c.) closer to the chooser (e.g., in front row) d.) in the middle of the tray, shelf, or showcase	Cafeteria, vending machines, events	Demanding	None	Product position [T] Easy (friction costs ↓) [E] Attractive (salience ↑) [M, E]	Small	[14,17,21–27]
	6.	Place less healthy options according to the following principles: a.) on less visible and easily noticeable spots b.) at the end of the buffet c.) further away from the chooser (e.g., in back row) d.) on the edge of the tray, shelf, or showcase	Cafeteria, vending machines, events	Demanding	None	Product position [T] Less easy (friction costs ↑) [E] Less attractive (salience ↓) [M,E]	Small	[14,17,21–27]
	7.	Place healthy options first on menus.	Cafeteria	Moderate	None	Related object position [T] Easy (ordering effect) [E] Attractive (salience ↑) [M,E]	Small	[14,28,29]
	8.	To avoid constant "grazing" at workplace events such as meetings, place provided foods and beverages so that accessing them requires standing up and taking a couple of steps.	Events	Moderate	None	Product position [T] Less easy (friction costs ↑, default) [M,E]	Large	[14,21]
	9.	To increase convenience, serve fruit and vegetable ready to eat, i.e., washed, peeled if needed, and cut into pieces.	Cafeteria, coffee rooms, events	Demanding	None	Product functionality [T] Easy (friction costs ↓) [E]	Large	[13,30]
	10.	To increase perceived variety and encourage greater consumption, serve various fruit and vegetable varieties from separate serving dishes instead of mixing them together.	Cafeteria, coffee rooms, events	Moderate	None	Product presentation [T] Attractive (salience ↑) [M ,E]	Small	[22]
	11.	Serve healthy options, such as fruit and vegetable temptingly using attractive displays and serving dishes.	Cafeteria, coffee rooms, events	Moderate	None	Product and related object presentation [T] Attractive (salience ↑) [M,E]	Medium	[13,31]
	12.	Guide employees to healthy options with bright-coloured directional signs, such as footprints, tapes, or arrows on the floor or walls.	Cafeteria	Easy	Minor	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M,E]	Small	[27]
	13.	Light healthy options brightly.	Cafeteria	Easy	Substantial	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M,E]	Small	[32,33]

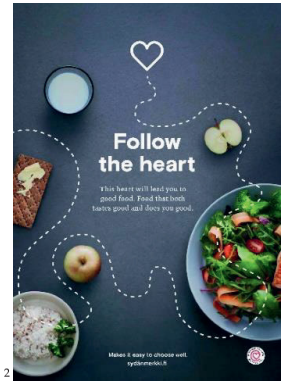
Target	Practical strategy	Workplace setting	Ease of implementation	Required purchases	Behaviour change mechanism [1]	Expected effect	Reference
	14. Where unhealthy foods and beverages are served, use reflecting surfaces such as mirrors to strengthen employee self-awareness.	Cafeteria, vending machines	Easy	Substantial	Atmospheric properties of the wider environment [T] Ego (maintain positive self-image) [M]	Small	[34,35]
	15. Use larger serving dishes for fruit and vegetable.	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	16. Use smaller serving dishes for less healthy options.	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	17. Use larger plates for salad.	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	18. Use smaller plates and bowls for main courses and desserts	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	19. User larger tongs and spoons for fruit and vegetable	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,26,36]
	20. Use smaller tongs and spoons for less healthy options	Cafeteria, events	Moderate	None	Product size [T] Less easy (default) [M,E]	Large	[13,26,36]
	21. Use larger serving sizes for fruit and vegetables	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	22. Use smaller serving sizes for less healthy options	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,30,36]
	23. Adopt a "one plate-policy" at workplace cafeteria; move separate bread and salad plates out of sight to guide employees choose one large plate; thus facilitating the composition of the meal according to the plate model (i.e., 1/2 vegetable, 1/4 protein, and 1/4 carbohydrates). For the strategy to be effective, salads should be placed first in the buffet line.	Cafeteria	Easy	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	24. Indicate healthy options with the Heart Symbol on menus and at the point-of-choice.	Cafeteria, vending machines	Demanding	Minor	Information on related objects [T] Attractive (salience ↑) [M,E] Timely (prompting) [E] Easy (simplification) [E]	Small	[13,23–25,27,37–39]
	25. Use *Follow the heart*-posters [2] at restaurant entrance and/or at the beginning of the buffet to guide customers notice and choose options labelled with the Heart Symbol.	Cafeteria	Easy	None	Information within the wider environment [T] Attractive (salience ↑) [M,E] Timely (priming) [M,E]	Small	[27,39]
	26. Name healthy options temptingly, for example, describing their taste, texture, or look.	Cafeteria	Moderate	None	Information on related objects [T] Attractive (salience ↑) [M,E] Affect [M] Timely (priming) [M,E]	Medium	[13,40,41]
	Drinking water						
	27. Use larger glasses for water.	Cafeteria, events	Moderate	None	Product size [T] Easy (default) [M,E]	Large	[13,36]
	28. Provide personal, reusable water bottles or mugs for all employees to facilitate and remind of drinking water.	Personal workstation	Easy	Minor	Related object availability ↑ [T] Easy (friction costs ↓) [E]	Small	[21,42]

Target		Practical strategy	Workplace setting	Ease of implementation	Required purchases	Behaviour change mechanism [1]	Expected effect	Reference
	29.	Place water coolers or pitchers and water glasses on easily noticeable spots at the workplace, for example, along common passing routes or where employees typically pause for a moment.	Common work environments	Demanding	Minor	Product and related object availability ↑ [T] Attractive (salience ↑) [M,E]	Small	[14,23,24,42]
		Packed lunches and snacks						
	30.	Promote and share temptingly named, visually attractive, and seasonal *StopDia Packed Lunch of the Week*-recipes [3] at workplace coffee rooms and/or via electronic channels, such as info-screens, company intranet, and newsletters. The campaign comprises one recipe for each week of the year, and all recipes meet the nutritional criteria of the Heart Symbol.	Coffee rooms	Moderate	None	Easy (friction costs ↓, chunking) [E] Attractive (salience ↑) [M,E] Social (descriptive norm) [M,E] Timely (priming) [M,E] Affect [M]	Small	[13,41,43]
	31.	Promote and provide employees the *Fruit Crew*-starting kit [4] that facilitates colleagues to found a fruit circle and consequently have fresh fruit available at the workplace.	Coffee rooms	Easy	None	Social (network nudge, commitment contracts, descriptive norm, reciprocity) [M,E] Attractive (gamification, salience ↑) [M,E] Timely (implementation intentions) [E]	Small	[13,43–45]
	32.	Make cold storage of packed lunches possible for travelling employees, for example, by providing a cool bag, thus facilitating healthy meals, maintenance of a regular meal pattern, and enjoying packed lunches fresh while travelling.	Personal workstation	Easy	Minor	Related object availability ↑ [T] Easy (friction costs ↓) [E]	Small	[46,47]
Physical activity		***Time spent sitting***						
	33.	Introduce height-adjustable desks to enable working by standing.	Personal and common work environments	Easy	Substantial	Product availability [T] Easy (friction costs ↓) [E]	Small	[48,49]
	34.	Make working by standing the default option, for example, by commonly agreeing on a practice of leaving height-adjustable desks in the upper position at the end of the workday.	Common work environments	Moderate	None	Easy (default) [M,E] Social norm [M,E]	Large	[13,50,51]
	35.	Introduce alternative seats, such as therapy balls, saddle or wobble chairs, or balance cushions to enable active sitting.	Personal and common work environments	Easy	Substantial	Product availability [T] Easy (friction costs ↓) [E]	Small	[48,49,52]
	36.	Make active sitting the default option by placing available alternative seats, such as therapy balls, saddle or wobble chairs, or balance cushions in front of workstations.	Common work environments	Moderate	None	Easy (default) [M,E]	Large	[13,50]
	37.	Enable physical activity during meetings by 1) arranging enough room for standing up, moving around, and stretching; and 2) introducing height-adjustable desks, alternative seats (e.g., therapy balls, saddle or wobble chairs, exercise bikes, or balance cushions), and pads or wheels under chair feet so that moving chairs and standing up can be done silently without disturbance.	Meeting rooms	Easy	1) None 2) Substantial	Product and wider environment availability [T] Easy (friction costs ↓) [E]	Small	[48,49,52]
	38.	Create “walking meeting” as a meeting option in online calendars. By booking, the system could suggest an appropriate-length walking route near the workplace.	Personal workstation	Easy	Substantial	Product availability [T] Easy (friction costs ↓) [E] Timely (prompting) [E] Ego (maintain positive self-image) [M]	Small	[48,49]

Target		Practical strategy	Workplace setting	Ease of implementation	Required purchases	Behaviour change mechanism [1]	Expected effect	Reference
	39.	Replace personal printers with shared copy machines, or move personal printers from within reach to a distance that requires standing up and taking a few steps.	Common work environments	Easy	Substantial (or none)	Product position [T] Easy (default) [M,E]	Large	[13,48,49,53]
	40.	Make physical activity a social norm. While opening the meeting, the chairperson encourages everyone to stand up, walk, and take break exercise whenever they feel like it, and follows the given recommendations him-/herself.	Meetings	Moderate	None	Social norm [M,E] Timely (prompting) [E]	Medium	[43,53,54]
	41.	Commonly agree on an organisational practice of walking to talk to colleagues instead of calling or sending e-mail.	All work environments	Moderate	None	Social norm [M,E]	Medium	[43,48,53]
		Stair use						
	42.	Keep stairwell doors open for easy access.	Stairs	Easy	None	Product functionality [T] Easy (friction costs ↓) [E] Attractive (salience ↑) [M,E]	Small	[55]
	43.	Slow down elevator doors or the elevator itself to encourage choosing the stairs.	Elevator	Easy	Minor	Product functionality [T] Easy (friction costs ↓) [E]	Large	[56]
	44.	Enhance stairwell visibility with motivational and/or directional signs, for example, footprints on the floor leading to stairs from the point-of-choice between the stairs and the elevator or escalator.	Elevator, escalator, stairs	Easy	Minor	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M,E] Timely (prompting) [E]	Small	[52,55,57–60]
	45.	Enhance stairwell attractiveness with, for example, decoration, artwork, plants, or lighting.	Stairs	Easy	Minor	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M,E] Affect [M]	Medium	[55,57,59–61]
	46.	Create an attractive sound scape in the stairwell, for example, with calming nature sounds (e.g., ocean waves or rain) or pleasant music.	Stairs	Moderate	Substantial	Atmospheric properties of the wider environment [T] Attractive (salience ↑) [M,E] Affect [2]	Medium	[57,62]
	47.	Introduce a captivating message, such as a story, a riddle, or a poem that leads to the stairs from the point-of-choice between the stairs and the elevator or escalator.	Elevator, escalator, stairs	Easy	Minor	Timely (prompting) [E] Attractive (salience ↑) [M,E] Affect [2]	Small	[57,61]
	48.	Place stickers with the StopDia project logo [5] on elevator doors, next to the call buttons, or in their immediacy.	Elevator	Easy	Minor	Timely (prompting) [E]	Small	[57,60]
		Movement breaks						
	49.	Place StopDia *Flex!*-movement posters [6] on salient spots where employees typically pause for a moment and have the opportunity to perform a movement or two. Such spots can be, for example, by copy machines, micros, or coffee makers.	Common work environments	Easy	None	Timely (prompting) [E] Attractive (salience ↑) [M,E] Easy (chunking) [E]	Small	[43,48,63–69]
	50.	Provide light exercise equipment, such as gym sticks, balance boards, or hanging bars for employees to use.	Common work environments	Easy	Minor	Product availability [T] Easy (friction costs ↓) [E]	Small	[35,49]
	51.	Place available exercise equipment on salient spots where employees typically pause for a moment, and an opportunity for a short exercise break occurs. Such spots can be, for example, by copy machines, micros, kettles, or coffee makers.	Common work environments	Moderate	None	Timely (prompting) [E] Attractive (salience ↑) [M,E]	Small	[35]

Target		Practical strategy	Workplace setting	Ease of implementation	Required purchases	Behaviour change mechanism [1]	Expected effect	Reference
	52.	Introduce an application that prompts employees to stand up, walk, or take short exercise breaks at pre-set intervals, for example, once every 1–2 hours.	Personal workstation	Easy	Minor	Timely (prompting) [E]	Small	[48,70–74]
Recovery from work		*Recovery*						
	53.	Introduce a silent space dedicated for relaxation and recovery from work.	Common work environments	Easy	None	Wider environment availability [T]	Small	[75]

[1] Behaviour change mechanisms: T = TIPPME [10], M = MINDSPACE [11], E = EAST [12]; ↑ = increase, ↓ = decrease



2

3

[2] *Follow the heart*-poster saying: "This heart will lead you to good food. Food that both tastes good and does you good." (sizes A4 and A3). Image reproduced and used with the permission of The Finnish Heart Association.

[3] StopDia Packed Lunch of the Week-materials: campaign poster (size A2), 52 various recipes (printed recipe card size 210 x 120 mm), and a cardboard stand for the recipe cards (width 285 mm, height 280 mm). The poster and the recipes were available in printed and/or electronic format. The poster and the stand featured a slogan that encouraged making a habit of enjoying a good packed lunch on a break, and a rhyme that prompted to pick up a recipe card, stop by the store, and prepare, pack, and grab the packed lunch.

[4] StopDia Fruit Crew-materials: a poster asking "Have you joined a fruit crew already?" (size A2), instructions and enrolment form (size A4, two-sided), and a recyclable cardboard box for fruit. The poster was available in printed and/or electronic format.

[5] The StopDia-logo (sticker size 105 x 150 mm)

[6] StopDia *Flex!*-movement pictures available in printed (sizes A6, A5, and A4) and/or electronic format.

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Supplementary material 2

Framework for assessing the quality of implementation in the StopDia at Work intervention

Table 1. Implementation quality assessment framework with implementation settings, implemented strategies, and essential elements of and evaluation scale for each strategy.

Target	Setting	Practical strategy	Essential element	Implementation quality		
				Successful (2 p)	**Imperfect (1 p)**	**Failed (0 p)**
Nutrition	***Food provision***					
	Meetings	1. Enable healthy choices	Healthy foods and beverages are available.	Healthy options are available by rule or frequently.	Healthy options are available occasionally.	No healthy options are available.
	Cafeteria	2. Widen selection	More options become available in the cafeteria that meet the nutritional criteria of the Heart Symbol.	The offering broadens with all or most of the agreed products, and these products are available most of the time.	The offering broadens with some but not all agreed products and/or the agreed products are available only occasionally.	The offering does not broaden with new Heart Symbol products.
	Meetings	3. Replace with better alternatives	Energy dense and nutritionally poor foods and beverages are replaced with nutritionally better options.	Healthier options replace unhealthy options by rule or frequently.	Healthier options replace unhealthy options occasionally.	Healthier options do not replace unhealthy options.
	Cafeteria	4. Increase visibility and proximity	Options that meet the nutritional criteria of the Heart Symbol are easy to notice and access.	All or most of the agreed changes to product placement materialise most of the time.	Some but not all agreed changes to product placement materialise and/or the changes materialise only occasionally.	Agreed changes to product placement do not materialise.
		5. Decrease visibility and proximity	Less healthy options are less easy to notice and access.	All or most of the agreed changes to product placement materialise most of the time.	Some but not all agreed changes to product placement materialise and/or the changes materialise only occasionally.	Agreed changes to product placement do not materialise.
	Meetings	6. Increase convenience	Fruit and vegetable are served ready to eat.	Fruit and vegetable are served ready to eat by rule or frequently.	Fruit and vegetable are served ready to eat occasionally.	Fruit and vegetable are not served ready to eat.
	Cafeteria	7. Increase perceived variety	Salad components are not mixed but available in separate serving dishes.	Salad components are available in separate serving dishes mostly as planned.	Salad components are available in separate serving dishes only occasionally.	Salad components are not available in separate serving dishes.
		8. Use smaller serving dishes	Less healthy food options are available in smaller serving dishes.	Agreed options are available in smaller serving dishes mostly as planned.	Agreed options are available in smaller serving dishes only occasionally.	Agreed options are not available in smaller serving dishes.
		9. Use smaller serving utensils	Less healthy food options have smaller serving utensils.	Agreed options have smaller serving utensils.	Some but not all agreed options have smaller serving utensils and/or the options have smaller utensils only occasionally.	Agreed options do not have smaller serving utensils.

Target	Setting	Practical strategy	Essential element	Implementation quality		
				Successful (2 p)	**Imperfect (1 p)**	**Failed (0 p)**
	Meetings	10. Use smaller serving sizes	Energy dense and nutritionally poor foods and beverages are available in smaller servings.	Unhealthy options are available in smaller servings by rule or frequently.	Unhealthy options are available in smaller servings occasionally.	Unhealthy options are not available in smaller servings.
	Cafeteria	11. One plate-policy	Separate bread and salad plates are moved out of sight to guide employees choose one large plate for lunch.	Separate bread and salad plates are out of sight most of the time.	Separate bread and salad plates are out of sight only occasionally.	Separate bread and salad plates are in sight.
		12. Point-of-choice prompts	The Heart Symbol adjoins and indicates products that meet its nutritional criteria.	Heart Symbol labels are in use and placed correctly most of the time.	Heart Symbol labels are in use and/or placed correctly only occasionally.	Heart Symbol labels are not in use or they are placed incorrectly.
		13. Prime for better choices	Follow the heart-posters are saliently on view at restaurant entrance and/or at the beginning of the buffet.	Follow the heart-posters are on view as planned.	Follow the heart-posters are on view but not as planned.	Follow the heart-posters are not on view.
	Drinking water					
	Personal workstation	14. Facilitate and remind of drinking water	Employees receive personal, reusable water bottles.	Each employee received a water bottle.	Not every employee received a water bottle.	No employee received a water bottle.
	Packed lunches and snacks					
	Coffee rooms	15. Encourage smart packed lunches	Packed Lunch of the Week-recipes are saliently on view and easily accessible to all employees, and the recipes change regularly.	The recipes are easily noticeable and change mostly every 1-2 weeks, except during holidays. Print recipe cards are on display in their cardboard stands or spread, for example, on coffee room table.	• The recipes are not on view or are not easily noticeable. • The recipes change only occasionally. • All recipes of the year are mixed up, for example, in a cardboard box.	Implementation never took off or it ceased at an early phase of the intervention.
		16. Encourage provision of fruit at work.	Materials needed for founding a fruit crew (i.e., the A4-sized instructions/enrolment form and the fruit box) are saliently on view and easily accessible to all employees.	Both the instructions/enrolment form and the fruit box are easily noticeable. Alternatively, the employer provides fruit to employees and dedicated employees organize the fruit offering regularly.	• The instructions/enrolment form is on view with or without the A2-sized campaign poster, but the fruit box is missing. • The fruit box and the A2-sized campaign poster are on view, but the instructions/enrolment form is missing. • The materials are not easily noticeable.	• Only the A2-sized poster or the fruit box is on view. • The materials were never on view as planned or they were taken away at an early phase of the intervention.
Physical activity	***Time spent sitting***					
	Common environments	17. Enable active sitting	Wobble chairs or balance cushions are available and enable more active sitting.	Wobble chairs or balance cushions are available to all employees.	Wobble chairs or balance cushions are available to some but not all employees.	Wobble chairs or balance cushions are not available.
	Stair use					

Target	Setting	Practical strategy	Essential element	Implementation quality		
				Successful (2 p)	**Imperfect (1 p)**	**Failed (0 p)**
	Elevator, stairs	18. Enhance stairwell visibility	Footprints saliently guide to stairwell from the point-of-choice between the stairs and the elevator.	Footprints are easily noticeable and placed correctly.	Footprints are not easily noticeable and/or placed incorrectly.	Footprints are not in use.
	Elevator	19. Prompt choosing the stairs	Stickers with the StopDia project logo are saliently on view on elevator doors, next to the call buttons, or in their immediacy.	The StopDia logos are easily noticeable and placed correctly.	The StopDia logos are not easily noticeable and/or placed incorrectly.	The StopDia logos are not in use.
	Movement breaks					
	Common environments	20. Prompt context-specific movement	Where employees pause and movement is possible, Flex!-movement posters are saliently on view. The posters reach all employees independent of where they work.	The posters are located as planned, easily noticeable, and accessible to all employees.	The posters are located where performing suggested movements is not possible, the posters are not easy to notice, and/or they are sparsely on view considering the size of the workplace.	The posters were not laid out or they were taken away at an early phase of the intervention.
		21. Enable movement with exercise equipment	Exercise equipment is available for employees to use.	Exercise equipment is available to all employees.	Exercise equipment is available to some but not all employees.	Exercise equipment is not available.
		22. Prompt movement with exercise equipment	Exercise equipment is saliently on view and easily accessible for all employees.	Exercise equipment is easily noticeable and accessible as planned. Additionally, the equipment can be accompanied with a corresponding Flex!-movement poster (see #20).	Exercise equipment has moved from its place, but is still available.	Exercise equipment is not available or placed completely out of sight, for example, in a cupboard.
	Personal workstation	23. Prompt movement with automatic reminders	Employees have access to an application that prompts to move at pre-set intervals.	The application is available to all employees.	The application is available to some but not all employees.	The application is available to no employee.

II

Acceptability of workplace choice architecture modification for healthy behaviours

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Acceptability of workplace choice architecture modification for healthy behaviours

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Abstract

Background Altering the choice architecture of decision contexts can assist behaviour change, but the acceptability of this approach has sparked debate. Considering hypothetical interventions, people generally welcome the approach for promoting health, but little evidence exists on acceptance in the real world. Furthermore, research has yet to explore the implementers' perspective, acknowledging the multidimensionality of the acceptability construct. Addressing these knowledge gaps, this study evaluated the acceptability of a quasi-experimental implementation-effectiveness trial that modified the worksite choice architecture for healthy eating and daily physical activity.

Methods Fifty-three worksites participated in the 12-month intervention and implemented altogether 23 choice architecture strategies (Mdn 3/site), including point-of-choice prompts and changes to choice availability or accessibility. Retrospective acceptability evaluation built on deductive qualitative content analysis of implementer interviews ($n=65$) and quantitative analysis of an employee questionnaire ($n=1124$). Qualitative analysis examined implementers' thoughts and observations of the intervention and its implementation, considering six domains of the Theoretical Framework of Acceptability: ethicality, affective attitude, burden, intervention coherence, opportunity costs, and perceived effectiveness. Quantitative analysis examined employees' acceptance (7-point Likert scale) of eight specific intervention strategies using Friedman test and mixed-effects logistic regression.

Results Implementers considered the choice architecture approach ethical for workplace health promotion, reported mostly positive affective attitudes to and little burden because of the intervention. Intervention coherence supported acceptance through increased interest in implementation, whereas low perceived utility and high intensity of implementation reduced cost acceptance. Perceived effectiveness was mixed and varied along factors related to the implementer, social/physical work environment, employer, and employee. Employees showed overall high acceptance of evaluated strategies (Mdn 7, IQR 6.4–7), though strategies replacing unhealthy foods with healthier alternatives appeared less supported than providing information or enhancing healthy option availability or accessibility (p-values <0.02). Greater proportion of male employees per site predicted lower overall acceptance (OR 4.4, 95% CI 1.2–16.5).

Conclusions Work communities appear to approve workplace choice architecture interventions for healthy eating and physical activity, but numerous factors influence acceptance and warrant consideration in future interventions.

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The study contributes with a theory-based, multidimensional evaluation that considered the perspectives of implementers and influenced individuals across heterogeneous real-world settings.

Keywords Acceptability, Choice architecture, Nudge, Workplace, Health promotion, Prevention, Type 2 diabetes

Background

Altering the choice architecture—the way available options are presented in behavioural contexts—is a subtle approach to "nudge" healthy behaviours without bans or substantial changes to incentives [1, 2]. The approach exploits people's sensitivity to contextual cues and tendency to invest little deliberation in everyday choices [3], such as those related to eating or daily physical activity. The approach is rooted in the dual-systems models that assume behaviour to result from the interplay of automatic and reflective processes [4], and in the evidence of cognitive biases and heuristics that may prevent rational behaviour [2, 5]. At the workplace, choice architectures conducive to healthy eating and physical activity can promote the wellbeing and health of the workforce, which benefits the employer and the society as well [6, 7].

Choice architecture interventions typically work by increasing the salience or attractiveness of healthy options, by reducing the effort required to choose such options, or by leveraging social norms [8]. Due to the subtleness of these interventions and ability to change behaviour without people being aware of their presence or influence on behaviour [9], the ethicality of the choice architecture approach has stimulated a lively debate [10, 11]. While choice architecture strategies in principle maintain targeted individuals' freedom of choice, in practice this freedom is questionable as the strategies target contexts where people typically fail to deliberate on their actions and to follow their reasoned preferences [10]. Hence, the intentional use of choice architecture strategies calls for careful consideration and responsibility, including comprehensive acceptability evaluation. Such evaluation reveals the approval of interventions among deliverers and receivers and facilitates the detection of factors that may influence implementation and effectiveness, hence supporting the interpretation of study outcomes and the development of enhanced interventions [12, 13].

Research on the acceptability of choice architecture interventions for healthy eating or daily physical activity relies predominantly on surveys that have examined public opinions on hypothetical interventions [14–27]. In these studies, the portrayed sources behind interventions have often been policymakers [14–20, 24, 27] but rarely employers [26] or related actors such as catering services [14, 21, 22]. Few studies have measured people's approval of interventions after they have experienced the interventions in the real world [28–31]. Acceptability has been evaluated from the perspective of influenced individuals [14–31], and evaluations have covered varying interventions, including ones that alter the availability [15, 20, 24, 27], visibility and accessibility [16–20, 23, 25, 26, 28, 29], or labelling of choice options [15–17, 19, 24–27], or that provide tips, leverage social norms, or encourage commitment [21, 22, 25]. Whether measured as the proportion of approving respondents or as the degree of respondents' approval, study participants have expressed overall support for evaluated interventions [14–31]. Acceptance appears to depend on various factors, however, including the type [15–21, 24, 26, 27], perceived effectiveness [14, 15, 18, 19], and intention of interventions [14, 16, 17, 23].

Henceforth, research on the acceptability of choice architecture interventions could start shifting focus from the public acceptance of hypothetical interventions towards the evaluation of real-world implementations, because predicted responses to imagined scenarios may not translate to interventions actually encountered [11]. Workplaces, in turn, merit more attention because the majority of working age population spends a substantial part of their time at work, making workplaces a suitable setting for health-promoting choice architecture interventions. Acceptability evaluations could also broaden their scope from the perspective of influenced individuals to that of the implementers who determine how interventions materialise. Moreover, besides commonly measured overall approval or beliefs about intervention effectiveness [14–31], studies could evaluate also other dimensions of acceptability. Acceptability has been defined as a multi-faceted construct that reflects the extent to which intervention deliverers or receivers consider the intervention appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention [13]. An accompanying framework, the Theoretical Framework of Acceptability (TFA), proposes seven key dimensions of acceptability: ethicality, affective attitude, burden, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy [13]. The framework has served the acceptability evaluation of various health-promotion programmes (e.g., [32, 33]), including choice architecture interventions [34].

To broaden our understanding of the acceptability of the choice architecture approach, we aimed to evaluate the acceptability of a choice architecture intervention for healthy eating and daily physical activity at the workplace. The work contributes with a theory-based, multidimensional evaluation that included the perspectives of implementers and influenced employees once they had experienced the intervention. Simultaneously, the work provides insights on the feasibility of upscaling a broad range of choice architecture strategies to heterogeneous worksites. Such insights are valuable, as the success in translating promising interventions from controlled behavioural labs [35] or realistic living labs [36] to real-world operations is not guaranteed [37].

Methods

Study design and setting

The acceptability evaluation built on data collected during a 12-month quasi-experimental hybrid type 2 implementation-effectiveness trial [38], "StopDia at Work", that was conducted between 2017 and 2019 in natural settings at workplaces in three regions of Finland (Northern Savo, South Carelia, and Päijät-Häme) [39]. The intervention promoted healthy dietary choices and daily physical activity with subtle modifications to the worksite choice architecture. The intervention was a part of a larger type 2 diabetes prevention study "StopDia" (Trial registration: NCT03156478) [40, 41] that was reviewed by the research ethics committee of the hospital district of Northern Savo (statement number: 467/2016, date of approval: 3 January 2017). The employees of intervention sites received general information on the StopDia study and the collaboration between their workplace and the study. However, the employees were not disclosed the specific aim of the StopDia at Work-intervention to alter the worksite choice architecture to promote healthy behaviours. This non-disclosure was to avoid interfering with employees' natural responses to the intervention.

Participating organisations

Sixteen organisations from various fields participated in the intervention with altogether 53 distinct worksites that employed in total 5100 employees (M 43% men) (Table 1). Ten of the organisations represented private sector and six public sector. Four organisations had worksite cafeterias that were involved in the intervention.

Intervention content and implementation

The content and implementation of the intervention were tailored to each worksite to fit local contexts (facilities, resources, and employees' needs concerning diet and physical activity), as detailed elsewhere [39]. Following bilateral dialogues between the research team and the participating organisations, intervention strategies were selected individually for each site from the StopDia Toolkit for creating health-promoting worksite environments [39]. The toolkit comprised evidence-based strategies that either altered the availability of healthy and/or

Table 1 Characteristics of participating organisations

Region[a]	Organisation[a]	Field of operation	Types of sites	n Sites	n Employees[b]	% Men
A	O1	Retail	Grocery	5	360	21
A	O2	Metal industry	Factory	1	600	80
A	O3	Forest industry	Factory[c]	1	950	78
B	O4	Retail	Grocery	3	300	20
B	O5	Higher education	University building	5	370	34
B	O6	Municipality	Bureau	1	70	29
B	O7	Chemical industry	Factory[c]	1	400	75
C	O8	Farming	Farm	1	140	35
C	O9	Municipality	Bureau	1	80	39
C	O10	Municipality	Bureau, kindergarten	3	250	32
C	O11	Construction industry	Construction yard, office	5	180	91
C	O12	Healthcare	Hospital department[c]	20	490	46
C	O13	Food industry	Factory	1	250	70
C	O14	Retail	Grocery	3	320	18
C	O15	Municipality	Bureau[c]	1	300	20
C	O16	Welfare	Welfare services centre	1	40	5

[a] Geographical regions and organisations are indicated with codes due to data protection

[b] Approximate number of employees exposed to the intervention

[c] Worksite cafeterias involved in the intervention

less healthy options or that redesigned the arrangement, properties, or presentation of already available opportunities. The content built on the nudge approach [1, 2], the dual-systems models [4], and frameworks that characterise diverse choice architecture interventions [42–44].

Each organisation had at least one member of their personnel involved in designing and delivering the intervention at their sites. While designing included the planning of the content and implementation of the intervention to the worksite, delivery included the launch of selected intervention strategies and sustaining them over the 12-month intervention. Depending on the organisation, the designers and the deliverers could be the same or different individuals. Either way, we consider both the designers and the deliverers the implementers of the intervention. The implementers could also change over the intervention year due to staff turnover at the participating organisations.

In total 23 choice architecture strategies were implemented across participating worksites, sixteen promoting healthy eating and seven physical activity (Table 2). The strategies applied numerous behaviour change mechanisms, including primes, prompts, and alterations to the availability, visibility, accessibility, convenience, or size of choice options. The median number of strategies intended to implement per site was three (range 2—14), a median of two (range 1—9) focusing on healthy eating and one (range 1—5) on physical activity. Except for one site, all sites also implemented at least one strategy. The three most often implemented strategies were a packed lunch recipe campaign (#15), a movement prompt strategy (#20), and a fruit crew-strategy (#16), respectively (Table 2, Fig. 1). Implementation settings comprised cafeterias, meetings, coffee rooms, common working areas, personal workstations, stairwells, and elevators. Participation was free of charge for the organisations, and the study provided intervention sites with materials for priming and prompting strategies, including posters, labels, and signs. If the sites chose to implement strategies that required other materials, such as exercise equipment or new food products to cafeterias, the sites were responsible for their procurement.

We defined the ease of implementation of each intervention strategy on a three-point scale (easy, moderate, demanding) based on discussion within the research team (Table 2) [39]. The classification reflected the amount of knowledge and effort required from the implementer to sustain the strategy after its launch. Easy strategies required little specialised knowledge, and besides occasional check-ups, no actions after launch. Examples included laying out posters and introducing new equipment or furniture. Moderate strategies required some knowledge on correct implementation and light maintenance on a regular basis. Examples included maintaining exercise equipment in pre-defined places and running the packed lunch recipe campaign that required a weekly delivery of materials. Demanding strategies required more specialised knowledge on correct implementation and daily maintenance. Examples included the use of nutrition labels and the placement of healthy vs. unhealthy foods at worksite cafeterias. We judged ten of the employed strategies easy to sustain, nine moderate, and four demanding. The three most often implemented strategies fell under the categories easy and moderate.

Data collection

Implementer perspective

For qualitative, implementer-level evaluation of acceptability, we collected data with semi-structured interviews from the implementers of participating organisations (Additional file 1). Email and text messages received from the implementers complemented the interview data. As applicable, we portray the qualitative data collection and analysis following the checklist of the consolidated criteria for reporting qualitative studies (COREQ) [46].

The first two authors (E.R., female MSc student in nutrition, and S.V., female PhD in nutrition) interviewed the implementers twice along the intervention. Majoring in clinical nutrition, both interviewers had received training in interviewing people. The interviewers had become acquainted with 55% of the implementers over the recruitment of participating organisations and the development and launch of the intervention. The implementers were familiar with the purpose of the intervention and the interviewers' institutional affiliations, job titles, and roles in the study. In a healthcare organisation (O12) with 20 intervention sites, sites with patients were not accessible to externals. Hence, the head implementer of this organisation (female HR assistant) conducted the data collection at these sites with instructions from the research team.

In total 65 implementers contributed to the acceptability evaluation, at least one from each participating organisation (Table 3). The implementers represented diverse occupational groups and both management- and employee-level personnel. Of the implementers, 49% had been involved in designing the content and implementation of the intervention to their sites (i.e., "designers"), and 28% had jobs that essentially focused on the promotion of employee wellbeing and health (i.e., "health promoters"). The health promoters comprised HR, occupational wellbeing, and work ability personnel, and health and safety representatives. Without a couple of exceptions, the health promoters were also designers. The

Table 2 Choice architecture strategies implemented and the number of organisations (sites) intending to implement each strategy

Target	Intervention strategy	Description	Ease of implementation	Setting	n[a]
Healthy eating					
Food provision	1. Enable healthy choices	Healthy food/beverage choices made available	Moderate	Meetings	6 (6)
	2. Widen selection	Greater variety of healthy food/beverage options available	Moderate	Cafeteria	4 (4)
	3. Replace with better alternatives	Less healthy options replaced with nutritionally better alternatives	Moderate	Meetings	1 (1)
	4. Increase visibility and proximity	Healthy options placed: (a) on visible spots, (b) at the beginning of the buffet, (c) closer to the chooser (e.g., in front row), and/or (d) in the middle of the tray, shelf, or showcase	Demanding	Cafeteria	4 (4)
	5. Decrease visibility and proximity	Less healthy options placed: (a) on less visible spots, (b) at the end of the buffet, (c) further away from the chooser (e.g., in back row), and/or (d) on the edge of the tray, shelf, or showcase	Demanding	Cafeteria	4 (4)
	6. Increase convenience	Fruit and vegetables served ready to eat (i.e., washed, peeled, cut into pieces)	Demanding	Meetings	1 (1)
	7. Increase perceived variety	Salad components served from individual containers	Moderate	Cafeteria	1 (1)
	8. Use smaller serving dishes	Less healthy options served from smaller serving dishes	Moderate	Cafeteria	1 (1)
	9. Use smaller serving utensils	Less healthy options served with smaller tongs and spoons	Moderate	Cafeteria	1 (1)
	10. Use smaller serving sizes	Less healthy options served in smaller sizes	Moderate	Meetings	2 (2)
	11. One plate-policy at lunch	Separate bread/salad plates moved out of sight to facilitate choosing one large plate and composing a meal according to the plate model (i.e., 1/2 vegetables, 1/4 protein, and 1/4 carbohydrates)	Easy	Cafeteria	1 (1)
	12. Point-of-choice prompts	Healthy options indicated with the Heart symbol[b] on menus/at the point of choice	Demanding	Cafeteria	4 (4)
	13. Prime for better choices	"Follow the heart"-posters[b] at cafeteria entrance/at the beginning of the buffet to facilitate noticing and choosing options carrying the Heart symbol	Easy	Cafeteria	4 (4)
Drinking water	14. Facilitate and remind of drinking water	Personal, reusable water bottles provided for employees	Easy	Personal workstation	2 (6)

Table 2 (continued)

Target	Intervention strategy	Description	Ease of implementation	Setting	n[a]
Packed lunches and snacks	15. Encourage smart packed lunches	A year-long recipe campaign with temptingly named, visually attractive, seasonal, and healthy packed lunch recipes promoted at worksite coffee rooms, via electronic channels (info-screens, company intranet, newsletters), and on social media (Facebook, Instagram). The recipes covered various meal options (warm courses, salads, smoothies, sandwiches), included traditional Finnish dishes and dishes from around the world, and emphasised appealing sensory properties or ease of preparation. Campaign materials included one recipe for each week of the year, a poster, and a cardboard stand for printed recipe cards (Fig. 1)[b]. Campaign slogan encouraged to form a habit of enjoying good food during breaks and featured a rhyme that prompted to pick up a recipe, stop by the store, and prepare, pack, and grab the meal	Moderate	Coffee rooms	16 (53)
	16. Encourage provision of fruit at work	The promotion and provision of the "Fruit Crew"-starter set for forming fruit circles whose members take turns to organise fruit serving at work. The kit included a poster that asked: "Already a member of the fruit crew?", an instruction and enrolment form, and a recyclable basket for fruit (Fig. 1)[b]	Easy	Coffee rooms	9 (37)
Physical activity					
Time spent sitting	17. Enable active sitting	Introduction of balance cushions or wobble stools	Easy	Common environments	1 (1)
Stair use	18. Enhance stairwell visibility	Footprints on the floor leading to stairs from the elevator	Easy	Elevator, stairs	2 (2)
	19. Prompt choosing the stairs	StopDia logo (a stop hand-sign with a heart on the palm)[b] placed on elevator doors, next to elevator call buttons, or in their immediacy	Easy	Elevator	3 (6)
Movement breaks	20. Prompt context-specific movement	Posters encouraging to "flex" or "loosen up" and depicting simple movements suitable to be performed, e.g., by the copy machine, microwave, coffee maker, or bathroom (Fig. 1)[b]	Easy	Common environments	16 (53)
	21. Enable movement with exercise equipment	Light exercise equipment made available, e.g., gym sticks, balance boards, or hanging bars	Easy	Common environments	7 (10)
	22. Increase visibility and proximity of exercise equipment	Available exercise equipment placed on salient spots suitable for short exercise breaks, e.g., by the copy machine, microwave, or coffee maker	Moderate	Common environments	7 (14)
	23.Prompt movement with automatic reminders	Computer-based break exercise application provided for employees	Easy	Personal workstation	1 (2)

Healthy foods/beverages were defined as products, meals, and recipes that met the product category-specific nutrition criteria of the Heart symbol—the nutrition label of the Finnish Heart Association and the Finnish Diabetes Association [45], as well as energy-free beverages

[a] Total number of organisations was 16 (total number of sites was 53)

[b] For images and additional details of the materials, see the Supplementary Material S1 of [39]

Fig. 1 Examples of materials of most frequently implemented intervention strategies: #15 (top), #20 (middle), #16 (bottom). For descriptions of content, see Table 2

proportion of implementers without the designer's and health promoter's role (i.e., "other implementers", such as assistants and catering personnel) was 48%. Information on gender was available for 51/65 implementers, and of these, 40 were female. Unknown gender concerned the implementers who were interviewed by the head implementer of O12.

The first interview round took place halfway through the intervention approximately at month six and the second round at the end of the intervention approximately at month twelve. The interviews were conducted in person at the intervention sites as part of follow-up visits for monitoring implementation. The median duration of the follow-up sessions was 60 min on the first round and 30 min on the second round. These sessions comprised the interview and an implementation quality assurance tour in the worksite environment. The interviews took place at meeting rooms or at the implementers' personal workstations. In open and shared workspaces, personnel not involved in the interviews could be within earshot. If on-site visits were not feasible, the interviews were conducted via Skype for Business-online meeting tool (Microsoft Corp., Redmond, WA, USA), on the phone, or by email. The interviewers made notes during the interviews and typed the notes up after the interviews. The transcribed notes were not returned to the interviewees. The number of interviews per organisation and the number of interviewees per interview varied along the number of intervention sites and implementers each organisation had. Additionally, the interviewees of each organisation could vary from one time point to another, for example, due to staff turnover.

Table 3 Number and work substance of implementers who contributed to the acceptability evaluation

Organisation	Total[a]	Designers[b]	Health promoters[c]	Other implementers[d]	Substance of work
O1	1	1	1	0	HR, communication
O2	1	1	1	0	Occupational wellbeing
O3	4	2	2	1	Work ability, communication, supervision of employees' interests regarding employment, physical activity coaching
O4	1	1	1	0	Occupational wellbeing
O5	5	2	2	3	HR, assistance
O6	1	1	1	0	Occupational wellbeing
O7	7	4	2	2	HR, production, catering
O8	1	1	1	0	HR, finance
O9	2	2	2	0	HR, work ability
O10	6	1	1	5	HR, finance, building security and maintenance, early childhood education, administrative assistance, catering
O11	6	5	0	1	Housing construction, housekeeping
O12	18	3	1	15	HR, catering, healthcare
O13	1	1	1	0	HR
O14	5	3	0	2	Management, sales
O15	3	3	2	0	HR, health and safety, catering
O16	3	1	0	2	Management, administrative assistance, social work
Total	65	32	18	31	

[a] Total number does not equal the sum of designers, health promoters, and other implementers because most health promoters were also designers

[b] Involved in intervention design

[c] Substance of work focused on the promotion of employee wellbeing and health

[d] Implementers who were not designers nor health promoters

The interviews followed a semi-structured outline devised by the research team (E.R., S.V., K.P., L.K., P.A.). Besides the first two authors, the team included professors and senior lecturers with expertise in the fields of public health, nutrition, behavioural sciences, and implementation research. See Additional file 1 for English translations of the interview questions relevant to the acceptability evaluation. The first interview round mapped the implementers' views on the ethicality of the employer's attempts to influence the employees' health behaviour and enquired about the acceptability of the choice architecture approach in the promotion of healthy eating and physical activity among employees. Choice architecture interventions were portrayed to alter the worksite environment to subtly guide employees to health-promoting choices. In addition, the interviews asked about the implementers' experiences of the implementation and about observed effects of the intervention. The second interview round collected complementary data on implementation and observed effects. Regarding the sites of O12 that were not accessible to externals, the head implementer toured the sites once after six months and collected experiences of the intervention and its implementation with an adapted interview outline.

Employee perspective

For quantitative, employee-level acceptability evaluation, we conducted a questionnaire at the end of the intervention among the employees of intervention sites. The employees were invited to answer a short questionnaire either online via the Questback®-tool (www.questback.com) or with paper and pen, depending on which was feasible for the worksite. A cover letter informed that the questionnaire was a part of the StopDia study and aimed to explore employees' thoughts on workplace wellbeing promotion. Completing the questionnaire was voluntary and anonymous, took approximately five minutes, and required no identifiable information.

The questionnaire included nine acceptability-related items. One item asked whether the respondent finds acceptable (yes/no) that the employer seeks to influence the employees' dietary and physical activity patterns with the aim of promoting the employees' wellbeing. Eight items were informed by measures used in prior acceptability evaluations [20, 21, 24] and asked the respondent to rate on a seven-point Likert scale (completely disapprove—completely approve) the acceptability of eight specific choice architecture strategies that would be implemented by the employer (for strategy descriptions,

see results). Additionally, the respondent could choose an opt-out option "I cannot say". The rated strategies employed four types of behaviour change mechanisms: 1) the provision of information/tips, 2) point-of-choice prompts, 3) alterations to the availability of healthy options, and 4) enhancements to the visibility and accessibility of healthy options. The strategies resembled those most frequently implemented in the StopDia at Work-intervention.

The questionnaire also asked the respondent's predominant quality of work (physical vs. less physical), typical meal location (worksite cafeteria vs. else), and whether the respondent wished for support for healthy eating or physical activity from the employer. Data on the percentage of male employees per intervention site during the intervention year were received from the implementers (Table 1).

Analyses

Implementer perspective

The implementer-level acceptability evaluation applied deductive qualitative content analysis [47], building the coding framework upon the domains of the Theoretical Framework of Acceptability (TFA): ethicality, affective attitude, burden, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy [13]. The TFA defines ethicality as the extent to which the intervention fits an individual's value system; affective attitude as how an individual feels about the intervention; burden as the perceived amount of effort that is required to participate in the intervention; intervention coherence as the extent to which an individual understands the intervention and how it works; opportunity costs as the extent to which benefits, profits, or values must be given up to engage in the intervention; perceived effectiveness as the extent to which the intervention is perceived as likely to achieve its purpose; and self-efficacy as the participants' confidence that they can perform the behaviours required to participate in the intervention [13].

The analysis built on pooled data from the two interview rounds. Comparison between the two rounds was not meaningful, as the samples of interviewees and discussed topics were not identical across the two time points. The first author (E.R.) familiarised herself with the interview data through reading and rereading, simultaneously coding the data according to the domains of the TFA. The coding was not mutually exclusive, meaning that the same comment could relate to multiple themes and hence receive several codes. As the analysis identified no content related to the self-efficacy domain, we removed the domain from the coding framework.

We promoted the validity and reliability of the coding through a peer-checking process common in qualitative research [48, 49]. The first author reviewed quotes from the interview data against suggested coding with three other authors (S.V., L.K., P.A.), and the four authors refined and agreed on the coding. For data management and analysis, we used NVivo R1 (QRS International) and Microsoft Excel® 2016 (Redmond, WA, USA). As the period between data collection and analysis was substantial, contacts were lost to many interviewees and asking the interviewees to provide feedback on the results was not feasible.

Employee perspective

The employee-level acceptability evaluation examined the questionnaire data with descriptive statistics (frequencies/percentages, measures of central tendency and dispersion). Friedman test—the non-parametric alternative for repeated measures ANOVA—with Dunn-Bonferroni post hoc analysis for pairwise comparisons tested for differences in the distributions of acceptance across the eight specific choice architecture strategies rated. A non-parametric test was appropriate because the acceptance of the strategies proved non-normally distributed based on visual inspection of histograms and the Kolmogorov–Smirnov test of normality (p-values < 0.001). An overall acceptance score of the specific strategies was computed by averaging the ratings of respondents who rated all eight strategies. A mixed-effects logistic regression model with site-level random intercept explored associations between the overall acceptance score and relevant available site-level predictors: the proportion of male employees, respondents with physical work, respondents eating at the worksite cafeteria, and respondents hoping for support in healthy eating or physical activity (for details of the model, see Additional file 1). For the model, the acceptance score was transformed into a dichotomous variable, with scores below the 25th percentile treated as the target category and scores at or above the 25th percentile as the reference category. This cut-off point ensured both categories had sufficient sample sizes and variation in the predictors and the acceptance score. Statistical analyses were performed with IBM SPSS® Statistics 29.0 (IBM Corp., Armonk, NY, USA), considering p-values < 0.05 statistically significant.

In questionnaires completed with paper and pen, responses that fell between two options or that indicated multiple options were coded missing in the dichotomous yes/no-item (0.1% of total responses) and according to the lower rating in the scale items (0.1% of total). The overall percentage of missing data ranged from 0 to 0.9% across the questionnaire items. Opt-out responses ("I cannot say") to the scale items were examined separate from the numeric responses.

Results

Implementer perspective

Acceptability-related findings drawn from the implementer interviews reflected six of the seven domains of the Theoretical Framework of Acceptability (TFA): ethicality, affective attitude, burden, intervention coherence, opportunity costs, and perceived effectiveness [13] (Table 4). The findings projected the implementers' thoughts and observations on the content, implementation, and effectiveness of the StopDia at Work-intervention, as well as engagement in the promoted behaviours. The absence of the seventh TFA domain, self-efficacy (i.e., confidence in ability to participate in the intervention [13]), was unsurprising because choice architecture interventions are relatively simple to implement and typically encourage behaviours that require no advanced skills.

The domains with the greatest number of contributing implementers were perceived effectiveness, ethicality, and affective attitude, respectively (Fig. 2). Among the implementers who contributed to each domain, the share of designers (i.e., implementers involved in the designing phase of the intervention), health promoters (i.e., implementers whose work focused on the promotion of employee wellbeing and health), and other implementers (i.e., individuals not involved in designing nor health promotion) varied across domains.

The following sections portray our findings related to each included domain. In accordance with the coding used in Tables 1 and 3, we indicate the organisations whose implementers contributed to each finding with the identifiers O1–16. Where feasible, we refer to specific intervention strategies to which the implementers referred using the numbering (#) presented in Table 2.

Ethicality

Regarding the legitimacy of workplace health promotion in general, implementers across participating organisations (O1–16) and implementer groups (27 designers, 16 health promoters, 11 other implementers) considered acceptable that the employer attempts to influence the employees' health behaviour to promote the employees' wellbeing and health. The employer's efforts to support healthy behaviours were considered to benefit everyone, the employer and the employee (O11, O13), as well as the society (O15). Omitting such efforts could at worst lead to dismissals if employees were no longer able to work (O15), and societal resources would not suffice to cover health care costs (O15). Another argument was that when hiring personnel, employers have the right to expect employees to stay able to work (O10). Yet, some implementers noted that the line between acceptable and non-acceptable attempts to influence employees' health behaviour is fine (O3, O16); while some greet health promotion measures with enthusiasm, some find them fraught (O14).

When the implementers were asked to specify the ways in which the employer may attempt to influence the employees' health behaviour, they characterised acceptable attempts as positive (O3, O5, O15) and encouraging (O2, O8, O10, O14–15) measures that provide voluntary opportunities (O1—16). Mentioned opportunities could target the worksite environment with various choice architecture strategies or rely on the provision of information, incentives, or work arrangements.

Choice architecture interventions were considered ethical across organisations (O1–O16) and implementer groups (27 designers, 16 health promoters, 11 other implementers), mainly because they maintain employees' freedom of choice (O4–6, O10, O12)—or as one implementer (O9) put it: "because they do not force employees to do anything. The environment just offers opportunities, and employees may choose whether to follow the cues". Mentioned opportunities through which the worksite environment could promote healthy behaviours included ergonomic furniture such as height-adjustable desks (O10, O16); the availability, arrangement, and presentation of healthy foods at worksite cafeterias and meetings (O1, O7, O9, O12), as well as facilities and equipment for physical activity (O10). Implementers also supported the way in which choice architecture interventions can create contexts that "wake up" (O1) without being too "flagrant" and hence "pushing" (O11), and how these contexts can facilitate choices that experts have evaluated beneficial for health (O13). One implementer (O15) expressed their support for choice architecture strategies by noting: "The living environment influences behaviour anyway, so we can just as well build an environment that guides to healthy choices".

Affective attitudes

Positive affective attitudes Positive affective attitudes were expressed by 26 implementers (18 designers, 11 health promoters, 8 other implementers), at least one from each participating organisation. Positive attitudes focused on the choice architecture approach, implemented intervention strategies, intervention materials, intervention implementation, and the StopDia project as a whole. The choice architecture approach was well received, as implementers described the approach "very nice", "good", "friendly", and/or "sensitive" (O2, O4). Regarding implemented strategies and materials, implementers reported positive attitudes towards strategies targeting the food provision at worksite cafeterias (Table 2: strategies #1, 2, 4, 5, 8, 9, 12, 13; organisation

Table 4 Key findings of the implementer-level evaluation of acceptability

Domain	Definition[a]	Topic of implementer reports[b]	Key findings[b]
Ethicality	The extent to which the intervention fits the implementers' values	Workplace health promotion in general or with the choice architecture approach	• Workplace health promotion benefits everyone and is acceptable with voluntary, positive, and encouraging interventions • The choice architecture approach is an ethical, gentle, and freedom-preserving way to encourage healthy choices
Affective attitudes	Feelings about the intervention	Intervention content and implementation	• Expressed attitudes were mainly positive and covered the choice architecture approach, implemented strategies, intervention materials, implementation, and the StopDia project • Packed lunch recipes drew some criticism • Perceived ineffectiveness reduced motivation for implementation
Burden	The perceived amount of effort that participation requires	Implementation, engagement in the promoted behaviours	• Once fallen into a routine, implementation felt effortless • Recipes could have been simpler
Intervention coherence	The extent to which the implementers understand the intervention and how it works	Implementation	• Understanding increased interest in implementation
Opportunity costs	The extent to which benefits, profits, or values must be given up due to the intervention	Financial investments required for intervention materials and implementation	• Low perceived utility of the intervention and high intensity of implementation reduced cost acceptance
Perceived effectiveness	The extent to which the implementers perceive the intervention likely to achieve its purpose	Observed effects or beliefs about the effectiveness of specific intervention strategies, general reflections on effectiveness	• Perceived effectiveness was mixed, clustering around positive and neutral observations • Facilitators for effectiveness involved an active implementer, supportive social and physical work environment, and employer-granted financial support for implementation • Suggested explanations for ineffectiveness included varying individual preferences, needs, and understanding of the intervention; and unsupportive circumstances at work

[a] Adapted from the Theoretical Framework of Acceptability [13]

[b] Unless otherwise specified, the topics of implementer reports and the key findings refer to the content, implementation, or perceived effectiveness of the StopDia at Work-intervention, or to engagement in the behaviours this intervention promoted

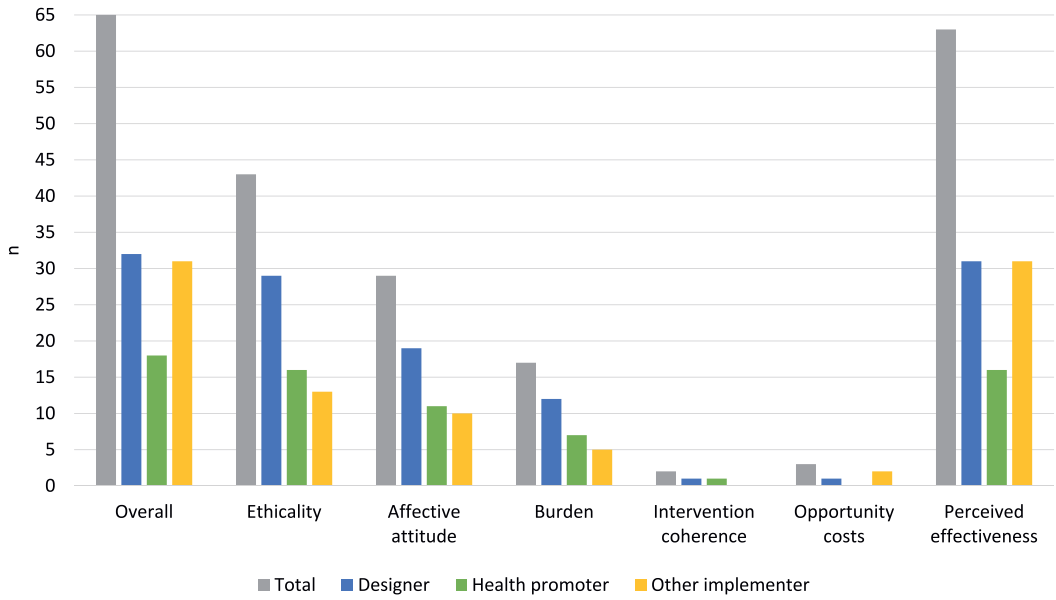

Fig. 2 The number of implementers who contributed to the acceptability evaluation overall and by domain. Total does not equal the sum of designers, health promoters, and other implementers because most health promoters were also designers

O3), strategies targeting packed lunches (#15; O3, O7, O9, O10–13, O15–16) and snacks (#16; O12, O14) in coffee rooms, and strategies encouraging physical activity (#18—20; O1, O3, O9, O16). In one organisation (O3), implementers described strategies implemented at the worksite cafeteria "brilliant" and "the best offering of the project" and found the changed look of the cafeteria "refreshing". These implementers were satisfied also with the materials provided for other implemented strategies, which encouraged smart packed lunches (#15), stair use (#18—19), and context-specific movement (#20): "The materials were good, clear, and easily accessible, and instructions were good. Particularly the packed lunch recipes were good material". The implementer of another organisation (O13) was content with the tone of the packed lunch recipes (#15): "The recipe cards do not feel pushing or imposing; their health-promoting message does not come across negatively". In a couple of organisations (O1, O8), implementers found that the strategies implemented (#1, 10, 15, 20) suited their organisation and supported prior occupational wellbeing measures.

As for the implementation, several implementers were gladly involved (O10, O12), particularly after the implementation had formed into a routine (O10). Additionally, implementers welcomed the opportunities for breaks and physical activity that their implementation tasks afforded (O7–8, O11). One implementer (O5) was unable to suggest any improvements to the implementation process. In addition, implementers were content with the 12-month duration of the intervention (O10, O14). Regarding the StopDia project, several implementers expressed their satisfaction and found the project and its cause good, positive, and/or useful (O3–4, O6, O8, O14).

Critical affective attitudes More critical attitudes came from altogether eleven implementers (6 designers, 1 health promoter, 5 other implementers) who represented five organisations. These attitudes focused on the packed lunch recipe strategy (Table 2, Fig. 1: #15), including its materials and their implementation. Regarding the materials, comments showed the variability of inter- and intra-individual food preferences. On one hand, implementers could hope for more basic recipes that include common, local ingredients (O8, O16). On the other hand, they could state that the recipes appeared tasteless and required "tuning", for example, with added fat or seasoning (O16, O10). In terms of implementation, one implementer (O10) struggled finding motivation in the beginning of the intervention: "At first, I didn't find motivating to change the recipe cards because the job felt an additional, unconnected work task that required remembering". However, once the task formed into a routine, motivation increased. Related to perceived effectiveness,

implementers at three sites (O11, O14) lost their motivation to sustain the recipe strategy due to perceived ineffectiveness.

Burden

Burden-related comments referred to implementation and engagement in the promoted behaviours. Fifteen implementers (11 designers, 6 health promoters, 4 other implementers) from nine organisations (O1, O5–6, O9–12, O14, O16) considered the implementation to cause little or no burden, portraying the implementation "easy", "simple", "natural", and/or "effortless". A couple of implementers, however, experienced the packed lunch recipe strategy (Table 2: #15) more burdensome. According to our categorisation, this strategy was moderate to sustain, defined as requiring some knowledge on correct implementation and light maintenance on a regular basis. One of the implementers (O10, other implementer) noted that remembering to update the recipe materials weekly was challenging at first. This burden reduced over time, however, as the implementation "fell into a routine". The other implementer (O1, designer and health promoter) found the recipe strategy too burdening to sustain, as regards uploading the recipes on info screens and timing their display. Regarding the engagement in the promoted behaviour, two implementers (O8, designer and health promoter; O11, designer) felt that the packed lunch recipes should have been less burdensome, meaning "simpler" and "quicker" to prepare.

Intervention coherence

Comments that reflected intervention coherence were related to implementation. One implementer (O12, designer and health promoter) portrayed that understanding the rationale behind the intervention motivated them to implement: "The study woke me to think of type 2 diabetes and that I wouldn't want to get it. That raised my interest in the choice architecture approach as well". Via personal interest, this comment draws a link between intervention coherence and affective attitudes. Another implementer (O4, designer and health promoter) had an opposite experience. This implementer participated in intervention design but delegated the responsibility of delivery to site managers via email instructions. The implementation in this organisation proved less successful. The implementer pondered that the lack of understanding could explain the poor performance: "the site managers might not see the connection between health promotion activities, diabetes, and, for example, absence from work".

Opportunity costs

Cost-related remarks concerned the financial investments that intervention materials and their implementation required. Two implementers (O12, other implementers) criticised the public funding and efforts invested in the packed lunch recipe strategy (Table 2: #15). These comments reflected frustration with the labour policy that the ruling government had implemented. One implementer said: "I don't really understand why they (i.e., the recipe cards) are like this (i.e., printed). Wouldn't electronic materials be more contemporary? The cards have consumed plenty of money and printing materials. I admit that the past years' cuts in hourly wages nag me while I change the cards and sign the checklist—that this can be afforded". The other implementer thought: "taxpayers' money should not be spent on this (i.e., the recipe materials) but on something more important".

At one site (O14) that chose to implement the fruit crew strategy (#16) by treating employees with unlimited fruit daily, costs appeared too high for sustained implementation. Interestingly, at another site of the same organisation, no cost-related issues emerged once the same strategy was delivered with less intensive implementation; by providing each employee one fruit on two days of the week.

Perceived effectiveness

Perceived effectiveness was overall mixed, clustering around positive and negligible findings and varying both between and within strategies, organisations, and implementers (designers, health promoters, other implementers). Reports of perceived effectiveness consisted mostly of implementers' observations of effects that specific intervention strategies had elicited in themselves or in the rest of the personnel of their worksites. These observations concerned strategies that targeted the food provision at worksite cafeterias or meetings, drinking water, packed lunches and snacks, stair use, and movement breaks (Fig. 3, Table 5). Across the strategy-specific observations, positive perceived effects were reported from 15, negligible from 12, and negative from four organisations. In addition, the comments of a few implementers reflected beliefs rather than actual observations, and some implementers discussed effectiveness more generally.

Positive perceived effects of eating-related strategies appeared in increased availability and consumption of nutritionally high-quality foods, such as vegetables and fruit at worksite cafeterias, meetings, or coffee rooms (Table 5). Further positive observations

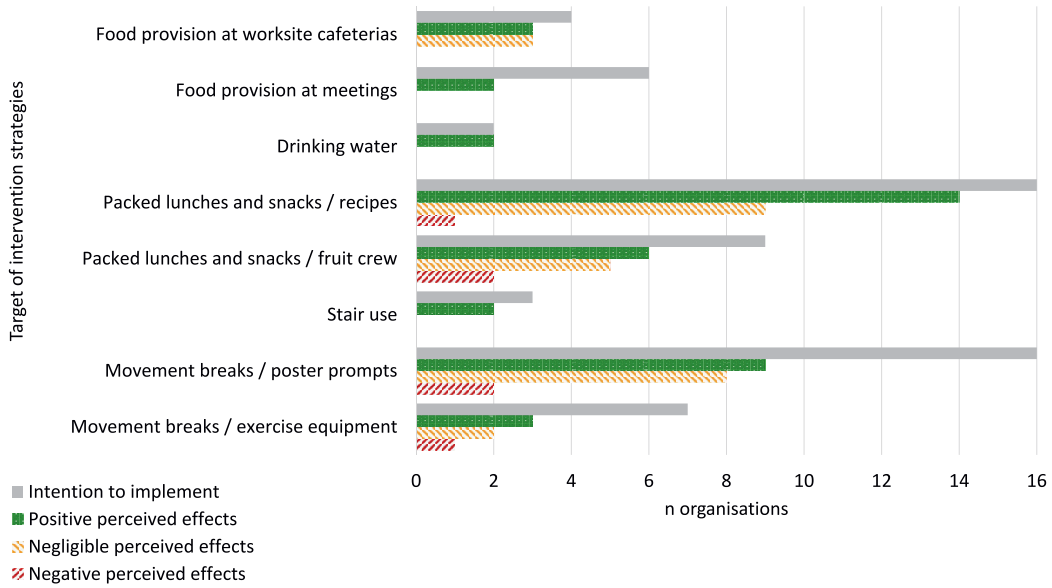

Fig. 3 Strategy-specific perceived effects reported from organisations that intended to implement corresponding strategies. Total number of participating organisations 16. Coding is not mutually exclusive

included employees' interest in and the use of the promoted packed lunch recipes, as well as the use of water bottles provided for employees. With strategies promoting daily physical activity, positive perceived effects emerged as increased movement and the use of stairs and available exercise equipment. Factors that accompanied positive observations were related to the implementer, the social and physical work environment, and the employer. Examples included the implementers' initiative to present and deliver print intervention materials to employees personally (O10), positive behavioural examples set by colleagues (O11), high community spirit and active employees that were used to organising common activities (O15), the opportunity to use working hours and worksite facilities to prepare and enjoy packed lunches together with colleagues (O16), and the employer's financial support for organising fruit provision in coffee rooms (O14).

Reports of negligible perceived effects were nearly as common as reports of positive perceived effects. In addition, perceptions of positive and negligible effects often coexisted, as implementers could observe positive effects in some employees or behaviours while negligible effects in other employees or behaviours. Regarding strategies targeting packed lunches and snacks (Table 2: #15–16), implementers reflected potential reasons for the mixed or negligible effects. Suggested explanations included employees' varying needs for (O10, O12, O16) and understanding of (O1, O8) the strategies, varying food preferences (O9, O11), as well as large work communities and shift work that challenged the organisation of and engagement in common activities (O1, O12).

Negative perceived effects were rare and appeared in tearing down of posters (O2, O7), in hoarding of fruit that the employer provided (O14), and in reports of unpleasant feelings after the use of certain exercise equipment (O9). Some of these effects occurred only in the beginning of the intervention and disappeared through enhanced implementation and communication with the employees (O7, O14).

Besides actual observations, a few implementers expressed sceptical beliefs in the effectiveness of strategies promoting healthier eating. While one implementer (O10, other implementer) considered that "eating at work can hardly be influenced", another (O15, designer) thought that strategies at the worksite cafeteria "won't help if people have no motivation" and "matter little because people eat what they wish at home". One implementer of a healthcare organisation (O12, other implementer) expected the packed lunch recipes to bear little effect: "I doubt the resulting health benefits are very significant. Particularly in hospitals people have so much nutrition knowledge that a few recipe cards will hardly prevent any type 2 diabetes case". This comment was

Table 5 Examples of positive (+), negligible (~), and negative (−) perceived effects of specific intervention strategies

Target and corresponding intervention strategies	Examples of perceived effects (O = organisation, # = strategies implemented)
Healthy eating	
Food provision at worksite cafeterias 2. Widen selection 4. Increase visibility and proximity 5. Decrease visibility and proximity 7. Increase perceived variety 8. Use smaller serving dishes 9. Use smaller serving utensils 11. One plate-policy 12. Point-of-choice prompts 13. Prime for better choices	+Changes in the cafeteria were eye opening; how small changes influenced behaviour. Implementers perceived that the intervention had resulted in lighter eating (O3: #2, 4, 5, 8, 9, 12, 13) +Consumption of salads and fruit increased, consumption of main courses and carbohydrate accompaniments (i.e., mashed/boiled potatoes, rice, pasta) decreased. The implementers also noticed that they themselves started to consume more salad in the cafeteria (O7: #2, 4, 5, 11 – 13) +/~Some customers noticed the point-of-choice Heart symbols and chose corresponding foods, some did not (O12: #2, 4, 5, 7, 12, 13) ~No observed effects on customers' food choices (O15: #2, 4, 5, 12, 13) ~No observed effects on breakfast porridge consumption (O7: #2, 4, 5, 11 – 13)
Food provision at meetings 1. Enable healthy choices 3. Replace with better alternatives 6. Increase convenience 10. Use smaller serving sizes	+Meeting organisers increased orders of fruit and decreased orders of sweet buns (O10: #1; O11: #1, 3, 6) +Serving fruit ready to eat (e.g., peeled) reduced food waste (O11) +Employees gave positive feedback on fruit served at meetings (O11). [A positive change in attitudes over the intervention]
Drinking water 14. Facilitate and remind of drinking water	+Water bottles were used (O5, O9)
Packed lunches and snacks 15. Encourage smart packed lunches (the packed lunch recipe campaign)	+At least some employees/implementers took recipes (O1–2, O6–12, O14–16) +At least some employees/implementers tried recipes (O2, O5–6, O9–10, O12–13, O16) +The employees were allowed to try a recipe at work during working hours, and the prepared food was served at the worksite's weekly brunch (O16) +More recipes were taken when presented and handed out to employees personally (O10) +If one employee reviewed and commented on a recipe, other employees could take the recipe as well (O11) +Employees looked forward to upcoming recipes (O7, O12–13, O15) and asked when they appear (O12–13) +Employees who did not speak Finnish as their first language tried to translate the recipes in English (O8) ~Overall, few recipe cards were taken (O1, O6, O9–12, O14–16) ~Recipes were taken but not prepared (O14, O16) ~Recipes could remain unused if they included ingredients not available at home or ingredients not usually used in home cooking (O11, O14, O16) −Posters were torn down over the intervention year (O2)
Packed lunches and snacks 16. Encourage the provision of fruit at work (the Fruit Crew-strategy)	+The strategy was in active use at least in some coffee rooms or some parts of the worksite, with the costs of provided fruit covered by the employees (O9, O15) or by the employer (O14) +The strategy was in use in coffee rooms where the community spirit was high and where the employees actively organised events and common activities (O15) +Employees occasionally brought fruit for everyone to enjoy, e.g., during the harvest season (O10) or Christmas (O16) +/− In the beginning of the intervention, employees in the day shift took so many fruit that none were left for employees in the evening shift. Once instructions were clarified (one fruit/employee), the strategy began to work, and the fruit sufficed for everyone (O14) ~The strategy was not in active use (O1, O10, O12, O15, O16) ~No fruit crews were formed because the employees ate plenty of fruit anyway and found the strategy useless (O12) ~The fruit basket of the "Fruit Crew"-starter set was used for something else than for serving fruit, e.g., for keeping pens (O15, O12)
Physical activity	
Stair use 18. Enhance stairwell visibility 19. Prompt choosing the stairs	+Implementers perceived increased stair use (O3, O6)

Table 5 (continued)

Target and corresponding intervention strategies	Examples of perceived effects (O = organisation, # = strategies implemented)
Movement breaks 20. Prompt context-specific movement	+ Movements were performed (O5–12, O14) ~ Implementers saw no one perform any movements (O10–14) ~ Implementers themselves performed no movements although the posters were in sight (O12, O16) − In the beginning of the intervention, the posters were removed from bathrooms (O7)
Movement breaks 21. Enable movement with exercise equipment 22. Increase visibility and proximity of exercise equipment	+ At least some employees used at least some of the available equipment (O3, O9, O14) + The equipment tended to disappear/travel away from its intended place, indicating potential use (O9) +/~ Balance cushions on seats shared opinions; some used them, some not (O9) ~ Equipment was not used (O14) − For some, sitting on balance cushions caused nausea (O9)

related to the criticism of intervention costs that was described in the opportunity costs section.

Regarding general reflections on effectiveness, several implementers (O3, O4, O11, O14) discussed the time needed for interventions to take effect. The implementers noted that changes rarely happen overnight, referring both to intervention implementation, which may require changes in organisational culture and practices, and to intervention impact, which requires readiness from the employees to adopt the intervention and to change own behaviour. Hence, to enhance adoption, one implementer (O14) suggested leveraging messengers that show the way and encourage colleagues to try out new things. This suggestion aligns with the observation on how the social work environment can enhance effectiveness. Further propositions included a digital app-assisted delivery besides print materials (O14) and the provision of intervention materials in English besides Finnish to consider employees with immigrant background (O8).

Concerning the persistence of intervention effects, the reports of several implementers (O2, O10, O11, O12) indicated that over time people may get numb to the intervention and initial effects may begin to fade. This remark applied to strategies that prompt suggested behaviours with attention-capturing cues and to strategies that require commitment and active participation. To sustain the effectiveness of attention-capturing prompts, one implementer (O2) suggested refreshing intervention materials and their placement occasionally. To encourage the continuation of commitment-requiring activities, the same implementer suggested minor rewards. For example, the employees might find more motivating to keep arranging fruit provision in coffee rooms if the employer occasionally organised the fruit service for them. This remark aligns with the above-mentioned observation that the employer's financial support for the arrangement of healthy food provision at the worksite, either in the form of money, time, or facilities needed for implementation, appeared to accompany positive perceived effects.

Employee perspective

In total 1124 employees from 15/16 participating organisations completed the questionnaire at the end of the intervention. The sample represents approximately 22% of the total number of employees who worked at the intervention sites. The mean response rate across organisations, including the one with zero respondents, was 31% (SD 23, range 0–68%). Of the respondents, 20% had a physical work, 29% used to eat at the worksite cafeteria, 37% wished that the employer would provide support for healthy eating, and 61% wished for support in physical activity.

Of all respondents, 95% considered acceptable that the employer seeks to influence the employees' dietary and physical activity patterns to promote the employees' wellbeing. The median overall acceptance of the specific choice architecture strategies evaluated was 7 (interquartile range IQR 6.4–7) (Table 6). The same applied to each specific strategy (Mdn 7, IQRs 6–7 to 7–7). Yet, we observed statistically significant differences between the distributions of acceptance of specific strategies ($\chi^2(7) = 150.421$, $p < 0.001$, $n = 977$). The level of acceptance of strategy (f.) that would improve the healthiness of foods and beverages available at the worksite—or in other words, replace less healthy options with healthier alternatives—was significantly lower compared to strategies that would (a.) provide information or tips on healthy eating and physical activity ($p < 0.001$), (c.) increase the relative availability of healthy options at the worksite cafeteria ($p < 0.001$), (d.) enhance the visibility and accessibility of healthy options at the worksite cafeteria ($p = 0.018$), (e.) clearly indicate healthy options at the worksite cafeteria

Table 6 Acceptance among employees of specific strategies that the employer would implement

Strategy	Behaviour change mechanism	n (%)[a]	Mdn[b]	IQR	Range	Opt-out, n (%)[c]
a. Information or tips related to healthy eating and physical activity distributed at the workplace	Provision of information	1103 (98.1)	7[b]	7–7	1–7	20 (1.8)
b. Reminders of wellbeing-promoting acts during working hours placed in the worksite environment	Point-of-choice prompt	1107 (98.5)	7[ab]	6–7	1–7	15 (1.3)
c. The proportion of healthy options increased at the worksite cafeteria supply	Availability	1040 (92.5)	7[b]	7–7	1–7	77 (6.9)
d. Healthy options placed on the most visible spots with the easiest access at the worksite cafeteria	Visibility, accessibility	1030 (91.6)	7[b]	7–7	1–7	85 (7.6)
e. Healthy options clearly marked at the worksite cafeteria	Provision of information, point-of-choice prompt	1032 (91.8)	7[b]	7–7	1–7	82 (7.3)
f. Foods and beverages served at the worksite made healthier, for example, at meetings or coffee breaks	Availability	1068 (95.0)	7[a]	6–7	1–7	49 (4.4)
g. Physically more active working enabled at the worksite, for example, with standing desks or exercise equipment for employees	Availability	1078 (95.9)	7[b]	7–7	1–7	40 (3.6)
h. Using the stairs instead of the elevator encouraged at the worksite, for example, with encouraging illustrations or markings that lead to the stairs	Point-of-choice prompt	1069 (95.1)	7[ab]	6–7	1–7	48 (4.3)
Overall acceptance score		977 (86.9)	7	6.4–7	1–7	na

[a] Number of numeric responses (% of total responses)

[b] Rating scale: 1 = completely disapprove, 7 = completely approve. Different superscript letters indicate statistically significant differences (p-value < 0.05) in pairwise comparisons

[c] Number of opt-out responses "I cannot say" (% of total responses). na = not applicable

($p = 0.005$), and (g.) increase opportunities for physical activity at the worksite ($p < 0.001$). No significant differences were observed between any other strategies. Greater proportion of male employees at the intervention site was significantly associated with a lower overall acceptance score (OR 4.4, 95% CI 1.2 to 16.5) (Additional file 1). Physical work, eating at the worksite cafeteria, and wish for support in healthy eating or physical activity appeared unrelated with the acceptance. The proportion of opt-out responses ("I cannot say") ranged from 1.3% to 7.6% across the strategies evaluated.

Discussion

This study evaluated the acceptability of a large-scale choice architecture intervention for healthy eating and daily physical activity at the workplace, considering the perspectives of implementers and influenced employees. The intervention applied a broad range of strategies, including primes, prompts, and alterations to the availability, visibility, and accessibility of choice options. Implementers considered the choice architecture approach ethical for workplace health promotion, expressed mostly positive affective attitudes to the intervention, and experienced little burden due to implementation. Intervention coherence supported acceptance through increased interest in implementation, whereas cost acceptance appeared dependent on the perceived utility and intensity of implementation. Perceived effectiveness was mixed. Employees expressed overall high acceptance of evaluated choice architecture strategies.

The support we observed for the choice architecture approach in workplace health promotion aligns with the results of population surveys that have demonstrated overall support for a range of choice architecture strategies implemented by various actors, including the employer [26], catering services [14, 21, 22], and policymakers [14–19, 24, 27]. The acceptance we observed might be partly explained by the intention of our intervention to promote small daily choices that contribute to the targeted individuals' wellbeing and health. Populations across the globe appear to support choice architecture interventions perceived to have legitimate goals that serve the interests or values of most choosers [16, 17]. Relatedly, interventions intended to promote social good such as health have proved better accepted compared to interventions intended to increase the profits of the implementer [14, 23].

Another factor that may have contributed to the high acceptance of our intervention is the type of strategies implemented. Besides a few less transparent strategies in cafeterias and meetings, such as changed placement and portion sizes, most strategies and their intentions were transparent to the influenced employees. These transparent strategies either introduced new healthy choice options or cued the selection of such options with visual, attention-capturing cues that encouraged the promoted

choices by making them attractive or salient, or by leveraging social norms and commitment. The dominance of these strategies in our intervention may be related to their applicability to diverse worksites regardless of resources, such as cafeterias or vending machines [39], or to their appeal to the designers who participated in their selection. The transparent strategies have been characterised as "epistemic transparent type 2 nudges", or "empowerment nudges", that engage automatic attention processes to facilitate reflected choices that individuals themselves evaluate as consistent with their preferences and interests [10]. While intentionally guiding people towards certain behaviours, these strategies promote autonomous decision-making and count as the least intrusive choice architecture interventions [10]. When disagreeing with the cues, people can easily and consciously neglect them. In prior acceptability evaluations, more transparent and less intrusive strategies such as nutrition labels have consistently received greater support compared to less transparent and more intrusive strategies, such as reductions to portion sizes or limitations to availability [15–21, 24, 26, 27]. Our employee-level data lent support for these findings. While the employees expressed high approval for all evaluated strategies, the data indicated that more intrusive strategies that replace less healthy foods with healthier alternatives may receive less support compared to less intrusive strategies that provide information or enhance the availability, visibility, or accessibility of healthier choices. Nevertheless, work communities and people in general appear to welcome the assistance that behavioural contexts can provide in overcoming the obesogenic influence of the contemporary living environment, which often translates to energy-dense and nutritionally poor food choices and sedentariness.

In terms of intervention coherence, our interview data indicated the importance of ensuring that implementers reach sufficient understanding of the purpose and working mechanism of applied intervention strategies. Such understanding could remain poor among implementers who did not participate in the designing phase of the intervention and whose role was to merely deliver the intervention. Relatedly, low perceived utility of the intervention was linked to poor approval of opportunity costs. Greater intervention coherence, in turn, not only promoted acceptability but appeared to enhance motivation for implementation as well. This observation supports the findings of our implementation evaluation [39] that demonstrated the importance of proper knowledge transfer to everyone involved in the implementation process, including those who miss the initial orientation and planning phase. Such knowledge sharing should help implementers to see the purpose and relevance of the intervention for themselves, their work community, and the organisation [39]. These insights provide empirical support for the Normalization Process Theory according to which the implementation, embedding, and integration of new practices in social contexts require that the practices are apprehended as meaningful, valuable, and useful [50].

Implementers expressed mostly positive affective attitudes to the content and implementation of the intervention, experienced overall little burden due to implementation, and rarely criticised costs; thus capturing the principle of choice architecture interventions being simple and inexpensive to implement [1, 42]. Yet, a small group of implementers criticised the content and costs of the intervention, as well as the burden related to engaging in the promoted behaviour. This criticism concerned particularly the packed lunch recipe campaign, which all sites intended to implement and which was the most extensively discussed intervention strategy. The critique applied to the type of recipes included in the campaign, the money spent on producing the materials (although the worksites received the materials free of charge), and the resources needed to deliver the materials. The criticism is understandable taken people's varying values, food preferences, and resources for food preparation. People tend to agree with choice architecture interventions that meet their preferences and support needs [25, 26]. Yet, our employee-level data provided no evidence of an association between employees' wish for support in healthy eating or physical activity and their overall approval of the evaluated strategies. Greater proportion of male employees per site, however, predicted lower acceptance; corroborating earlier evidence of a gender difference in the acceptance of choice architecture interventions [15–17, 19, 20, 24, 27].

An interesting feature of the received critique was that it often (though not always) came from implementers who were not involved in designing the intervention. While we tailored the content and implementation of the intervention to fit local contexts in collaboration with selected members of the personnel of the participating organisations, the personnel involved in the design process may have been insufficiently familiar with the employees of the intervention sites and hence unable to consider the hopes and needs of all employee groups. On the other hand, related to the above-discussed observations on intervention coherence, the implementers who missed the design process may have had poorer understanding of the purpose, rationale, and working mechanism of the intervention, which may have negatively influenced their attitudes to the intervention. In addition, the implementers behind the critique were mostly individuals whose work substance was unrelated to the promotion of employee wellbeing and health. Consequently,

they might have been overall less interested in activities for nutrition and health. While these findings highlight the importance of designing publicly funded health-promotion interventions that acknowledge the target population's preferences, they simultaneously demonstrate the difficulty of finding population-level strategies that appeal to everyone.

Although the implementers perceived many strategies to elicit positive effects, reports of negligible effects were also common. Factors accompanying positive effects involved an active implementer, supportive social and physical work environment, and employer-granted financial support for implementation. Besides supporting the target audience in engaging in the promoted behaviour, these factors facilitate implementation [39], which in turn predicts greater effectiveness [51, 52]. In terms of perceived ineffectiveness, the explanations our implementers suggested included varying individual preferences, needs, and understanding of the intervention. The suggestions relate to the discussed relationship between preferences and affective attitudes to the intervention and receive support from prior choice architecture research in which conflicts between the intervention and the target group's preferences have proved barriers to intervention effectiveness [11, 53].

Another potential explanation to the varying perceived effectiveness is the type of intervention strategies employed. As mentioned, the most frequently implemented strategies in our intervention count as so-called epistemic transparent type 2 nudges [10]—also known as cognitively oriented nudges [54]—that promote reflected choices. While such strategies are the least intrusive and appear best accepted within the choice architecture approach [15–21, 24, 26, 27], their effect sizes tend to be small [54, 55]. Yet, anticipated and true effectiveness of choice architecture strategies seem inversely correlated [19]. This misconception may have contributed to our designers' proneness to select strategies that yield relatively small effects.

In our implementer reports, perceived effectiveness was linked with affective attitudes and views on opportunity costs. More specifically, perceived effectiveness could influence the implementers' interest in sustaining the intervention and their approval of the resources that were invested in the intervention. These observations are analogous to our findings on factors that facilitate implementation [39] and support prior research that has found perceived effectiveness an important predictor of acceptability [14, 15, 18, 19]. Yet, we remind that perceived effectiveness may deviate from true effectiveness [19] and can depend on, for example, received information on expected impact [15] or personal experiences of intervention effects [14]. Hence, perceived effectiveness mainly reflects the implementers' attitudes to the usefulness of the intervention [23].

Strengths and limitations

The strengths of this study include the theory-based, multidimensional acceptability evaluation of a broad range of choice architecture strategies that were selected for implementation in collaboration with participating organisations and integrated into the daily operations of heterogeneous worksites. The evaluation covered the perspectives of two key groups within work communities, implementers and influenced employees, finding both groups to support the choice architecture approach for promoting healthy eating and daily physical activity at the workplace. The implementers included both individuals who had participated in designing the intervention to their worksites and individuals who had not. Regarding the implementers, the evaluation covered experienced (i.e., concurrent and retrospective) acceptability of the intervention and its implementation, acknowledging the multi-faceted definition of acceptability. The evaluation drew a nuanced view of the multitude of factors that influence acceptance and consequently implementation and effectiveness, providing support for the development of improved interventions [12, 13]. The study stretches beyond prior research that has mainly evaluated anticipated (i.e., prospective) acceptability of hypothetical choice architecture interventions among potential target audiences [14–27]. Regarding employees, our evaluation covered the retrospective evaluation of eight specific intervention strategies employed in the intervention. In this respect, the work adds to the few existing choice architecture studies that have examined the influenced individuals' experienced acceptance in the real world [28–31]. Moreover, with rich data from the field, the present study contributes to the translation and upscaling of choice architecture interventions from controlled behavioural laboratories and living labs to diverse real-world settings, providing insights on the feasibility of various choice architecture strategies in the workplace context.

The study has its limitations as well. The strategies most frequently implemented in the intervention either introduced new healthy choice options or prompted healthy choices with attention-capturing visual cues. Such strategies represent the least intrusive choice architecture interventions that leave the freedom of choice fully to the targeted individuals. Hence, our results largely reflect the acceptability of the gentlest nudges. In addition, since the participating worksites implemented several intervention strategies simultaneously, the implementer-level analysis was unable to evaluate the acceptability of each individual strategy. Yet, where feasible, we indicated the specific

strategies to which our implementers referred. Another limitation of the implementer-level assessment is that our implementers' interview reports reflected to some extent a dual perspective, that of the intervention deliverer and that of the intervention receiver, and in certain domains, these two perspectives were impossible to distinguish. The reason for this mixing was that the implementers were selected among the personnel of the intervention sites. Consequently and unavoidably, similar to other employees at their sites, the implementers too became exposed to and influenced by the intervention. The positive side of this dual perspective is that the implementer-level data partly complements the employee-level data. As for the employee-level analysis, due to privacy protection, our questionnaire did not collect identifiable data on individual respondents. We were hence unable to examine the extent to which our sample represents the employee population across the participating organisations, and whether individual characteristics such socio-economic background influence acceptance.

Implications for practice and research

Our empirical findings suggest that from the perspective of acceptability, workplaces can safely adopt the choice architecture approach as a tool to create worksite environments that support the personnel in adopting and maintaining healthy lifestyles. For a broad acceptance within the work community, including both implementers and influenced employees, we recommend involving representative members of each personnel group in designing intervention content and implementation, acknowledging the factors this study identified to influence acceptance. Particularly, we recommend ensuring sufficient understanding of the intervention among implementers, and tailoring intervention content to the personnel's needs, values, and preferences as far as possible within a group-level intervention. Future studies could evaluate the acceptability of more intrusive choice architecture strategies for promoting healthy eating and daily physical activity at the workplace, for example, setting healthy options the default choices. Additionally, studies could compare the acceptance of choice architecture interventions with other types of workplace interventions for healthy eating and daily physical activity, for example, limitations to the availability of unhealthy options at the worksite, knowledge-based lifestyle coaching programs, and financial (dis)incentives for (un) healthy choices. Regarding the perspective of influenced employees, collecting demographic data on individual respondents would enable the comparison of acceptance between diverse employee groups.

Conclusions

This acceptability evaluation of a large-scale choice architecture intervention for healthy eating and daily physical activity at the workplace found a broad range of choice architecture strategies overall acceptable for workplace health promotion, yet identified numerous facilitators and barriers of acceptance. The work adds to prior research with a theory-based analysis that considered multiple dimensions of acceptability and included the perspectives of two key groups within work communities, implementers and influenced employees, once they had experienced the intervention. The work provides insights on the upscaling of choice architecture interventions to heterogeneous real-world settings and supports the development of improved interventions.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-023-17331-x.

Additional file 1.

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Authors' contributions

Conceptualisation and methodology, E.R., S.V., F.J.A.P., K.P., L.K., and P.A.; investigation, E.R. and S.V.; data curation, E.R. and S.V.; formal analysis, E.R., S.V., L.K., and P.A.; writing—original draft preparation, E.R.; writing—review and editing, E.R., S.V., F.J.A.P., J.P., K.P., L.K., and P.A.; visualization, E.R.; funding acquisition, E.R., J.P., K.P., L.K., and P.A.; supervision, J.P., K.P., L.K., and P.A.; project administration, K.P.; principal investigator of the StopDia consortium, J.P. All authors have read and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study, including quantitative data and qualitative Finnish language data, are available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted according to the EU General Data Protection Regulation (GDPR), the Finnish code of conduct for research integrity, and the ethical principles of research with human participants as specified by the Finnish National Board on Research Integrity TENK. The management and implementers of participating organisations gave their verbal informed consent to participate in the study and related data collection that focused

on the implementation and acceptability of the study. The employees who responded the questionnaire gave their informed consent by voluntarily completing the anonymous questionnaire. The study was a part of the STOP DIABETES—knowledge-based solutions (StopDia)-research and development project that was approved by the Research Ethics Committee of the Hospital District of Northern Savo (statement number: 467/2016, date of approval: 3 January 2017).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Publisher's Note

Supplementary material

Acceptability of workplace choice architecture modification for healthy behaviours

Data collection

Acceptability-related questions of implementer interviews translated from Finnish to English

First interview halfway through the intervention

1. What intervention strategies did you implement?
2. How did the launch of the intervention go?
3. How has the sustaining of the intervention gone?
4. What has worked well in the implementation? What factors have contributed to these successes?
5. Have there been difficulties in the implementation? If so, what kind of difficulties have there been and how have the difficulties been resolved?
6. How could the implementation be promoted at your workplace? What would it take?
7. What has motivated you in the implementation? Has something been unmotivating?
8. Have you presented the intervention materials to the employees or encouraged the employees to use the materials?
9. Are you the most appropriate person in your organisation to take care of the implementation, or would someone else be more appropriate?
10. How has the intervention been received? Have the employees noticed or discussed the intervention? Have you heard any feedback?
11. What kind of effects have you observed? Have the intervention materials been used? Have you noticed changes in the employees' behaviour?
12. Do you find it acceptable that the employer attempts to influence the employees' health behaviour?
13. In your opinion, in what ways is the employer allowed to aim at influencing the employees' health behaviour?
14. Do you find choice architecture interventions an acceptable approach to promote healthy dietary choices and physical activity among employees? Choice architecture interventions mean modifying the work environment in such a way that it gently guides employees to health-promoting habits.

Second interview at the end of the intervention

1. Has anything changed in the implementation after the 6-month follow-up? For example, the schedule of completing implementation-related tasks; informing the employees of intervention materials or promoting the materials to the employees.
2. How has the intervention been received? Have the employees noticed or discussed the intervention? Have you heard any feedback?
3. What kind of effects have you observed? Have the intervention materials been used? Have you noticed changes in the employees' behaviour?

Statistical analyses

Mixed-effects logistic regression model examined the association between the employees' overall (i.e., mean) acceptance of eight specific choice architecture strategies (dependent variable) and five site-level predictors (independent variables). For the model, the overall acceptance score was transformed into a dichotomous variable, with scores below the 25th percentile at 6.38 treated as the target category (n=230) and scores at or above the 25th percentile as the reference category (n=747). The site-level predictors included in the model were: (1) the proportion of male employees at the site during the intervention year, (2) the proportion of respondents with physical work, (3) the proportion of respondents with a habit of eating at the worksite cafeteria, (4) the proportion of respondents who wished that the employer would provide support for healthy eating, and (5) the proportion of respondents who wished that the employer would provide support for physical activity. The model was specified with a 2-level data structure using intervention worksite (or organisation if the questionnaire data was collected at the level of the participating organisation) as the clustering variable. The model was built with the generalised linear mixed model (GENLINMIXED) routine of IBM SPSS statistics® version 29.0 (IBM Corp., Armonk, NY, USA). In GENLINMIXED, the default estimation method is a quasilikelihood approach called active set method (ASM) with Newton-Raphson estimation (Heck et al., 2012, p. 27). We included random intercept as the random effect and selected variance components as the covariance structure for the random coefficients. We selected the Satterthwaite

approximation to the degrees of freedom that were used to compute significance tests for model parameters, as recommended for data with varying number of individuals across clusters (Heck et al., 2012, p. 147). Additionally, we selected a robust, more conservative approach to the calculation of the standard errors of regression coefficients to allow departures from normality.

The predictors included in the model were summarised to the site-level and grand-mean centred within the dataset that was included in the analysis by subtracting the overall sample mean from the site-level value. Grand-mean-centring recentres the site's standing on the variable against the sample mean and facilitates the interpretation of the coefficients of model parameters (Heck et al., 2012, p. 21). Summarising to the site level was necessary for the following dichotomous variables that were measured at the individual level: physical work, a habit of eating at the worksite cafeteria, and wish for support in healthy eating/physical activity. The summarising involved computing the proportion of individuals per site with the desired characteristic (e.g., physical work), and assigning the resulting values to the individual respondents of the corresponding site.

Results

Table S1. Associations between site-level predictors and an overall acceptance score below the 25th percentile (n=977).

Predictors included in the model	OR (95% CI)[1]	p-value[1]
Male employees per site	4.4 (1.2; 16.5)	.033
Respondents with physical work	2.2 (0.3; 15.5)	.388
Respondents eating at the worksite cafeteria	0.9 (0.1; 7.6)	.919
Respondents hoping for support in healthy eating	0.3 (0.0; 5.7)	.391
Respondents hoping for support in physical activity	1.2 (0.0: 128.3)	.930

[1] Odds ratio (95% confidence interval) and the significance of association between each predictor and an overall acceptance score below the 25th percentile, controlling for all the other predictors in the mixed-effects logistic regression model.

Reference

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III

Effectiveness of workplace choice architecture modification for healthy eating and daily physical activity

Rantala E, Vanhatalo S, Valtanen M, Lindström J, Pihlajamäki J, Poutanen K, Absetz P, Karhunen L

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RESEARCH

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Effectiveness of workplace choice architecture modification for healthy eating and daily physical activity

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Abstract

Background Modifying the choice architecture of behavioural contexts can facilitate health behaviour change, but existing evidence builds mostly on small-scale interventions limited in duration, targets, strategies, and settings. We evaluated the effectiveness of a one-year hybrid type 2 implementation-effectiveness trial aimed at promoting healthy eating and daily physical activity with subtle modifications to the choice architecture of heterogeneous worksites. The intervention was contextualised to and integrated into the routine operations of each worksite. Effectiveness was evaluated in a quasi-experimental pre-post design.

Methods Intervention sites ($n=21$) implemented a median of two (range 1–9) intervention strategies for healthy eating and one (range 1–5) for physical activity. Questionnaires pre ($n=1126$) and post ($n=943$) intervention surveyed employees' behavioural patterns at work (food consumption: vegetables/roots, fruit/berries, nuts/almonds/seeds, sweet treats, fast food, water; physical activity: restorative movement, exercise equipment use, stair use). The post-intervention questionnaire also measured employees' perception of and response to three intervention strategies: a packed lunch recipe campaign, a fruit crew-strategy, and movement prompts. Multi- and single-level regression models evaluated effectiveness, treating intervention as a continuous predictor formed of the site-specific dose (n intervention strategies employed) and mean quality (three-point rating per strategy halfway and at the end of the intervention) of implementation relevant to each outcome.

Results Multinomial logistic regression models found the intervention significantly associated with a favourable change in employees' fruit and berry consumption (interaction effect of time and implementation $p=0.006$) and with an unfavourable change in sweet treat consumption ($p=0.048$). The evidence was strongest for the finding concerning fruit/berry consumption—an outcome that sites with greater dose and quality of implementation targeted by using strategies that reduced the physical effort required to have fruit/berries at work and by covering multiple eating-related contexts at the worksite. The quality of implementation was positively associated with the

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perception of ($p = 0.044$) and response to ($p = 0.017$) the packed lunch recipes, and with response to the fruit crew-strategy ($p < 0.001$).

Conclusions The results suggest that a contextualised, multicomponent choice architecture intervention can positively influence eating behaviour in diverse real-world settings over a one-year period, and that higher implementation quality can enhance intervention perception and response. However, outcomes may depend on the type of intervention strategies used and the extent of their delivery.

Keywords Choice architecture, Nudge, Workplace, Health promotion, Prevention, Type 2 diabetes, Behaviour change, Diet, Physical activity

Background

The living environment can either help or hamper the adoption of healthy, sustainable lifestyles. A line of behavioural interventions pursues the former with focus on physical and social microenvironments. These interventions modify the way available options are presented in decision-making contexts to create choice architectures that gently "nudge" towards favourable behaviours without bans, substantial incentives, or rational argumentation [1, 2]. The approach acknowledges people's sensitivity to contextual influences and tendency to invest little deliberation in many daily choices related to health [3]. The theoretical foundation lies in the dual-systems models that suggest behaviour to stem from the interaction of automatic and reflective cognitive processes, which are fallible and sometimes lead to unfortunate directions [4, 5].

Within the field of behaviour change research, choice architecture interventions mostly target the opportunity component of the COM-B system that defines three interacting conditions that are necessary for a behaviour to occur: capability, opportunity, and motivation [6]. Opportunity refers to the social and physical factors outside the individual that make a behaviour possible or prompt it [6]. Choice architecture interventions can influence behaviour directly via automatic processes or more indirectly via reflective processes that advance individual agency by facilitating deliberation on personal preferences, values, or goals [5, 7, 8]. The more direct, behaviourally oriented interventions typically reduce the physical effort required to engage in the desired behaviour [9, 10]. The more indirect, cognitively or affectively oriented interventions reduce cognitive effort, appeal to emotions, or support self-regulation, for example, with increased visibility or comprehensibility of behaviour-related information; with enhanced salience or attractiveness of preferred behaviours; with reminders or social reference points, or by facilitating commitment to beneficial actions [9, 10].

Efficacy trials conducted in controlled laboratory or field settings suggest that on average, choice architecture interventions promote behaviour change with small to medium effect sizes across behavioural domains; eating behaviour appearing particularly responsive to these interventions [8]. However, effects vary substantially across studies [8], and many trials have failed to demonstrate significant effects [11]. Simultaneously, scientific literature seems biased towards successful interventions with small sample sizes, creating overoptimistic expectations of intervention impact [12–14].

Workplaces provide an optimal setting for health-promoting choice architecture interventions because they reach the majority of working age population regularly. Published interventions have nevertheless been limited along several dimensions of scale-up, such as intervention settings, targets, strategies, and duration. Worksite choice architecture interventions for healthy lifestyles have mainly nudged food choices at worksite cafeterias [15, 16] or prompted stair use over the elevator [17] but rarely targeted eating or daily physical activity in other contexts at the workplace [18–20]. Equally rare are real-world interventions that have lasted longer than few months [21] or involved multiple implementation sites with broader target populations [22–25]. Furthermore, few choice architecture interventions have integrated implementation metrics in their effectiveness evaluations, albeit implementation influences the impact of health promotion programmes at workplaces [26] and other community settings [27].

Greater focus on implementation could assist the interpretation of study outcomes [28] and explain part of the heterogeneity observed in intervention effects. Within the choice architecture domain, effects may depend on, inter alia, the number [24] and type [8, 9] of intervention strategies implemented, the extent to which implementation covers behaviour-relevant contexts [24] and choice options [22] in the targeted environment, as well as the magnitude of modifications made to the choice architecture [23, 29, 30].

To advance understanding of the potential of the choice architecture approach to promote healthy lifestyles, we need wider-scale interventions and effectiveness evaluations that acknowledge implementation. We hence evaluated the effectiveness of a one-year quasi-experimental choice architecture intervention for healthy eating and daily physical activity. The evaluation was based on the

dose (i.e., the number of intervention strategies applied) and quality of implementation. The intervention was conducted in real-world settings, adapted to local contexts, and integrated into the routine practices of diverse worksites. The study had two specific aims: (1) to assess intervention effectiveness on employees' self-reported food consumption and physical activity patterns at work, and (2) to assess the association between implementation quality and employees' self-reported perception of and response to the three most commonly applied intervention strategies.

Methods

Study design and setting

We rolled out a one-year hybrid type 2 implementation-effectiveness trial, StopDia at Work, between 2017 and 2019 in natural settings at workplaces from three regions of Finland (Northern Savo, South Karelia, and Päijät-Häme) [31]. The intervention aimed to promote healthy dietary choices and daily physical activity with subtle modifications to the worksite choice architecture. Hybrid type 2 designs have a dual focus on implementation and effectiveness outcomes, and they allow studying intervention effectiveness in new settings or populations while examining how to successfully implement the intervention [32]. Building on our implementation evaluation that was reported earlier [31], the current study evaluated the effectiveness of the StopDia at Work-intervention in a quasi-experimental pre-post design. The intervention was a part of a larger type 2 diabetes prevention study, Stop Diabetes (StopDia), that was approved by the research ethics committee of the hospital district of Northern Savo (statement 467/2016), Trial registration: NCT03156478 [33, 34].

Participating worksites

Fifty-three distinct worksites participated in the intervention. The worksites represented sixteen medium-to-large organisations from various fields (industry, retail, education, municipality, farming, healthcare, and welfare), had physical work environments suitable for choice architectural modification, and employed altogether approximately 5100 employees. From the effectiveness evaluation, we excluded ten sites that represented two organisations: an institute of higher education (5 worksites, ~370 employees) that moved to new premises halfway through the intervention and a retail operator (5 worksites, ~360 employees) with incomplete data collection. From 25 worksites that represented three organisations, we received data only at the level of organisation instead of individual worksite. Hence, with these worksites, the organisations served as the observational units of analysis. Our final study sample comprised thus 21 observational units (representing 43 worksites, 14 organisations, and ~4370 employees), which we refer to as "sites" (Additional file 1: Table S1). The sites represented both public (33%) and private (67%) sector and had a median of 46% (interquartile range, IQR 25–79%) male employees.

The management of participating sites gave their verbal informed consent for participation in the intervention. The employees of the intervention sites received general information on the larger Stop Diabetes study and the collaboration between their workplace and the study but were not disclosed the specific aim of the StopDia at Work-intervention to alter worksite choice architecture for healthy behaviours. This non-disclosure was to avoid interfering with employees' natural perception of and response to the intervention.

Nineteen (90%) sites completed the full one-year intervention and two sites a slightly shorter 9-month intervention. The sites with the shorter duration were construction yards that completed their construction work after nine months, and the sites were closed.

Intervention content and implementation

The content and implementation of the intervention were designed and contextualised to each participating worksite in collaboration between the research team and representatives of the worksites, as detailed earlier [31]. The representatives were local implementers selected among the personnel of the intervention sites. The implementers represented various occupational groups, including human resources (HR), occupational wellbeing, and work ability personnel; health and safety representatives; management; assistants; and catering staff. The co-design between the researchers and the implementers involved the selection of intervention strategies individually for each site from the StopDia Toolkit for creating health-promoting worksite environments. The toolkit was a hands-on instrument that described over 50 evidence-based strategies for modifying generic worksite choice architectures to facilitate healthy behaviours. The toolkit advanced the implementation of nutrition [35, 36] and physical activity [37, 38] guidelines and was informed by the nudge approach [1, 2], dual-systems models [4], and typologies of choice architecture interventions [39–41]. Additionally, the toolkit considered the needs and challenges of workplace health promotion that were identified in workshops and interviews conducted with contacted organisations over the recruitment process of the intervention [31].

The implementers of participating worksites delivered the intervention with the assistance of the research team. All adaptations maintained the essential elements of applied intervention strategies and were recorded carefully. In total 23 choice architecture strategies were employed across sites, sixteen for healthy eating and

seven for daily physical activity (Table 1). The strategies modified the worksite choice architecture by altering the availability, position (visibility or proximity), functionality (convenience or default), presentation (attractiveness), size (tableware or portion), or information (primes, prompts, simplification, or references to social norms) of choice options, or by supporting self-regulation (commitment or reminders) required for the promoted behaviour. Strategies for healthy eating were typically implemented in coffee rooms, worksite cafeterias, or meetings, and

Table 1 Description of strategies implemented in the intervention

#	Strategy	Target/type (subtype)[1]	Setting
	HEALTHY EATING		
1.	Make healthy food/beverage options available.	Availability	Meetings
2.	Increase (decrease) the selection/variety of healthy (less healthy) options.	Availability	Cafeteria
3.	Replace less healthy options with nutritionally better alternatives.	Availability	Meetings
4.	Enhance the placement of healthy options.	Position (visibility, proximity)	Cafeteria
5.	Worsen the placement of less healthy options.	Position (visibility, proximity)	Cafeteria
6.	Serve fruit ready to eat.	Functionality (convenience)	Meetings
7.	Increase perceived variety by serving salad components from individual containers.	Position (visibility), Presentation (attractiveness)	Cafeteria
8.	Use smaller serving dishes for less healthy options.	Size (tableware)	Cafeteria
9.	Use smaller serving utensils for less healthy options.	Size (tableware)	Cafeteria
10.	Use smaller serving sizes for less healthy options.	Size (portion)	Meetings
11.	One plate-policy, i.e., no separate salad/bread plate at lunch.	Functionality (default), Size (tableware)	Cafeteria
12.	Facilitate the recognition of healthy options with the Heart Symbol-nutrition labels at the point of choice.	Information (simplification, prompt)	Cafeteria
13.	Cue better choices with "Follow the heart"-posters that facilitate the recognition of options labelled with the Heart Symbol-nutrition label.	Information (prime)	Cafeteria
14.	Facilitate and remind of drinking water by providing employees with personal, reusable water bottles.	Availability	Personal workstation
15.	Encourage smart packed lunches with a year-long recipe campaign featuring temptingly named and visually attractive packed lunch recipes. The recipes covered various types of packed lunch options, including warm courses, salads, smoothies, and sandwiches with season's vegetables, fruit, and berries. The recipes met the nutritional criteria of national dietary guidelines but did not mention healthiness. Instead, they emphasised appealing sensory properties or ease of preparation. Campaign materials included one recipe for each week of the year, a poster, and a cardboard stand for printed recipe cards. The campaign slogan encouraged to form a habit of enjoying good packed lunches during breaks and featured a rhyme that encouraged to pick up a recipe card, stop by the store, and prepare, pack, and grab the packed lunch.	Presentation (attractiveness), Information (prompt, social norm)	Coffee rooms, lobbies, info screens, intranet, newsletters
16.	Encourage the provision of fruit at work by promoting and providing the "Fruit Crew"-starter set for forming fruit circles whose members take turns to organise fruit serving at work. The starter set included a poster that asked: "Already a member of the fruit crew?", instructions and enrolment form, and a recyclable fruit basket.	Self-regulation (commitment, reciprocity), Information (prompt, social norm)	Coffee rooms
	DAILY PHYSICAL ACTIVITY		
17.	Enable active sitting with balance cushions or wobble stools.	Availability	Common spaces
18.	Encourage stair use with footprints leading to stairs.	Information (prompt), Self-regulation (reminder)	Stairwell
19.	Encourage stair use with the StopDia logo (a stop hand-sign with a heart on the palm) by the elevator.	Information (prompt), Self-regulation (reminder)	Elevator
20.	Encourage movement with posters depicting simple exercises suitable to be performed, e.g., by the copy machine, microwave, coffee maker, or bathroom.	Information (prompt)	Common spaces
21.	Make light exercise equipment available, e.g., gym sticks, balance boards, or hanging bars.	Availability	Common spaces
22.	Enhance the placement of exercise equipment.	Position (visibility, proximity)	Common spaces
23.	Encourage movement with a computer-based break exercise application.	Information (prompt), Self-regulation (reminder)	Personal workstation

Healthy foods were defined as compliant with the nutritional criteria of national dietary guidelines [36] and the Heart Symbol system of the Finnish Heart Association and the Finnish Diabetes association [42], which define product category-specific criteria for fat (quantity and quality), salt, sugar, and fibre

[1]Target or type of choice architectural modification with concepts compiled from existing frameworks of choice architecture interventions [9, 10, 39–41]

strategies for daily physical activity in various common spaces, such as coffee rooms, copy rooms, monitoring rooms, bathrooms, or stairwells.

The median number of strategies implemented per site was four (range 2–14), a median of two (range 1–9) for healthy eating and one (range 1–5) for daily physical activity. The most common strategies were a packed lunch recipe campaign (#15) and a movement prompt strategy (#20) that all sites implemented, followed by a fruit crew-strategy (#16) that nine sites implemented (Table 1). These strategies could be delivered with print materials and/or digitally via info screens, emails, newsletters, or intranet. Participation in the intervention was free of charge for the sites, and the study provided materials for strategies that involved specific communication materials (#12, 13, 15, 16, 18, 19, 20). The sites were responsible for procuring any other materials needed for implementation, such as exercise equipment or new food products to worksite cafeterias.

Data collection

The effectiveness evaluation used employee-level data collected with questionnaires pre and post intervention and site-level implementation data collected with implementer interviews and on-site observation halfway through and at the end of the intervention. The pre-intervention questionnaire was conducted immediately before intervention launch and the post intervention questionnaire a year later at the end of the intervention. At the two intervention sites that completed a shorter, 9-month intervention, the post intervention data collection took place at nine months. The sites launched the intervention in a schedule that was convenient for them between December 2017 and May 2018.

The employee questionnaires were designed to be brief to enable completion during a short break at work and to keep the threshold for completion low. The employees of intervention sites were invited to answer the questionnaires online via the Questback®-tool (www.questback.com) or with paper and pen, depending on which was feasible for the site. Site implementers forwarded the invitations and questionnaires from the research team to the employees. A cover letter informed that the questionnaire was anonymous, a part of the StopDia-study, and aimed to explore employees' eating and physical activity habits at work. In the post intervention questionnaire, employees were encouraged to complete the questionnaire regardless of whether they had completed the pre intervention questionnaire. The collected questionnaire data comprised thus two cross-sectional datasets with partially overlapping samples. While the post intervention questionnaire enquired if the respondent had answered the pre intervention questionnaire as well, collected information did not enable linking individuals in the two datasets. Respondents gave their informed consent by voluntarily completing the questionnaire.

The site-level implementation data (implementer interviews and on-site observation) were collected over follow-up sessions at the intervention sites and/or via phone by the first two authors (ER, SV), as detailed elsewhere [31]. These authors were familiar with the intervention sites and the strategies the sites intended to implement. The authors had led the recruitment of participating organisations and the co-design of the intervention with the participating worksites. They also assisted the intervention sites in intervention implementation. The implementers who contributed to the data collection gave their verbal informed consent for participation.

Measures

Employee characteristics and behavioural patterns at work

The questionnaires pre and post intervention collected information on the respondent's predominant quality of work (physical vs. less physical), typical meal location (worksite cafeteria vs. else), and food consumption and physical activity patterns at work. The questionnaires asked the respondent to consider a typical work shift and respond accordingly. Data on the percentage of male employees per intervention site during the intervention year were received from site implementers.

Food consumption during a typical work shift was measured with six items that were adapted from a validated food frequency questionnaire (FFQ) [43] and selected as most relevant to the eating-related intervention strategies implemented. The items measured the consumption of vegetables and roots; fruit and berries; plain nuts, almonds, and seeds; sweet treats (e.g., confectionery, ice cream, chocolate, or sweets); fast food (e.g., meat pie, croissant, hamburger, sausage, or pizza); and water on a four-point scale (≥2 portions, 1 portion, < 1 portion, none). Additionally, we computed a diet quality score variable using the five FFQ-items of energy-containing foods (Additional file 1: Table S2). The score ranged from 0 to 26, a higher score reflecting higher diet quality at work. The scoring was based on a validated diet quality score, Healthy Diet Index (HDI) [44], that builds on the same FFQ as our questionnaires and evaluates adherence to a health-promoting diet congruent with the Nordic and Finnish nutrition recommendations.

Physical activity during a typical work shift was measured with three items, each with four response options, constructed to match the physical activity-related intervention strategies implemented. The items measured the performing of restorative movements (e.g., stretching), the use of exercise equipment when available (e.g., gym stick, therapy ball, hanging bar, or balance board), and the use of stairs when available. Regarding restorative movements and exercise equipment use, the response

options were several times, once or twice, less than once, and never. Regarding stair use, the response options were always, frequently, seldom, and never. Respondents who reported never performing restorative movements or never using available exercise equipment were additionally asked about reasons for these choices.

Employees' perception of and response to intervention

The post intervention questionnaire measured respondents' perception of and response to the three most commonly applied intervention strategies: the packed lunch recipe campaign (#15, Table 1) and the movement prompt strategy (#20) that all sites implemented, and the fruit crew-strategy (#16) that nine sites implemented. The questionnaire asked the respondent to consider the past twelve months and facilitated responding with images of intervention materials. Regarding strategy #15, the questionnaire enquired whether the respondent had noticed the packed lunch recipes at their worksite, and if yes, whether the respondent had become interested in the recipes, and whether the respondent had tried the recipes. Regarding strategies #20 and #16, the questionnaire enquired whether the respondent had noticed corresponding intervention materials at the worksite, and if yes, whether they had acted upon them. The post intervention questionnaire also asked whether the respondent wished for support for healthy eating or physical activity from the employer, and whether the respondent had completed the pre intervention questionnaire.

Dose and quality of implementation at intervention sites

For a meaningful evaluation of intervention effectiveness on the measured food consumption and physical activity patterns, we organised the intervention strategies implemented at each site according to targeted behavioural patterns (Table 2). This categorisation enabled forming behaviour-specific implementation variables by multiplying the number of strategies implemented per behavioural pattern (i.e., dose) by their mean implementation quality (Additional file 1: Tables S3–S4). Implementation quality was evaluated by the first two authors (ER, SV) who independently rated each intervention strategy at each site at two follow-up time points (halfway through and at the end of the intervention) on a three-point scale (2=successful, 1=imperfect, 0=failed) [31]. The evaluation built on an assessment framework that considered the essential elements of each strategy, fidelity to site-specific plans, the continuity of implementation, and accessibility to all employees. For behavioural patterns that were not targeted by specific strategies, i.e., the diet quality score and fast-food consumption (Table 2), we formed a global implementation variable of all eating-related intervention strategies implemented (Additional file 1: Table S3) to evaluate the effectiveness of the entire intervention.

To control for the effect of strategies implemented that did not target but potentially influenced each behavioural pattern measured, we formed a complementary implementation variable for each behaviour-specific primary implementation variable. The complementary variables excluded the strategies that were used to form the corresponding primary implementation variables and included the remaining strategies related to food consumption (with food consumption patterns) or physical activity (with physical activity patterns). For example, if a site implemented strategies targeting fruit use, vegetable use, and sweet treat use, the behaviour-specific primary implementation variable of fruit use considered the strategies implemented for fruit use, whereas the complementary variable considered the remaining strategies that targeted vegetable and sweet treat use.

Outcomes

Primary outcomes were employees' diet quality score; consumption of vegetables/roots, fruit/berries, nuts/almonds/seeds, sweet treats, fast food, and water; frequency of performing restorative movements, using exercise equipment, and using stairs during a typical work shift. Secondary outcomes were the noticing of, interest in, and trying of the packed lunch recipes (#15, Table 1); noticing of the fruit crew materials (#16) and joining a fruit crew; and noticing of and following the movement prompts (#20).

Statistical analyses

Statistical analyses were performed with IBM SPSS statistics® version 29.0 (IBM Corp., Armonk, NY, USA), considering p-value 0.05 of a 2-tailed test an indication of statistical significance. We describe the analyses concisely here and provide more details in the supplementary material (Additional file 1).

Intervention effectiveness on employees' behavioural patterns at work

For the continuous diet quality score outcome, we fitted a linear mixed model with site-level random intercepts. For the categorical food consumption and physical activity outcomes, we fitted single-level multinomial logistic regression models because including site-level random intercepts resulted in model convergence issues. The convergence issues were often accompanied with estimates of negligible variation in the random intercepts, suggesting that ordinary single-level regression models would be an appropriate choice [45, 46]. Missing data ranged from 0.0 to 0.8% across the models.

The models included the main effect of time (post vs. pre intervention) and implementation (dose*quality),

Table 2 Strategies implemented to increase (↑) or decrease (↓) specific food consumption and physical activity patterns

Site	Strategies									
	↑ Vegetables/roots	↑ Fruit/berries	↑ Nuts/seeds	↓ Sweet treats	↓ Fast food	↑ Water	Other foods[2]	↑ Movement	↑ Exercise equipment	↑ Stairs
a. Kindergarten	15	15, 16	15	-	-	-	-	20	-	-
b. Factory	15	15	15	-	-	-	-	20	-	-
c. Grocery	15	15	15	-	-	-	-	20	-	-
d. Construction yard	15	15	15	-	-	-	-	20	-	-
e. Construction yard	15	15	15	-	-	-	-	20	-	-
f. Grocery	15	15	15	-	-	-	-	20	-	-
g. Construction yard	15	15	15	-	-	-	-	20	-	-
h. Construction yard	15	15	15	-	-	-	-	20	-	-
i. Social services centre	15	15, 16	15	-	-	-	-	20	-	-
j. Grocery	15	15, 16	15	-	-	-	-	20	-	-
k. Greenhouse	15	1, 15	15	10	-	-	-	20	-	-
l. Factory	15	15, 16	15	-	-	-	-	20, 21, 22	21, 22	-
m. Bureau	15	1, 15, 16	15	-	-	-	-	20, 23	-	-
n. Bureau	15	15	15	-	-	-	-	20	-	18,19
o. Office	15	1, 6, 15	15	3	-	-	-	20	-	-
p. Grocery	15	15, 16	15	-	-	-	-	20, 21, 22	21, 22	-
q. Bureau	15	15, 16	15	-	-	14	-	20, 21, 22	17, 21, 22	-
r. Bureau[1]	4, 12, 13, 15	1, 4, 15, 16	2, 4, 12, 13, 15	5	-	4, 12, 13	2, 4, 5, 12, 13	20, 21, 22	21, 22	-
s. Hospital[1]	7, 12, 13, 15	15, 16	2, 12, 13, 15	-	-	-	2, 4, 5, 12, 13	20	-	-
t. Factory[1]	4, 12, 13, 15	1, 2, 4, 12, 13, 15	2, 12, 13, 15	2, 10	-	4	2, 4, 5, 11, 12, 13	20	-	-
u. Factory[1]	2, 4, 12, 13, 15	1, 2, 4, 12, 13, 15	2, 4, 12, 13, 15	2, 5, 8	-	2, 4	1, 2, 4, 5, 9, 12, 13	20, 21, 22	21, 22	18, 19

Strategies: (1) enable healthy choices, (2) ↑/↓ selection, (3) replace with healthier alternatives, (4) ↑ visibility/proximity, (5) ↓ visibility/proximity, (6) ↑ convenience, (7) ↑ perceived variety, (8) ↓ serving dish size, (9) ↓ serving utensil size, (10) ↓ serving size, (11) one plate-policy, (12) prompt with point-of-choice Heart symbols, (13) prime with "Follow the heart"-posters, (14) provide personal water bottles, (15) promote packed lunch recipes, (16) promote the Fruit Crew-starter set, (17) enable active sitting, (18) prompt stair use with footprints, (19) prompt stair use with the StopDia logo, (20) prompt movement with posters, (21) ↑ exercise equipment availability, (22) ↑ exercise equipment visibility/proximity, (23) prompt movement with a break exercise application

[1] Worksite cafeteria involved in the intervention

[2] Strategies for other food consumption patterns, including dairy (milk, sour milk, yoghurt, cheese), whole grain (bread, sandwiches, porridge, snack biscuits, casseroles), fats (salad dressing, fat spread), meat (cold cuts, bacon), salted herring, olives, healthier pastries (sweet buns, berry pies), sugar-sweetened beverages, and lunch portion sizes (one plate-policy)

as well as their interaction, which was interpreted as intervention effectiveness. The interaction parameters describe how the log odds ratio of belonging to a certain outcome category post versus pre intervention changes depending on the level of implementation. We present these estimates at exponentiated scale, i.e., as ratios of two odds ratios (ORR). In multinomial models, the overall significance of the interaction was assessed with likelihood ratio test. We adjusted the models with relevant available site-level covariates: the proportion of male employees at the site during the intervention year, the proportion of respondents with physical work at each time point, and the proportion of respondents with a habit of eating at the worksite cafeteria at each time point (in models related to food consumption). These variables reflected the gender distribution, occupational status, and meal patterns of site employees—factors proven to influence diet and physical activity [47–51]. Models with the behaviour-specific implementation variables additionally included the complementary implementation variables and their interaction with time to adjust for the strategies implemented that did not target but potentially influenced the given behavioural outcome.

In multinomial models, we set the least beneficial outcome category as the reference level. With vegetables and roots; fruit and berries; nuts, almonds, and seeds; water; and all physical activity outcomes, the reference was the lowest category. With sweet treats and fast food, the reference was the highest consumption category. We used the original four-category outcome variables in all models except for the one related to water consumption, which was transformed into a three-category variable by merging the two lowest levels due to model identification issues. As a sensitivity analysis, we ran all the models also without the two sites with a shorter, 9-month intervention to control for the potential influence of premature termination.

Association between implementation and employees' perception of and response to intervention

We assessed the association between implementation quality and employees' perception of and response to the three most commonly applied intervention strategies cross-sectionally based on post-intervention questionnaire data. For outcomes related to the packed lunch recipe campaign (#15, Table 1) and the movement prompt strategy (#20), we fitted mixed-effects logistic regression models with site-level random intercepts. For outcomes related to the fruit crew-strategy (#16), we used logistic regression models without site-level random intercepts due to convergence issues. Missing data ranged from 0.7 to 1.7% across the models.

The primary predictor of interest was the implementation quality of the outcome-related intervention strategy. Additionally, the models included relevant available site-level covariates: the proportion of male employees at the site during the intervention year, the proportion of respondents with physical work, the proportion of respondents who wished for support in healthy eating (in models related to #15–16) or physical activity (in models related to #20), and the proportion of respondents who reported having completed the questionnaire both pre and post intervention.

Results

Employee characteristics

The data collected among site employees comprised 1126 completed questionnaires pre intervention (median response rate across sites 34%, IQR 19–44%) and 943 completed questionnaires post intervention (median response rate 28%, IQR 23–58%) (Additional file 1: Table S1). The percentage of respondents with a physical work was 24% pre intervention and 23% post intervention. The percentage of respondents with a habit of eating at the worksite cafeteria was 23% at both time points. In the post intervention questionnaire, 24% reported that they had also completed the pre intervention questionnaire, 28% were not sure, and 46% had not.

Dose and quality of implementation at intervention sites

Each intervention site implemented at least one strategy that encouraged the consumption of fruit and berries (range 1–6 strategies per site), vegetables and roots (range 1–5 strategies), and nuts, almonds, and seeds (range 1–5 strategies), and at least one strategy for the performing of restorative movements (range 1–3 strategies) (Table 2). Five sites (24%) targeted sweet treat consumption (range 1–3 strategies) and five sites exercise equipment use (range 2–3 strategies). Four sites (19%) implemented strategies for water consumption (range 1–3 strategies) and two sites (10%) for stair use (2 strategies each). Mean implementation quality (scale: 0–2) was overall high, with a site-level median of 1.8 (IQR 1.5–2) for all eating-related intervention strategies implemented and 1.7 (IQR 1.5–2) for all physical activity related strategies implemented (Additional file 1: Table S3–S4).

Intervention effectiveness on employees' behavioural patterns at work

Food consumption

Multinomial logistic regression models detected a statistically significant association between the intervention and a favourable change in employees' fruit and berry consumption at work over the intervention year (interaction effect of time and implementation $p=0.006$) (Table 3). The intervention was associated with an increase in the proportion of employees who consumed one portion (ORR 1.2, 95% CI 1.0 to 1.3) and the proportion who consumed two or more portions (ORR 1.2, 95% CI 1.0 to 1.4) of fruit and berries during a typical work shift compared to the proportion who consumed none. Additionally, the intervention had a significant association with an unfavourable change in employees' sweet treat consumption ($p=0.048$). The intervention was associated with a decrease in the proportion of employees who consumed less than one portion (ORR 0.6, 95% CI 0.4 to 1.0) and the proportion who consumed zero portions (ORR 0.6, 95% CI 0.4 to 0.9) of sweet treats during a typical work shift compared to the proportion who consumed at least two portions. No significant associations were observed between the intervention and changes in the diet quality score or in the consumption of vegetables and roots; nuts, almonds, and seeds; fast food; or water. Model results were robust to the exclusion of the two sites with a shorter intervention.

Daily physical activity

Multinomial logistic regression models detected a statistically significant association between the intervention and changes in the frequency at which employees

Table 3 Intervention effectiveness on employees' behavioural patterns during a typical work shift

Outcome variable	n (%) pre[1]	n (%) post[1]	ORR (95% CI)[2]	*p*-value[3]
FOOD CONSUMPTION	1126	943		
Diet score (range 0–26 p.)	13 (9–17)	13.5 (9.5–18)	0.08 (-0.02; 0.18)	0.137
Vegetables/roots				0.849
≥ 2 portions	310 (27.5)	293 (31.1)	1.03 (0.69; 1.52)	
1 portion	432 (38.4)	376 (39.9)	1.09 (0.74; 1.58)	
< 1 portion	271 (24.1)	216 (22.9)	0.98 (0.66; 1.45)	
None	113 (10.0)	58 (6.2)	(ref)	
Fruit/berries				0.006
≥ 2 portions	216 (19.2)	184 (19.5)	1.22 (1.05; 1.41)	
1 portion	449 (39.9)	404 (42.8)	1.16 (1.01; 1.33)	
< 1 portion	283 (25.1)	254 (26.9)	1.03 (0.89; 1.19)	
None	178 (15.8)	101 (10.7)	(ref)	
Nuts/almonds/seeds				0.525
≥ 2 portions	36 (3.2)	29 (3.1)	0.98 (0.65; 1.47)	
1 portion	109 (9.7)	135 (14.3)	1.15 (0.93; 1.41)	
< 1 portion	344 (30.6)	325 (34.5)	1.08 (0.93; 1.24)	
None	637 (56.6)	454 (48.1)	(ref)	
Sweet treats				0.048
None	451 (40.1)	358 (38.0)	0.58 (0.35; 0.95)	
< 1 portion	546 (48.5)	473 (50.2)	0.60 (0.37; 0.99)	
1 portion	114 (10.1)	98 (10.4)	0.70 (0.42; 1.17)	
≥ 2 portions	15 (1.3)	14 (1.5)	(ref)	
Fast food				0.067
None	674 (59.9)	583 (61.8)	1.03 (0.88; 1.21)	
< 1 portion	347 (30.8)	288 (30.5)	1.08 (0.92; 1.27)	
1 portion	88 (7.8)	59 (6.3)	1.01 (0.85; 1.21)	
≥ 2 portions	17 (1.5)	13 (1.4)	(ref)	
Water				0.076
≥ 2 glasses	886 (78.7)	758 (80.4)	1.82 (1.03; 3.19)	
1 glass	168 (14.9)	137 (14.5)	1.70 (0.93; 3.11)	
< 1 glass or none	72 (6.4)	48 (5.1)	(ref)	
PHYSICAL ACTIVITY				
Performing of movements	1124	940		0.188
Several times	110 (9.8)	128 (13.6)	1.23 (0.99; 1.54)	
once or twice	396 (35.2)	330 (35.1)	1.15 (0.97; 1.37)	
Less than once	415 (36.9)	343 (36.5)	1.18 (1.00; 1.40)	
Never	203 (18.1)	139 (14.8)	(ref)	
Exercise equipment use[4]	386	405		0.040
Several times	9 (2.3)	15 (3.7)	1.78 (0.93; 3.40)	
once or twice	58 (15.0)	55 (13.6)	0.89 (0.70; 1.13)	
Less than once	109 (28.2)	105 (25.9)	0.82 (0.67; 1.00)	
Never	210 (54.4)	230 (56.8)	(ref)	
Stair use[4]	1030	881		0.170
Always	684 (66.4)	589 (66.9)	0.67 (0.33; 1.38)	
Frequently	227 (22.0)	212 (24.1)	0.76 (0.37; 1.57)	
Seldom	107 (10.4)	75 (8.5)	0.81 (0.39; 1.71)	
Never	12 (1.2)	5 (0.6)	(ref)	

[1]Frequencies (percentages) of valid observations pre and post intervention, except for the continuous diet score outcome, for which the data indicate medians (interquartile ranges)

[2]Exponentiated parameter estimates (95% confidence intervals) for the interaction of time and implementation

[3]Overall significance of the interaction effect of time and implementation in the model

[4]Among respondents who reported having exercise equipment/stairs available

used available exercise equipment at work (interaction effect of time and implementation $p=0.040$) (Table 3). Estimates suggested the intervention was associated with a decrease in the proportion of employees who used the equipment up to two times per work shift and with an increase in the proportion who used the equipment several times per work shift compared to the proportion who never used the equipment. No significant associations were observed between the intervention and changes in the performing of restorative movements or stair use. Model results were robust to the exclusion of the two sites with a shorter intervention.

Reasons for never performing restorative movements or never using available exercise equipment were abundant (Additional file 1: Table S5). The most common reasons across time points were that the idea never crossed one's mind; forgetting; the lack of time, space, or motivation; and embarrassment.

Table 4 Association between implementation quality and employees' perception of and response to three specific intervention strategies

Outcome variable	n (%)	OR (95% CI)	*p*-value
Packed lunch recipes			
Noticed materials	932		
Yes	649 (69.6)	5.42 (1.05; 27.83)	0.044
No	283 (30.4)	(ref.)	
Became interested in at least one recipe[1]	645		
Yes	434 (67.3)	1.19 (0.65; 2.20)	0.565
No	211 (32.7)	(ref.)	
Tried at least one recipe[1]	646		
Yes	203 (31.4)	2.32 (1.19; 4.54)	0.017
No	443 (68.6)	(ref.)	
Fruit crew-starter set[2]			
Noticed materials	533		
Yes	448 (84.1)	0.40 (0.20; 0.84)	0.015
No	85 (15.9)	(ref.)	
Joined a fruit crew[1]	444		
Yes	122 (27.5)	2.94 (1.82; 4.73)	< 0.001
No	322 (72.5)	(ref.)	
Movement prompts			
Noticed materials	928		
Yes	701 (75.5)	5.28 (0.86; 32.37)	0.067
No	227 (24.5)	(ref.)	
Followed the prompts[1]	701		
Yes	351 (50.1)	1.14 (0.57; 2.24)	0.633
No	350 (49.9)	(ref.)	

[1]Among respondents who noticed the materials

[2]Among respondents ($n=537$) of the nine sites that implemented the fruit crew-strategy

Association between implementation and employees' perception of and response to intervention

In the post intervention questionnaire, most respondents reported that they had noticed the packed lunch recipes (70%), the fruit crew-materials (84%), and the movement prompts (76%) (Table 4). Of these respondents, respectively, 67% had become interested in and 31% had tried at least one recipe, 28% had joined a fruit crew, and 50% had followed the movement prompts. In the post intervention sample, the proportion of respondents who wished that the employer would provide support for healthy eating was 37%, and the proportion who wished for support for physical activity was 61%.

Logistic regression models indicated that the quality of implementation was positively associated with the odds of noticing (OR 5.4, 95% CI 1.1 to 27.8) and trying (OR 2.3, 95% CI 1.2 to 4.5) the packed lunch recipes but unrelated with the odds of becoming interested in the recipes (OR 1.2, 95% CI 0.6 to 2.2) (Table 4). With the fruit crew-strategy, the quality of implementation was negatively associated with the odds of noticing the fruit crew materials (OR 0.4, 95% CI 0.2 to 0.8) yet positively associated with the odds of joining a fruit crew (OR 2.9, 95% CI 1.8 to 4.7). Implementation quality was not significantly associated with the odds of noticing or following the movement prompts.

Discussion

This study evaluated the effectiveness of a contextualised, multicomponent choice architecture intervention for healthy eating and daily physical activity conducted in real-world settings at heterogeneous worksites. Building on the interaction effect of time and site-specific dose and quality of implementation, the evaluation found the intervention significantly associated with a favourable change in employees' fruit and berry consumption and with an unfavourable change in sweet treat consumption at work over the one-year intervention. The intervention was also significantly associated with a change in the use of exercise equipment, but the meaning of this association was less straightforward to interpret. Associations with changes in other behavioural outcomes were non-significant. Implementation quality was positively associated with the perception of and response to the packed lunch recipes, and with response to the fruit crew-strategy.

Intervention effectiveness on employees' behavioural patterns at work

Food consumption

The strongest evidence we found on the effectiveness of the intervention concerned the consumption of fruit and berries. The intervention was associated with increased fruit and berry consumption, and the strength

of this association seemed to increase consistently from the lowest to the highest consumption level. Intervention sites implemented up to six strategies for fruit and berry consumption. An increased number of strategies meant greater diversity in the types of strategies used and in the mechanisms through which the strategies supposedly influence behaviour. Noteworthy, sites with greater dose and quality of implementation applied not only cognitively or affectively oriented strategies that influenced behaviour via reflective processes (i.e., the packed lunch recipes, the fruit crew-starter set, visibility enhancements, and/or nutrition labels) but also behaviourally oriented strategies that tangibly reduced the physical effort required to choose and consume fruit at work (i.e., increased availability and/or convenience). At sites with greater dose and quality of implementation, the intervention also targeted several eating-related contexts at the worksite (coffee rooms, meetings, and/or cafeterias). Consistent with our findings, other worksite choice architecture interventions have observed favourable effects on food consumption after implementing various types of strategies that function through various mechanisms (availability, visibility, proximity, promotion, and price incentives) [24] and after reducing effort with enhanced relative availability [23] and/or convenience [19] of targeted foods. Meta-analyses also suggest that behaviourally oriented strategies in general yield on average greater effects compared to cognitively or affectively oriented strategies [8, 9]. A further factor that may explain the association the present study found between the intervention and a favourable change in fruit and berry consumption is that fruit are a practical snack at work.

Besides fruit and berries, we detected no favourable associations between the intervention and changes in the consumption of other foods. For foods other than fruit and berries, sites used mainly subtle cognitively or affectively oriented strategies that demanded greater deliberation, motivation, and agency from the employees. While our acceptability evaluation that was based on implementer interviews and an employee questionnaire indicated that the strategies employed in the intervention were overall well received [52], the strategies were unlikely able to appeal to each individual in the broad target population, thus reducing effectiveness [8]. This rationale receives support from our field experiment at a worksite cafeteria that found three cognitively oriented strategies—priming health messages, prominent nutrition labels, and minor visibility enhancements—ineffective in improving food choices among customers who prioritised sensory appeal and familiarity [53]. On the contrary, health messages and labels accompanied with improved availability and/or visibility proved effective in a hospital cafeteria [21, 54, 55] and in a military dining hall [56]—contexts where health and fitness were likely appreciated.

Unexpectedly, the intervention appeared associated with an unfavourable change in sweet treat consumption. This association has at least two possible explanations. First, the strategies that reduced the serving sizes of sweet treats or replaced available sweet treat options with nutritionally better alternatives may have increased the number of portions consumed. Second, observations from intervention sites revealed that the reductions made to the visibility, proximity, or availability of sweet treats were overall small and covered only a part of the contexts at the worksites that provided sweet temptations and only a part of the sweet treat options available in these contexts. Prior research has found relatively small changes to visibility and availability ineffective in reducing the sales of snacks, such as candy and confectionery at worksite cafeterias [24]. Reviews on proximity [29, 30] strategies also suggest that intervention effects are proportionate to the magnitude of modifications. At the same time, reducing sweet treat consumption may be more challenging than increasing healthy food consumption and might thus require substantial changes to the physical and social worksite environment. The availability of indulging foods that conflict with attempts to eat healthily challenges self-regulation [57] and can trigger deliberate reasoning processes that justify the indulgence—as portrayed by the self-licensing effect [58, 59]. Providing sweet treats and enjoying them with colleagues can also be an important part of the work culture, with social norms preventing refusals [57].

Daily physical activity

The intervention appeared associated with a reduction in the proportion of employees with infrequent use of available exercise equipment yet an increase in the proportion with frequent use of the equipment, as compared with the proportion who never used the equipment. The meaning of these findings remains unclear, however, as the data do not support a straightforward interpretation. No significant associations were observed with other physical activity outcomes. While a meta-analysis suggested eating behaviour to be particularly responsive to choice architecture interventions [8], increasing daily physical activity may require stronger guidance and support from the social and organisational environment. The proportion of our questionnaire respondents who wished for support in physical activity from the employer was markedly greater than the proportion of respondents who wished for support in healthy eating. Common reasons for never performing restorative movements or using exercise equipment at work included forgetting, lack of time or space, and embarrassment. The importance of a supportive social environment was demonstrated in an

intervention for increased walking at the workplace [20]. In this intervention, a digital app that promoted social support and social comparison through team challenges was effective in increasing employees' daily step count, but motivational messages and point-of-choice prompts in the worksite choice architecture failed to maintain the achieved effects [20].

Association between implementation and employees' perception of and response to intervention

Based on the self-reported perception of intervention materials, the three most commonly applied intervention strategies (i.e., the packed lunch recipes, the fruit crew-strategy, and movement prompts) reached a strong majority of respondents. This finding reflects the overall high implementation quality across intervention sites and supports earlier evidence according to which prominently displayed intervention materials capture visual attention [53].

Higher quality of implementation predicted the noticing and trying of the packed lunch recipes but was unrelated to becoming interested in the recipes. This suggests that the effect of the quality of implementation on behaviour be mediated predominantly via noticing. Once the recipes were noticed, implementation had little influence on whether employees became interested in them. The finding is logical considering the strong and stable food preferences people often have. Emerging evidence suggests people are more likely to act upon choice architecture interventions when they agree with or hold no strong preferences against the nudged behaviours; thus validating the legitimacy of choice architecture interventions [60]. As supposed by the core principles of the choice architecture approach [2], interventions seem to maintain people's freedom to choose according to their preferences.

Interestingly, we observed higher implementation quality to decrease the odds of noticing the fruit crew materials yet increase the odds of joining a fruit crew. This counter-intuitive finding could be explained by the overall high rate of noticing the materials and by our implementation quality assessment that omitted intervention launch. At the sites with the lowest quality ratings, the fruit crew-materials were delivered successfully at the launch of the intervention but by the first follow-up assessment halfway through the intervention, the implementation had ceased. Nevertheless, all the respondents from these sites reported that they had noticed the materials. The successful launch thus likely facilitated the noticing of materials, while the soon fading implementation discouraged seizing on them. Another possible explanation is that at sites with successful implementation, the focus was on the activity of forming fruit crews and organising fruit serving at the worksite with less attention paid on the provided intervention materials.

Strengths and limitations

The strengths of this study include a theory- and evidence-based intervention conducted in real-world settings at over twenty diverse worksites by integrating the intervention into the routine operations of the sites. For enhanced feasibility and acceptability, the intervention was designed and contextualised to each participating worksite in collaboration with the sites. The sites applied a broad range of choice architecture strategies whose implementation was monitored systematically at two follow-up time points. The work produced thus evidence on over twenty unique implementations. Building on a mixed-methods evaluation of implementation [31] and employee-level self-reports pre and post intervention, the study developed an approach to evaluate effectiveness by considering the dose and quality of implementation relevant to each outcome measured. The study contributes to the translation and upscaling of choice architecture interventions from more controlled research settings to diverse real-world operations, providing insights on the effectiveness of the choice architecture approach in the workplace context.

Key limitations of the study include the lack of control group, scarce information available on the employees who completed the questionnaires, partly overlapping samples with no possibility to link individuals in the pre and post intervention datasets, a relatively low questionnaire response rate at the participating worksites, and reliance on error-prone self-reported data on employees' perception and behaviour. These limitations increase uncertainty in the study outcomes. Whilst we had no proper control group, we had intervention sites with varying levels of implementation. This enabled us to consider the intervention as a continuous variable and assess the effectiveness of incremental increases in the dose and quality of implementation. With half of the primary outcomes, the smallest number of outcome-related strategies implemented per site was zero. With the other half, the smallest number was one. While the data did not enable assessing the effectiveness of individual intervention strategies, this was not the purpose of the study in the first place. Prior research has produced evidence on the efficacy of individual choice architecture strategies. The current intervention focused thus on their wider-scale implementation in real-world circumstances. The intervention was designed to increase our understanding of the overall feasibility [31], acceptability [52], and effectiveness of the choice architecture approach in the workplace context.

Without identifiable data on questionnaire respondents, we were unable to track individuals from baseline

to follow up, to evaluate the extent to which the respondents represented the personnel of the participating worksites, or to examine the effects of individual characteristics on intervention effectiveness. Yet, we adjusted statistical analyses with relevant available site-level covariates, including the proportion of male employees, respondents with physical work, respondents eating at the worksite cafeteria, and respondents who completed the questionnaire both pre and post intervention. The decision to limit data collection to unidentifiable data was related to our choice not to disclose to site employees the specific aim of the intervention, which was to modify worksite choice architecture for healthy behaviours. At the time, it was unclear whether such disclosure would influence employees' perception of and response to the intervention. Later on, research has touched upon the topic and suggests that study subjects' awareness of the presence, purpose, or working mechanism of choice architecture interventions does not reduce intervention effectiveness [60]. Future studies could hence inform their target populations more freely of implemented interventions.

The food consumption and physical activity patterns measured in this study covered time spent at work and were hence unable to reveal changes in behavioural patterns outside working hours. Covered food consumption patterns were limited to six key food groups most relevant to the intervention strategies implemented, and the FFQ-items used to measure food consumption were quite crude. Thus, the available data provides merely suggestive evidence on the effectiveness of the intervention on the consumption frequency of diverse food types. The rationale for the brief data collection was the aim to design a questionnaire that could be completed with minimal effort during a short break at work. This methodological choice was assumed to result in greater response rates.

The constructed implementation variables had their limitations as well. Implementation dose, measured as the number of intervention strategies applied, did not consider the type of intervention strategy or the mechanism through which it was expected to change behaviour, although these characteristics have proved to influence effect sizes [8, 9]. Implementation quality, in turn, was measured on a three-point scale that was rather insensitive to variations in diverse aspects of implementation, such as the extent to which implementation covered relevant contexts and available choice options in the worksite environment, and the magnitude of modifications made to the targeted choice architecture. Additionally, the quality assessment was based on merely two follow-up measurements over the one-year intervention.

Implications for practice and research

For more effective future interventions, we recommend workplaces to employ intervention strategies that reduce the physical effort required from employees to eat well and stay active at work, and that cover all relevant behavioural contexts and available choice options at the worksite. Relying on strategies that encourage desired choices with enhanced visibility or subtle visual or written cues may not be enough, particularly if not tailored to the target group's behavioural goals and preferences. For increased physical activity, efforts to build a supportive social and organisational environment may also be required. For more accurate estimates of the effectiveness of choice architecture interventions in the real world, future studies should adopt stronger study designs and invest in the quality and quantity of data collected on intervention implementation and the target audience's characteristics and behaviour.

Conclusions

This study evaluated the effectiveness of a contextualised, multicomponent, and year-long choice architecture intervention for healthy eating and daily physical activity conducted in real-world settings at heterogeneous worksites. The evaluation built on the interaction effect of time and site-specific dose and quality of implementation. Results suggested that the intervention had a positive influence on employees' fruit and berry consumption at work. Likely contributing to this finding, sites with greater dose and quality of implementation targeted fruit and berry consumption by employing intervention strategies that tangibly reduced the physical effort required to choose and consume fruit or berries at work and by extending intervention delivery to multiple eating-related contexts at the worksite. Moreover, results suggested that higher implementation quality can positively influence the perception of and response to cognitively or affectively oriented choice architecture strategies. This finding, however, varied along the strategy implemented.

Supplementary Information

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Supplementary Material 1

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Author contributions

Conceptualisation and methodology: ER, SV, MV, JL, JP, KP, PA, LK; investigation: ER, SV, MV; data curation: ER, SV; formal analysis: ER, SV, MV, JL, PA, LK; writing—

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted according to the EU General Data Protection Regulation (GDPR), the Finnish code of conduct for research integrity, and the ethical principles of research with human participants as specified by the Finnish National Board on Research Integrity TENK. The management and implementers of participating organisations and intervention sites gave their verbal informed consent for participation in the portrayed intervention and related data collection that focused on the implementation of the study. The employees who responded the questionnaires gave their informed consent by voluntarily completing the anonymous questionnaires. The study was a part of the STOP DIABETES—knowledge-based solutions (StopDia)-research and development project whose experimental protocols were approved by the Research Ethics Committee of the Hospital District of Northern Savo (statement number: 467/2016, date of approval: 3 January 2017).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Publisher's Note

Supplementary material

Effectiveness of workplace choice architecture modification for healthy eating and daily physical activity

Content

Participating worksites

Table S1. Characteristics of intervention sites and questionnaire data collected pre and post intervention.

Site	Organisation/field	Sector	% Men	Pre			Post		
				n (%)	Physical	Café	n (%)	Physical	Café
a. Kindergarten	Municipality	Public	7	13 (43)	62	15	9 (30)	44	22
b. Factory	Food industry	Private	70	59 (24)	22	24	71 (28)	31	14
c. Grocery	Retail	Private	18	11 (15)	73	0	20 (27)	55	0
d. Construction yard	Construction industry	Private	100	12 (28)	92	0	21 (49)	81	0
e. Construction yard	Construction industry	Private	97	8 (25)	100	0	20 (63)	55	0
f. Grocery (3 worksites combined)	Retail	Private	20	102 (34)	45	2	42 (14)	60	5
g. Construction yard	Construction industry	Private	100	19 (63)	68	0	8 (27)	63	0
h. Construction yard	Construction industry	Private	100	14 (54)	43	0	9 (35)	56	0
i. Social services centre	Welfare	Public	5	17 (43)	0	0	27 (68)	0	0
j. Grocery	Retail	Private	18	29 (17)	52	0	39 (23)	62	3
k. Greenhouse	Farming	Private	35	24 (17)	46	0	12 (9)	33	0
l. Factory	Metal industry	Private	80	85 (14)	18	14	33 (6)	3	21
m. Bureau (2 worksites combined)	Municipality	Public	45	100 (45)	3	29	135 (61)	1	35
n. Bureau	Municipality	Public	29	25 (36)	4	52	47 (67)	4	62
o. Office	Construction industry	Private	56	22 (44)	5	0	21 (42)	0	0
p. Grocery	Retail	Private	18	46 (61)	57	0	49 (65)	61	0
q. Bureau	Municipality	Public	39	40 (50)	3	5	46 (58)	2	4
r. Bureau[1]	Municipality	Public	20	74 (25)	5	22	70 (23)	4	26
s. Hospital (20 worksites combined)[1]	Healthcare	Public	46	91 (19)	24	40	129 (26)	22	41
t. Factory[1]	Chemical industry	Private	75	152 (38)	24	48	8 (2)	63	25
u. Factory[1]	Forest industry	Private	78	183 (19)	13	34	127 (13)	16	36

%Men: percentage of male employees at the site during the intervention year
n (%): number of completed questionnaires (response rate)
Physical: percentage of respondents with a physical job
Café: percentage of respondents who typically ate at the worksite cafeteria
[1]Worksite cafeteria involved in the intervention.

Measures

Table S2. Formation of the diet score variable based on the Healthy Diet Index (Lindström et al., 2021)

Healthy Diet Index Portions	Score	StopDia at Work Portions per work shift	Score	Maximum	% Maximum
Vegetables and roots[1]					
≥ 3/day	12				
2/day	8	≥ 2	10*	10	38
1/day	4	1	4		
4-6/week	2				
1-3/week	1	< 1	1.5*		
< 1/week or none	0	none	0		
Fruit and berries[2]					
≥ 2/day	8	≥ 2	8	8	31
1/day	5	1	5		
4-6/week	2				
1-3/week	1	< 1	1.5*		
< 1/week or none	0	none	0		
Nuts, almonds, and seeds[3]					
≥ 2/day	2	≥ 2	2	2	8
1/day	2	1	2		
4-6/week	1				
1-3/week	1	< 1	1*		
< 1/week or none	0	none	0		
Sweet treats[4]					
≥ 2/day	0	≥ 2	0		
1/day	0	1	0		
4-6/week	1				
1-3/week	2	< 1	1.5*		
< 1/week or none	3	none	3	3	12
Fast food[5]					
≥ 1/day	0	≥ 2	0		
		1	0		
4-6/week	0				
1-3/week	1				
1-3/month	2	< 1	1*		
< 1/month or none	3	none	3	3	12
Maximum				26	100

[1]portion = e.g., a medium-sized carrot or 1 dl of salad or grated or cooked vegetables
[2]portion = a medium-sized fruit or 1 dl of berries
[3]portion = 2 tablespoons or 30 g
[4]portion = e.g., a piece of pie or cake, a Danish pastry or doughnut, 3–4 cookies, an ice cream cornet, or a chocolate bar
[5]portion = e.g., a meat pie, a hamburger, or a slice of pizza
*Scoring equals the average of corresponding servings in the Healthy Diet Index.

Table S3. Formation and descriptive statistics of implementation variables related to eating. D = dose, Q = mean quality (range 0–2), # = intervention strategy

	Vegetable/root			Fruit/berry			Nut/almond/seed			Sweet treat			Fast food			Water			Global		
	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q
Site																					
a. Kindergarten	1 (#15)	1	1	2 (#15, 16)	0.8	1.5	1 (#15)	1	1	0	0	0	0	0	0	0	0	0	2 (#15, 16)	0.8	1.5
b. Factory	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
c. Grocery	1 (#15)	1.5	1.5	1 (#15)	1.5	1.5	1 (#15)	1.5	1.5	0	0	0	0	0	0	0	0	0	1 (#15)	1.5	1.5
d. Construction yard	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
e. Construction yard	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
f. Grocery[1]	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
g. Construction yard	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
h. Construction yard	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
i. Social services centre	1 (#15)	2	2	2 (#15, 16)	1	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	2 (#15, 16)	1	2
j. Grocery	1 (#15)	1	1	2 (#15, 16)	1.5	3	1 (#15)	1	1	0	0	0	0	0	0	0	0	0	2 (#15, 16)	1.5	3
k. Greenhouse	1 (#15)	2	2	2 (#1, 15)	2	4	1 (#15)	2	2	1 (#10)	2	2	0	0	0	0	0	0	3 (#1, 10, 15)	2	6
l. Factory	1 (#15)	1	1	2 (#15, 16)	1	2	1 (#15)	1	1	0	0	0	0	0	0	0	0	0	2 (#15, 16)	1	2
m. Bureau[1]	1 (#15)	2	2	3 (#1, 15, 16)	1.5	4.5	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	3 (#1, 15, 16)	1.5	4.5
n. Bureau	1 (#15)	2	2	1 (#15)	2	2	1 (#15)	2	2	0	0	0	0	0	0	0	0	0	1 (#15)	2	2
o. Office	1 (#15)	2	2	3 (#1, 6, 15)	1.7	5	1 (#15)	2	2	1 (#3)	2	2	0	0	0	0	0	0	4 (#1, 3, 6, 15)	1.8	7
p. Grocery	1 (#15)	1	1	2 (#15, 16)	1.5	3	1 (#15)	1	1	0	0	0	0	0	0	0	0	0	2 (#15, 16)	1.5	3
q. Bureau	1 (#15)	2	2	2 (#15, 16)	2	4	1 (#15)	2	2	0	0	0	0	0	0	1 (#14)	2	2	3 (#14, 15, 16)	2	6
r. Bureau[2]	4 (#4, 12, 13, 15)	1.1	4.5	4 (#1, 4, 15, 16)	1.5	6	5 (#2, 4, 12, 13, 15)	1.1	5.5	1 (#5)	1	1	0	0	0	3 (#4, 12, 13)	0.8	2.5	8 (#1, 2, 4, 5, 12, 13, 15, 16)	1.2	9.5
s. Hospital[1, 2]	4 (#7, 12, 13, 15)	1.7	6.6	2 (#15, 16)	1.1	2.2	4 (#2, 12, 13, 15)	1.9	7.6	0	0	0	0	0	0	0	0	0	8 (#2, 4, 5, 7, 12, 13, 15, 16)	1.7	13.2
t. Factory[2]	4 (#4, 12, 13, 15)	1.8	7	6 (#1, 2, 4, 12, 13, 15)	1.8	11	4 (#2, 12, 13, 15)	1.8	7	2 (#2, 10)	2	4	0	0	0	1 (#4)	2	2	9 (#1, 2, 4, 5, 10, 11, 12, 13, 15)	1. 9	17
u. Factory[2]	5 (#2, 4, 12, 13, 15)	1.1	5.5	6 (#1, 2, 4, 12, 13, 15)	1.3	7.5	5 (#2, 4, 12, 13, 15)	1.1	5.5	3 (#2, 5, 8)	1.5	4.5	0	0	0	2 (#2, 4)	1.3	2.5	9 (#1, 2, 4, 5, 8, 9, 12, 13, 15)	1.4	13
Descriptive statistics																					
Min	1	1	1	1	0.8	1.5	1	1	1	0	0	0	0	0	0	0	0	0	1	0.8	1.5
Q1	1	1.1	2	1	1.5	2	1	1.1	2	0	0	0	0	0	0	0	0	0	1	1.5	2
Median	1	2	2	2	1.7	2	1	2	2	0	0	0	0	0	0	0	0	0	2	1.8	2
Q4	1	2	2	2	2.0	4	1	2	2	0	0	0	0	0	0	0	0	0	3	2	6
Max	5	2	7	6	2.0	11	5	2	7.6	3	2	4.5	0	0	0	3	2	2.5	9	2	17

Intervention strategies (#): 1. enable healthy choices, 2. ↑/↓ selection, 3. replace with healthier alternatives, 4. ↑ visibility/proximity, 5. ↓ visibility/proximity, 6. ↑ convenience, 7. ↑ perceived variety, 8. ↓ serving dish size, 9. ↓ serving utensil size, 10. ↓ serving size, 11. one plate-policy, 12. prompt with point-of-choice Heart symbols, 13. prime with "Follow the heart"-posters, 14. provide personal water bottles, 15. promote packed lunch recipes, 16. promote the Fruit Crew-starter set.

The table shows the mean implementation quality ratings of corresponding intervention strategies with values rounded to one decimal place. The mean values represent the average of individual strategies whose quality was rated at two time points, halfway through and at the end of the intervention.

[1] Data of 3 (grocery), 2 (bureau), and 20 (hospital) worksites combined.

[2] Worksite cafeteria involved in the intervention.

Table S4. Formation and descriptive statistics of implementation variables related to physical activity. D = dose, Q = mean quality (range 0–2), # = intervention strategy

	Movement			Exercise equipment			Stair use			Global		
	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q	D (#)	Q	D*Q
Site												
a. Kindergarten	1 (#20)	1	1	0	0	0	0	0	0	1 (#20)	1	1
b. Factory	1 (#20)	1	1	0	0	0	0	0	0	1 (#20)	1	1
c. Grocery	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
d. Construction yard	1 (#20)	1.5	1.5	0	0	0	0	0	0	1 (#20)	1.5	1.5
e. Construction yard	1 (#20)	1.5	1.5	0	0	0	0	0	0	1 (#20)	1.5	1.5
f. Grocery[1]	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
g. Construction yard	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
h. Construction yard	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
i. Social services centre	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
j. Grocery	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
k. Greenhouse	1 (#20)	1	1	0	0	0	0	0	0	1 (#20)	1	1
l. Factory	3 (#20, 21, 22)	1.7	5	2 (#21, 22)	2	4	0	0	0	3 (#20, 21, 22)	1.7	5
m. Bureau[1]	2 (#20, 23)	1.6	3.3	0	0	0	0	0	0	2 (#20, 23)	1.6	3.3
n. Bureau	1 (#20)	2	2	0	0	0	2 (#18,19)	2	4	3 (#18, 19, 20)	2	6
o. Office	1 (#20)	1	1	0	0	0	0	0	0	1 (#20)	1	1
p. Grocery	3 (#20, 21, 22)	2	6	2 (#21, 22)	2	4	0	0	0	3 (#20, 21, 22)	2	6
q. Bureau	3 (#20, 21, 22)	1.7	5	3 (#17, 21, 22)	1.3	4	0	0	0	4 (#17, 20, 21, 22)	1.5	6
r. Bureau[2]	3 (#20, 21, 22)	1.7	5	2 (#21, 22)	1.5	3	0	0	0	3 (#20, 21, 22)	1.7	5
s. Hospital[1, 2]	1 (#20)	1.5	1.5	0	0	0	0	0	0	1 (#20)	1.5	1,5
t. Factory[2]	1 (#20)	2	2	0	0	0	0	0	0	1 (#20)	2	2
u. Factory[2]	3 (#20, 21, 22)	2	6	2 (#21, 22)	2	4	2 (#18,19)	2	4	5 (#18, 19, 20, 21, 22)	2	10
Descriptive statistics												
Min	1	1	1	0	0	0	0	0	0	1	1	1
Q1	1	1.5	1.5	0	0	0	0	0	0	1	1.5	1.5
Median	1	1.7	2	0	0	0	0	0	0	1	1.7	2
Q4	2	2	3.3	0	0	0	0	0	0	3	2	5
Max	3	2	6	3	2	4	2	2	4	5	2	10

Intervention strategies (#): 17. enable active sitting, 18. prompt stair use with footprints, 19. prompt stair use with the StopDia logo, 20. prompt movement with posters, 21. ↑ exercise equipment availability, 22. ↑ exercise equipment visibility/proximity, 23. prompt movement with a break exercise application.

The table shows the mean implementation quality ratings of corresponding intervention strategies with values rounded to one decimal place. The mean values represent the average of individual strategies whose quality was rated at two time points, halfway through and at the end of the intervention.

[1] Data of 3 (grocery), 2 (bureau), and 20 (hospital) worksites combined.

[2] Worksite cafeteria involved in the intervention.

Statistical analyses

We studied the effectiveness of the StopDia at Work-intervention on the defined outcomes with mixed-effects models and conventional regression models. Mixed-effects models were specified with a 2-level data structure using site (n=21) as the clustering variable. We built linear mixed models for continuous outcomes and generalised linear mixed models for categorical outcomes, respectively, with the MIXED and GENLINMIXED routines of IBM SPSS statistics® version 29.0 (IBM Corp., Armonk, NY, USA). The default estimation method SPSS employs is restricted maximum likelihood (REML) in MIXED (Heck et al., 2021, p. 20) and a quasilikelihood approach called active set method (ASM) with Newton-Raphson estimation in GENLINMIXED (Heck et al., 2012, p. 27). We included random intercept as the random effect and selected variance components as the covariance structure for the random coefficients. We selected the Satterthwaite approximation to the degrees of freedom that were used to compute significance tests for model parameters, as recommended for data with varying number of individuals across clusters (Heck et al., 2012, p. 147). In the generalised linear mixed models for categorical outcomes, we additionally selected a robust, more conservative approach to the calculation of the standard errors of regression coefficients to allow departures from normality. Conventional single-level logistic regression models were built with the IBM SPSS NOMREG procedure for multinomial outcomes and with the IBM SPSS GENLIN procedure for dichotomous outcomes. Both procedures employ maximum likelihood estimation (Heck et al., 2012, p. 27).

For all outcome variables, we fitted first an intermediate model that included the primary predictor of our interest and then a final model that was adjusted for relevant covariates. As we used sites as observational units, independent variables included in the models were summarised to the site level to reflect site-level properties. The summarising concerned the following individual-level variables: physical work, a habit of eating at the worksite cafeteria, wish for support in healthy eating/physical activity, and the completion of the questionnaire both pre and post intervention. The summarising involved computing the proportion of individuals with the desired characteristic (e.g., physical work) per site and timepoint, and assigning the resulting values to the individual respondents of the corresponding site and time. The summarised variables were additionally grand-mean centred within the dataset that was included in the analysis by subtracting the overall sample mean from the site-level value. Grand-mean-centring recentres the site's standing on the variable against the sample mean and facilitates the interpretation of the coefficients of model parameters (Heck et al., 2012, p. 21).

Results

Table S5. Reasons for never performing restorative movements or using available exercise equipment.

Reason	% Pre	% Post	Difference in percentage points (post – pre)
for never performing movements	(n=203)	(n=139)	
Has not occurred to me	46	35	-11
Have no time	37	31	-6
Don't remember	23	35	12
Have no space	17	13	-4
Feel embarrassed	10	17	7
Don't want	9	11	2
Don't know how	3	3	0
Another reason[1]	2	6	4
for never using available exercise equipment	(n=210)	(n=230)	
Have no time	36	29	-7
Has not occurred to me	33	29	-4
Don't remember	30	35	5
Don't want	12	9	-3
Feel embarrassed	11	13	2
The equipment is not easily accessible	4	7	3
Don't know where the equipment is	3	1	-2
Don't know how	2	2	0
Another reason[2]	7	9	2

[1]e.g., move at home, no need, medical reason, physical work, work clothes.

[2]e.g., no need, medical reason, move after work, use breaks for eating, use break exercise application, prefer moving without equipment, laziness, heavy work clothing, pregnancy, does not feel good/useful, work community's objection, don't get around to using the equipment alone.

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IV

Sensory Appeal and Routines Beat Health Messages and Visibility Enhancements: Mixed-Methods Analysis of a Choice-Architecture Intervention in a Workplace Cafeteria

Rantala E, Järvelä-Reijonen E, Pettersson K, Laine J, Vartiainen P, Närväinen J, Pihlajamäki J, Poutanen K, Absetz P, Karhunen L

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Sensory Appeal and Routines Beat Health Messages and Visibility Enhancements: Mixed-Methods Analysis of a Choice-Architecture Intervention in a Workplace Cafeteria

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Abstract: Easier recognition and enhanced visibility of healthy options supposedly increase healthy choices, but real-world evidence remains scarce. Addressing this knowledge gap, we promoted nutritionally favourable foods in a workplace cafeteria with three choice-architectural strategies—priming posters, point-of-choice nutrition labels, and improved product placement—and assessed their effects on visual attention, food choices, and food consumption. Additionally, we developed a method for analysing real-world eye-tracking data. The study followed a pretest–posttest design whereby control and intervention condition lasted five days each. We monitored visual attention (i.e., total number and duration of fixations) and food choices with eye tracking, interviewed customers about perceived influences on food choices, and measured cafeteria-level food consumption (g). Individual-level data represents 22 control and 19 intervention participants recruited at the cafeteria entrance. Cafeteria-level data represents food consumption during the trial (556/589 meals sold). Results indicated that the posters and labels captured participants' visual attention (~13% of fixations on defined areas of interest before food choices), but the intervention had insignificant effects on visual attention to foods, on food choices, and on food consumption. Interviews revealed 17 perceived influences on food choices, the most common being sensory appeal, healthiness, and familiarity. To conclude, the intervention appeared capable of attracting visual attention, yet ineffective in increasing healthier eating. The developed method enabled a rigorous analysis of visual attention and food choices in a natural choice setting. We discuss ways to boost the impact of the intervention on behaviour, considering target groups' motives. The work contributes with a unique, mixed-methods approach and a real-world setting that enabled a multi-dimensional effects evaluation with high external validity.

Keywords: choice architecture; workplace cafeteria; food choice; nutrition; health promotion; eye tracking; mixed methods

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1. Introduction

Redesigning choice architectures—the way available options are presented in choice environments [1]—is a gentle, non-intrusive approach to promote healthy eating. The approach acknowledges people's limited ability to regulate behaviour deliberately according to their self-declared interests [2], and seeks to facilitate healthy behaviours, inter alia, by making healthier options more effortless and visible [3]. For the working population, workplace cafeterias are regular food-choice environments that contribute to a substantial

proportion of overall dietary intake [4,5]. Interventions conducted at workplace cafeterias have the potential to reach large audiences and improve workers' nutrition and health [6], an outcome that benefits employers and the society as well [7,8].

Interventions that facilitate the recognition and enhance the visibility of health-promoting foods have proved capable of encouraging healthier eating [9]. Examples of such interventions include visual cues that prime for healthy choices [10], nutrition labels that communicate the nutritional properties of foods [11,12], and changes to product placement [13,14]. Primes can involve words or images that activate motivations for healthy eating, consequently enhancing people's ability to recognize and choose healthy foods [15,16]. Nutrition labels prompt people to reassess their food choices at the point of choice and assist in identifying healthier options [17]. Improvements in product placement increase both visibility and convenience, for example, by placing healthy options at the eye level [18], first in line [19], or physically closer to the chooser [20]. Evidence suggests that the closer foods are the greater their consumption, and vice versa [14]. While priming and placement interventions influence behaviour more directly, often without noticing, nutrition labels require somewhat greater cognitive involvement [9,10]. Learnings from behavioural sciences stress the importance of conveying nutrition information in a way that considers actual human behaviour [16]. In food purchasing contexts, such behaviour typically follows decisions that build on simple-to-interpret cues rather than in-depth processing of detailed information [21,22]. According to the dual process theories of cognition, this translates to decision-making processes that employ automatic rather than reflective cognitive processes [23,24].

Despite a wealth of literature about priming, nutrition labels, and placement strategies, real-world evidence from workplace cafeterias remains limited and inconsistent [18,20,25–29]. Conflicting findings could be explained, for example, by the varying capabilities of interventions to capture participants' visual attention, a prerequisite for strategies that influence via eyesight [9,30]. Alternatively, target populations' diverse preferences could explain varying responses to interventions [31,32].

Attention is a limited resource that allows us to notice particular objects and decide whether to act upon them [33]. Attention can be captured by external stimuli that stand out in the visual field (i.e., bottom-up processing), or it can be driven by internal influences, such as prior experiences or current goals (i.e., top-down processing) [34–36]. Studies on visual attention have mainly relied on self-reports, such as interviews or questionnaires, although these methods may yield biased results, typically overestimating true attention [21,22,30,37].

Eye tracking enables the measurement of eye movements and provides an objective method to study visual attention and behaviour [38]. Fixations are eye movements that reflect exposure to visual stimuli [39]. During fixations, eyes hold gazed objects steady on the foveal region of the retina—the central 1–2 degrees of visual angle—enabling a detailed perception of fixated objects [40,41]. Since attention typically determines where the eyes go, fixations serve as proxies for the location of visual attention [38,39]. Visual attention, in turn, often projects the focus of current active processing [33]. In the food-choice context, greater visual attention may reflect the attraction of targeted foods [42] and predict subsequent food choices [15,36,43–45].

Eye tracking is commonly used in psychological, marketing, and consumer research, but it is less familiar to the fields of nutrition and health promotion. Moreover, the method has been applied nearly exclusively in hypothetical or simulated choice contexts [42]. While recent food-related eye-tracking experiments have moved from laboratories to more naturalistic environments [22,36,44,46,47], intervention studies are lacking that employ eye tracking to explore the food choice process in fully unconstrained real-world settings.

The aim of this study was to assess the effects of an intervention that promoted food choices of high nutritional quality in a workplace cafeteria with three choice-architectural strategies for easier recognition and enhanced visibility of targeted foods: (1) priming posters, (2) prominent point-of-choice nutrition labels, and (3) improved product place-

ment. In addition, the study developed a method for analysing eye-tracking data collected in a natural choice setting. Quantitative effects evaluation considered individual-level visual attention (i.e., total number and duration of fixations) and food choices, as well as cafeteria-level food consumption. The hypotheses were that prominently displayed posters and labels would catch the eye, and that the intervention would increase visual attention to promoted foods as well as the choices and consumption of these foods. Qualitative analysis considered perceived influences on food choices, observations of the intervention, and understanding of the used nutrition label. The mixed-methods approach that employed objective and subjective data and integrated quantitative and qualitative elements [48] enabled a multi-dimensional examination of the cascade of intervention effects from perception to action.

2. Materials and Methods

2.1. Study Design

The study followed a quasi-experimental pretest–posttest design and took place in a workplace cafeteria in the Northern Savo region of Finland between January and February 2018. Pre-intervention measurements took place at baseline and served as control for post-intervention measurements that took place five weeks later, immediately after the launch of the intervention. Both measurement periods lasted five days (Monday through Friday), during which the cafeteria served identical menus. The study is an independent part of a larger type 2 diabetes prevention study, Stop Diabetes (StopDia) [49] reviewed by the research ethics committee of the hospital district of Northern Savo, Finland (statement number: 467/2016, date of approval: 3 January 2017).

2.2. Setting

The study cafeteria was located in a municipal office building in an urban area and served approximately 150 customers per day. The clientele consisted predominantly of employees of the office and nearby workplaces, yet also included some individuals outside the working life, such as senior citizens and students. Lunch hours were daily from 10.30 a.m. to 1 p.m.

The cafeteria operated in a self-service model in which customers choose and compose their meals from a serving line (Figure 1). The cafeteria provided daily four warm main course options: two fish/meat courses, one vegetarian course, and one soup, together with relevant carbohydrate accompaniments (rice and/or potatoes) and steamed vegetables (see Supplementary Table S1 for the entire menu). The warm meals also included bread, beverages, and side salad. In addition, the cafeteria provided a salad bar as a cold main course option. The salad bar consisted of 18−19 salad components per day, including vegetables and fruits, mixed salads, protein sources (meat, egg, cheese, pulses, fish, and tofu varieties), and condiments (seeds, nuts, tortilla chips, and roasted onion crumbs), as well as a variety of dressings. Furthermore, the cafeteria sold some snacks and desserts. The cafeteria and its food offering represented a typical workplace cafeteria in Finland.

The cafeteria belonged to the Heart-symbol system of the Finnish Heart Association and the Finnish Diabetes Association (www.sydanmerkki.fi/en, accessed on 9 September 2022). The Heart symbol (Figure 2) is a voluntary, positive nutrition label that EU-Regulation (EC No. 1924/2006) acknowledges as a nutritional claim, and that food manufacturers and caterers can apply for their products. The symbol indicates nutritionally better choices that meet product category-specific nutrition criteria for the quantity and quality of fat, and the quantity of salt, sugar, and fibre. The criteria build on the Finnish nutrition recommendations [50], acknowledge major public health nutrition challenges prevalent in Finland [4], and are updated regularly by an independent expert group that consist of professionals in nutrition and medicine [51]. Since its launch in 2000, the symbol has become familiar to the majority of Finnish adults [51]. As a member of the Heart-symbol system, the study cafeteria was committed to provide daily at least one option in defined product categories (main course, side dish, bread, fat spread, milk/sour milk, salad, and

salad dressing) that fulfilled the Heart-symbol criteria. Yet, the cafeteria was allowed to also provide options that did not meet the criteria. The cafeteria had standardised recipes with calculations of the nutritional content of all foods prepared in the kitchen, and knowledge on the food items in their offering that met and did not meet relevant Heart-symbol criteria. Additionally, the Finnish Heart Association had granted the cafeteria the right to label their criteria-fulfilling foods with the Heart symbol. At baseline, however, the cafeteria did not inform their customers about the Heart symbol nor indicate corresponding options on the serving line (Section 2.4). Hence, while the cafeteria was a member of the Heart-symbol system and offered corresponding options, the customers had no way of knowing this merely by observing the cafeteria environment. The study cafeteria provided thus an appropriate setting to study the effects of choice-architectural strategies that facilitate the recognition and enhance the visibility of nutritionally beneficial options while the food offering remained unchanged. Hereafter, we refer to options that meet the nutrition criteria of the Heart symbol as "heart-foods" and options that do not meet the criteria as "non-heart-foods".

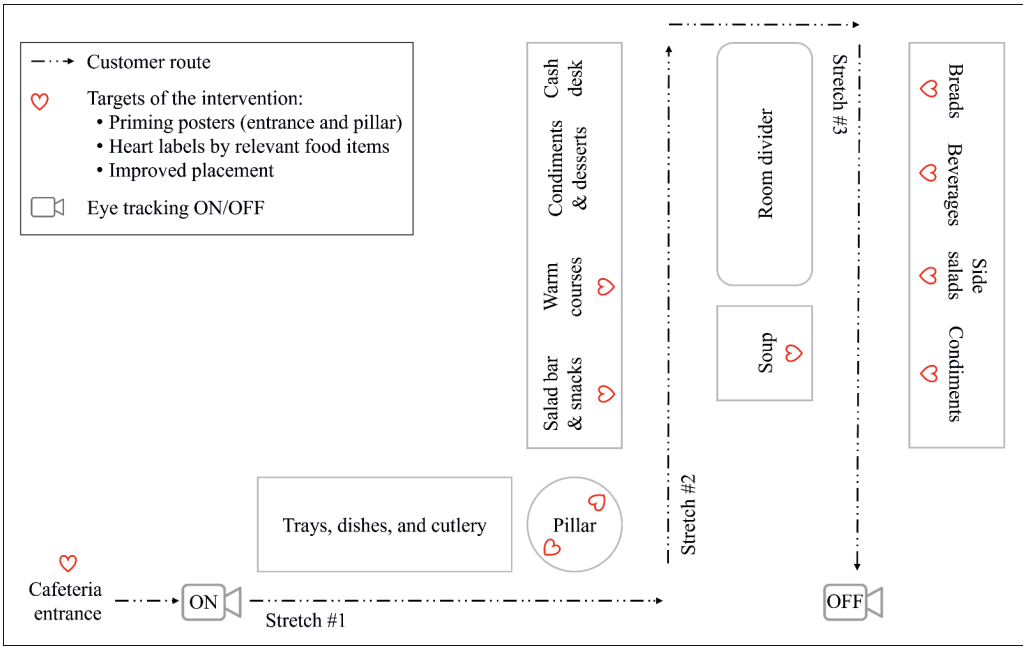

Figure 1. A schematic floor plan of the cafeteria serving line.

Figure 2. The Heart symbol with the text "better choice" in Finnish and Swedish. Image reproduced with the permission of the Finnish Heart Association.

2.3. Participants and Their Recruitment

A week before each study period, we displayed notices in the cafeteria that informed of a forthcoming consumer study and the opportunity for customers to participate. The personnel of the office building that housed the cafeteria received this information also via email from their human resources manager. During the study periods, we recruited participants at the entrance of the cafeteria. Participants were informed about study aims ("customer perceptions in the cafeteria") and data collection methodology. Participation in eye tracking required the ability to navigate through the cafeteria and to compose and pay for the lunch without eyeglasses. Hence, customers could participate either in eye tracking and interview or in interview only. During the intervention, to maximise data collected, we allowed participation both for customers that had participated during the control condition and for customers that had not. As a result, the samples recruited during control and during intervention included partly same and partly different individuals (Table 1). We thus apply statistical methods developed for comparing two partially overlapping samples that include both paired and independent observations [52–55]. Participants received fruit as a compensation for their contribution.

Table 1. The number of observations included in each analysis conducted in the study.

Analysis	Data	*n* Control + Intervention
Fixations on Heart-symbol materials and foods	Eye tracking	17 + 17 [1]
Food choices	Eye tracking	22 + 19 [2]
Perceived influences on food choices	Interview	22 + 19 [2]
Self-reported observations and understanding of the Heart symbol	Interview	22 + 19 [2]
Cafeteria-level food consumption	Food consumption	556 + 589 meals sold

[1] Excludes participants with unsuccessful eye tracking or zero fixations on defined areas of interest before food choices (control: $n = 5$, intervention: $n = 2$; see Section 2.6.1) and includes four individuals who participated in eye tracking and interviews in both study conditions. [2] Includes seven individuals who participated in eye tracking and interviews in both study conditions.

Altogether, 41 customers (control: $n = 22$, intervention: $n = 19$) participated in eye tracking and interviews, and an additional 51 customers (control: $n = 30$, intervention: $n = 21$) only in interviews. In this paper, we report the results of the sample that participated in both eye tracking and interviews because the data collected from the interview-only sample did not yield significant additional information relevant to the research questions of the current study (data not shown). The included sample of the control condition comprised 14 (64%) men and 8 (36%) women with a mean age of 43 years (SD 12, range 19–63). The included sample of the intervention condition comprised 10 (53%) men and 9 (47%) women with a mean age of 46 years (SD 10, range 31–63). No significant between-condition differences were found in the distributions of gender (partially overlapping samples "z_8"-test for comparing proportions [52]: statistic = −0.879, $p = 0.379$) or age (partially overlapping samples t-test "T_{new1}" with equal variances assumed [53,55]: statistic = −0.986, $p = 0.332$). The intervention sample included eight individuals (six men and two women with a mean age of 44 years [SD 9, range 31–58]) who had participated also during the control condition in eye tracking and interviews ($n = 7$) or only in interviews ($n = 1$). The gender and age distribution of these participants did not differ significantly from other participants of the intervention condition (Fisher's exact test $p = 0.170$; t [17] = −0.770, $p = 0.452$, respectively).

The majority of participants appeared to be familiar with the cafeteria. Although we did not enquire about this specifically, 11 (50%) participants of the control condition clearly implied in their reports that they had been in the cafeteria before. On the other hand, only one participant of the control condition mentioned not having been to the cafeteria before. In the intervention condition, all participants were assumed to be familiar with the cafeteria because none declared themselves first-timers when we asked if they noticed any changes in the cafeteria compared to earlier.

2.4. Control and Intervention Condition

During the control condition, we made no changes in the cafeteria. At this point, Heart-foods were not readily identifiable on the serving line. Their recognition required efforts to search for nutrition information typically provided in the small print of menus or product packages (Table 2). The arrangement of heart-food and non-heart-food options on the serving line was not systematic.

Table 2. Choice-architectural elements in place (x) during control and intervention. Heart-food refers to food items that met the product category-specific nutrition criteria of the Heart symbol.

Element	Description	Control	Intervention
Standard nutrition information	Heart-food main course options indicated with tiny black-and-white Heart symbols (font size ~8 pt.) next to allergen information on menu boards (size A4) at the cafeteria entrance and on the serving line.	x	x [1]
	Pre-packaged heart-food items such as salad dressings featured small front-of-pack or back-of-pack Heart symbols. Seeing the symbols required lifting the products up from the serving line and reviewing product information.	x	x [1]
Priming	Heart-foods promoted with posters (size A4–A3) at the cafeteria entrance and on two sides of a pillar at the end of serving line stretch #1. Each poster featured one of two slogans: "Follow the heart" or "A sign of good food".		x
Prominent point-of-choice nutrition labels	Heart-foods and salad-bar notices (size A4) labelled with up to 10 × 10 cm Heart symbols on the serving line.		x
Placement	Heart-foods placed first in line and towards the front row, non-heart-foods last in line and towards the back row within product categories (i.e., snacks, salad components, salad dressings, warm courses, breads, and beverages). Heart-food snack options lifted at the eye level.		x

[1] No changes were made to the information that was available already at baseline.

During the intervention, we promoted heart-foods with three choice-architectural strategies: priming, point-of-choice nutrition labels, and placement (Table 2). The first author (E.R.) was responsible for the implementation, made needed adjustments each day before the beginning of the lunch service, and monitored the quality of implementation throughout the intervention. The priming strategy displayed posters at the cafeteria entrance and on the serving line (Figure 3), and the point-of-choice labelling strategy indicated all available heart-foods with Heart symbols (Figure 4). The only exception was the salad bar whereby limited space impeded labelling individual salad components separately and unambiguously. The salad components were hence labelled as a whole, and a sign informed that the salad bar enables composing a meal that deserves the Heart symbol. Consequently, our data analyses categorised all salad components as heart-foods. Salad dressings, however, were labelled individually.

The placement strategy set heart-food items first in line and towards the front row and non-heart-food items last in line and towards the back row within product categories (Table 2). Heart-food snack items were additionally lifted on the top shelf of a display to enable eye-level view. On serving line stretch #2 (Figure 1), the placement manipulation excluded the soup whose position was fixed due to the layout of the serving line. In addition, according to the wishes of the cafeteria staff, the placement of a couple of other warm courses remained suboptimal on two days of the intervention week due to practicalities concerning cleanliness and food sufficiency. Otherwise, the implementation on stretches #1–2 followed plans. According to literature, expecting perfect or near-perfect implementation is unrealistic and unnecessary because few interventions have reached implementation levels closer than 80% of optimal and because studies have yielded pos-

itive results with levels around 60% [56]. We hence considered the implementation on stretches #1–2 overall satisfactory. On serving line stretch #3, however, the implementation faced major challenges throughout the intervention week because most food items kept travelling away from their assigned places and corresponding Heart labels as customers handled them. Such implementation quality was unacceptable, as the findings would not have reflected the intended intervention. Hence, our data analyses considered only data collected at stretches #1–2.

Figure 3. Posters that primed customers to notice and choose Heart-labelled foods. Original posters were in Finnish. Images reproduced with the permission of the Finnish Heart Association.

Figure 4. Examples of labelled heart-food items during the intervention. The dark green circle on the bottom left image indicates the point of a participant's fixation. Images reproduced with the permission of the study cafeteria.

2.5. Data Collection

Our data collection methods comprised eye tracking, recording cafeteria-level food consumption, and interviews. Collected data involved no identifiable information on study participants.

2.5.1. Eye Tracking

We collected eye-tracking data to study the effect of the intervention on visual attention to Heart-symbol materials, heart-foods, and non-heart-foods, as well as on food choices. The recording started before participants reached the beginning of the serving line and ended after they left the serving line (Figure 1). The data were collected with video-based mobile eye-tracking glasses (iViewETG 2.7, SensoMotoric Instruments GmbH, Teltow, Germany) that take 30 frames per second (i.e., 30 Hz binocular sampling rate) and feature a scene camera with a resolution of 1280 × 960 pixels (Figure 5). This device captures the wearer's eye movements with two small cameras on the bottom rim of the glasses and maps the point of gaze into a scene video [57]. An experienced research technician was responsible for handling the eye-tracking device throughout the study.

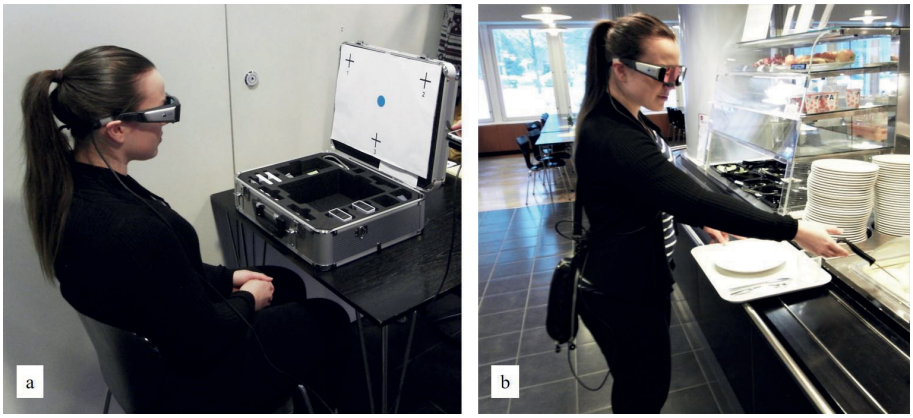

Figure 5. (**a**) The calibration of eye-tracking glasses; (**b**) Test subject wearing eye tracking glasses. Images reproduced with the permission of the study cafeteria and the test subject.

We calibrated the eye-tracking glasses for each participant with a three-point calibration protocol [57] (Figure 5a). After the calibration, we added study identification codes on participants' trays and instructed participants to proceed to the serving line, compose the lunch meal of their choice, and pay for the meal as they normally would (Figure 5b). After leaving the serving line, the research technician took the eye-tracking glasses and guided participants to the interview (Section 2.5.3).

2.5.2. Cafeteria-Level Food Consumption

To compute cafeteria-level food consumption, we manually recorded the weights (g) of all food items available on the serving line during the lunch service, as well as corresponding leftovers at the end of the service. This procedure recurred every day during control and intervention. Before the beginning of the lunch service, we obtained recorded measures by weighing served food items with the cafeteria's kitchen scale, by consulting waybills that reported the quantities of foods supplied from the caterer's central kitchen, and/or by information that manufacturers provided on packaged food products. During the lunch service, the cafeteria staff reported the type and quantity of foods they added on the serving line. At the end of the service, we weighed all leftovers with the same kitchen

scale as before the beginning of the service. The consumption data were recorded by the first and the second author (E.R. and E.J.-R.) together with three nutrition students.

2.5.3. Interviews

After participants had composed their meals and before they started to eat, we photographed their trays and interviewed them. The interview aimed to capture factors participants perceived to influence their food choices, as well as participants' observations of the intervention and understanding of the Heart symbol. During both control and intervention, we enquired perceived influences on food choices with three questions: one about factors participants paid attention to on the serving line while composing meals, one about factors that determined participants' choices on the participation day, and one about factors participants usually held to be important when choosing foods. In addition, we asked whether participants' choices on the participation day were typical of them. Recorded demographics comprised age and gender.

During the intervention, we additionally asked whether participants noticed any changes in the cafeteria. If they did, we asked them to elaborate the observed changes, their opinion on the changes, as well as perceived effects of the changes on their food choices. At the end of the interview, we showed participants the Heart symbol (Figure 2) and asked if they were familiar with it and how did they interpret it. Finally, participants reported whether they had participated in the study also during the control condition.

The interviews lasted up to five minutes per participant and were conducted by the second author—an authorised nutritionist (E.J.-R.)—together with two nutrition students. Longer interviews were not feasible, because participants had to be dismissed before their foods got cold. The interviewers took field notes of participants' answers and typed the answers as soon as possible after the interviews.

2.6. Analyses

2.6.1. Fixations on Heart-Symbol Materials and Foods

We analysed the collected eye-tracking data with SMI BeGaze™ 3.4 behavioural and gaze analysis software build 52, 2014© [58]. This software detects fixations with a dispersion-based algorithm that identifies fixations as groups of consecutive data points within a particular dispersion [59]. The software uses a minimum fixation-duration threshold of 80 ms. We analysed the detected fixations with a scan path visualisation that indicates the point of each fixation with a colourful circle on the scene video that represents participants' field of vision (Figure 4). In this visualisation, the software uses a maximum fixation-duration threshold of 500 ms. Following the software thresholds, we limited our analysis to 80–500 ms long fixations. The analysis covered the section between participants' arrival to serving line stretch #1 and the moment when they had passed by the targets of the intervention at stretch #2 (Figure 1). This section had satisfactory implementation throughout the intervention. We exported full reports of each participant's fixations from the eye-tracking data analysis software, and from these reports, extracted 80–500 ms long fixations within the target section.

We coded the extracted fixations manually based on visual inspection of freeze-frames from participants' eye-tracking videos; a method used in coding eye-tracking data from shopping environments [22,44]. The coded data comprised in total 7261 fixations (control: n = 3581, intervention: n = 3680) from 37 participants with unbroken eye-tracking recordings (control: n = 19, intervention: n = 18). The recordings of two participants (control: n = 1, intervention: n = 1) appeared to be poorly calibrated, however, and were excluded from the analysis. After this exclusion, the data covered 6949 fixations (control: n = 3368, intervention: n = 3581) from 35 participants with successful eye-tracking recordings (control: n = 18, intervention: n = 17).

The first author (E.R.) was responsible for coding the fixations. She had been involved in designing and implementing the intervention, and she knew the locations of all objects of interest on the serving line as well as the categorisation of available foods into heart-

and non-heart options. Such single-coder approach has been used in eye-tracking research with manually laborious analysis [46], and is a methodologically sound choice as long as it includes checks on validity and reliability [60]. We promoted validity and reliability through a peer-checking process typical of qualitative research [60,61]. The peer-checking meant that the first author iteratively reviewed samples of fixations and suggested coding with several other authors (E.J.-R., K.P. (Kati Pettersson), J.L., J.N., P.A., and L.K.), and the authors discussed, refined, and agreed on the coding.

For the coding, we listed all objects of interest on the serving line stretches #1–2 (Supplementary Table S1) and defined the area of interest (AoI) for each object (Supplementary Table S2). The AoIs covered the priming posters and point-of-choice Heart symbols added on the serving line during the intervention, as well as all heart-food and non-heart-food items available during control and intervention. We coded fixations whose point indicators touched any AoIs in the video frame (control: n = 1489 [44.2%], intervention: n = 1761 [49.2%]) according to three target groups: (1) Heart-symbol materials, (2) heart-foods, and (3) non-heart-foods. The coding was not mutually exclusive, because the fixation point indicator could touch several objects simultaneously. In such situations (control: n = 24 [0.7%], intervention: n = 206 [5.8%]), fixations received codes according to all touched objects. If fixation targets were unidentifiable due to long distance and/or blurry video, fixations were excluded and coded "unclear" (control: n = 1 [0.03%], intervention: n = 3 [0.08%]). Fixations that touched foods on participants' own or other customers' plates were coded according to their targets only when the plates and hence the fixated foods were lifted over corresponding AoIs on the serving line during portioning, and before the point of choice of the foods were passed (control: n = 116 [3.4%], intervention: n = 130 [3.6%]).

Besides coding the fixations that touched AoIs according to their targets, we also coded these fixations depending on their timing relative to food choices. A food choice referred to the first time when participants started to portion a given food. Moments of choice were determined case-by-case and involved, for example, reaches for food items or their serving utensils, reaches for salad bowls reserved for customers that chose the salad bar, or moments in which participants began to remove the caps of salad dressing bottles to enable pouring. Since the study aims to capture the potential effect of the intervention on food choices, we were particularly interested in fixations that preceded food choices. We gave fixations a code "pre" when they touched foods or related Heart-symbol materials before choices were made concerning the targeted foods (control: n = 674 [20.0%], intervention: n = 991 [27.7%]), and focus further analyses on these fixations. This coding was conducted at the level of food item, except for salad components in the salad bar that were considered as a whole (Supplementary Table S2).

At serving line stretch #1 (Figure 1), the intervention comprised one "Follow the heart"-poster (Figure 3) and one Heart symbol (Figure 2) attached to a salad bar notice. Only two participants of the intervention condition had fixations that swept the AoIs of these objects (2–3 fixations per participant). Hence, we chose to limit further analyses to fixations at serving line stretch #2, for which most of the AoIs were drawn and whereby participants made their actual food choices. The final data set comprises 1660 fixations (control: n = 674, intervention: n = 986) on AoIs before food choices were made. Within this sample, the proportion of fixations with overlapping targets (Heart-symbol materials, heart-foods, and/or non-heart-foods) is 12.0% (control 3.4%, intervention 17.8%).

Our main outcome measures are the total number and total duration of fixations participants had on Heart-symbol materials, heart-foods, or non-heart-foods before food choices at serving line stretch #2. Due to between-participant differences in the time spent at the serving line and in the number of fixations accumulated during this time, we follow a procedure used before [15,46] and report the outcomes as the percentages of participants' total fixations on AoIs before food choices at stretch #2. The final study sample consists of 17 participants of the control condition and 17 participants of the intervention condition, excluding one participant of the control condition who had zero fixations on

AoIs, and to whom we were thus unable to compute percentages. In addition to the main outcomes, to illustrate the share of overall visual attention that fixations on AoIs covered, we report the percentages of these fixations within participants' total fixations by the analysed section of serving line stretch #2. We examined differences between the control and the intervention condition using the partially overlapping samples *t*-test "T_{new1}" for comparing the means of normally distributed variables with equal variances [53,55], and the non-parametric counterpart "T_{RNK1}" test for assessing the location shift of non-normally distributed variables with equal variances [54]. We checked the normality assumption with the Shapiro-Wilk test and the visual inspection of distribution curves, and the equality of variances assumption with the partially overlapping samples variances test "T_{var1}" [62]. We report all *p*-values two-tailed, using *p*-value 0.05 as the level of statistical significance. For data management and analysis, we employed Microsoft Excel® 2016 (Redmond, WA, USA), IBM SPSS® Statistics 28.0 (Armonk, NY, USA), and R version 4.2.1 [63] with the "Partiallyoverlapping" R-package version 2.0 [64].

2.6.2. Food Choices

We tracked participants' food choices from their eye-tracking videos and recorded each food item participants added on their trays. With four participants whose eye tracking failed entirely so that the recordings could not be played (control: $n = 3$, intervention: $n = 1$), we relied on their interview answers and photos taken of their meals (Section 2.5.3). We examined food choices at the level of food item, considering individual snacks, salad components, salad dressings, warm courses, condiments, and desserts chosen from serving line stretch #2 (Supplementary Table S1).

Our main outcome measures are the number of food items chosen per participant during control and intervention, and the percentages of these items that were heart- and non-heart-options. As the outcome variables did not follow a normal distribution across the conditions (Shapiro-Wilk test $p < 0.05$), we examined differences between the control and the intervention condition using the non-parametric partially overlapping samples "T_{RNK1}" test with equal variances assumed [54]. We checked the equality of variances assumption with the partially overlapping samples variances test "T_{var1}" [62]. We report all *p*-values two-tailed, using *p*-value 0.05 as the level of statistical significance. We ran the analyses with and without participants who chose the salad bar as they had a greater number of items to choose from compared to warm-course choosers, and because all salad components were categorised as heart-food items (Section 2.4). For data management and analysis, we employed Microsoft Excel® 2016 (Redmond, WA, USA), IBM SPSS® Statistics 28.0 (Armonk, NY, USA), and R version 4.2.1 [63] with the "Partiallyoverlapping" R-package version 2.0 [64].

2.6.3. Cafeteria-Level Food Consumption

To obtain cafeteria-level estimates of food consumption, we subtracted the weight (g) of leftovers from the weight of foods served over the lunch service. The analysis covered food items available on serving line stretch #2 (Figure 1, Supplementary Table S1), excluding snacks and desserts due to incomplete data collection. Among the foods included in the analysis, missing data concerned 0.56% of total measurements. With food items that were available daily, missing measurements were replaced with the mean consumption of the given food item during the rest of the given study condition. With food items that were not available every day, missing data led to the removal of the items from the control and the intervention data of the given weekday. Our main outcome measures are the total volume of foods consumed (g) during control and intervention divided by the number of meals sold over each period, and the percentages of these consumption volumes that heart-foods and non-heart-foods covered. Similar to the food-choice analysis, we report the consumption results with and without meals composed from the salad bar. For data management and analysis, we employed Microsoft Excel® 2016 (Redmond, WA, USA).

2.6.4. Perceived Influences on Food Choices

We employed descriptive qualitative content analysis [65] to identify and code factors participants perceived to influence their food choices. We employed a coding matrix that built on the nine dimensions of the Food Choice Questionnaire (FCQ) that assesses perceived influences on food selection at the individual level [66]. The tool has proved applicable across cultures and populations [67]. The nine dimensions of the FCQ are: health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, and ethical concern. In addition, we included in our coding matrix the dimension "openness to experience" from the NEO Personality Inventory (NEO-PI) [68]. This personality trait predicts willingness to try new foods [69], and has proved to correlate negatively with the FCQ factor "familiarity" [66]. For data management and analysis, we employed NVivo R1.6 (QRS International) and Microsoft Excel® 2016 (Redmond, WA, USA).

The first author (E.R.) systematically coded the data according to the coding matrix, maintaining the freedom to modify category headings to reflect the content of the interview data better. For example, the NEO-PI dimension "openness to experience" evolved into "variation". When relevant, new categories were generated following the principles of inductive qualitative content analysis [65]. The coding was not mutually exclusive, meaning that individual interview answers could receive several codes. The validity and reliability of the coding was ensured with a peer-checking method common in qualitative research [60,61]. The first author reviewed example quotes from the interviews against suggested coding with the second and the last author (E.J.-R. and L.K.), and the three authors discussed, refined, and agreed on the coding. We portray identified influences narratively and report the number of individuals that mentioned each influence during control, during intervention, and altogether.

2.6.5. Self-Reported Observations and Understanding of the Heart Symbol

Regarding observations of the intervention and understanding of the Heart symbol, we report the number of participants in the intervention group that identified the intervention, and the number of participants that were familiar with and correctly understood the Heart symbol.

3. Results

3.1. Fixations on Heart-Symbol Materials and Foods

The median time that participants spent at the analysed section of serving line stretch #2 was 40 s (interquartile range [IQR] 37 s, range 17−126 s) in the control condition (n = 17) and 55 s (IQR 40 s, range 9–220 s) in the intervention condition (n = 17). The difference between the conditions was not statistically significant ($T_{RNK1} = -0.499$, $p = 0.622$). Within this time, participants accumulated a median of 103 (IQR 61, range 49–353) fixations during control and 141 (IQR 81, range 11–517) fixations during intervention ($T_{RNK1} = -0.667$, $p = 0.511$). Of these fixations, the median proportion that fell on the defined areas of interest (AoI, Supplementary Tables S1 and S2) before food choices was 34.0% (IQR 25.8%, range 5.7–68.5%) during control and 37.5% (IQR 23.2%, range 5.7–68.1%) during intervention ($T_{RNK1} = -0.995$, $p = 0.329$) (Figure 6a). These proportions, respectively, covered a median of 27.9% (IQR 28.2%, range 5.2–69.6%) and 37.8% (IQR 22.4%, range 4.8–69.2%) of the total duration of analysed fixations ($T_{RNK1} = -1.071$, $p = 0.294$) (Figure 6b). In absolute terms, before making their food choices, participants gazed at the AoIs for a median of 30 (IQR 36, range 17–89) fixations during control and for 52 (IQR 52, range 6–205) fixations during intervention ($T_{RNK1} = -1.172$, $p = 0.252$). The median total duration of these fixations was 4.7 s (IQR 6.7 s, range 2.8–17.4 s) during control and 10.0 s (IQR 10.2 s, range 0.8–41.3 s) during intervention ($T_{RNK1} = -1.294$, $p = 0.207$).

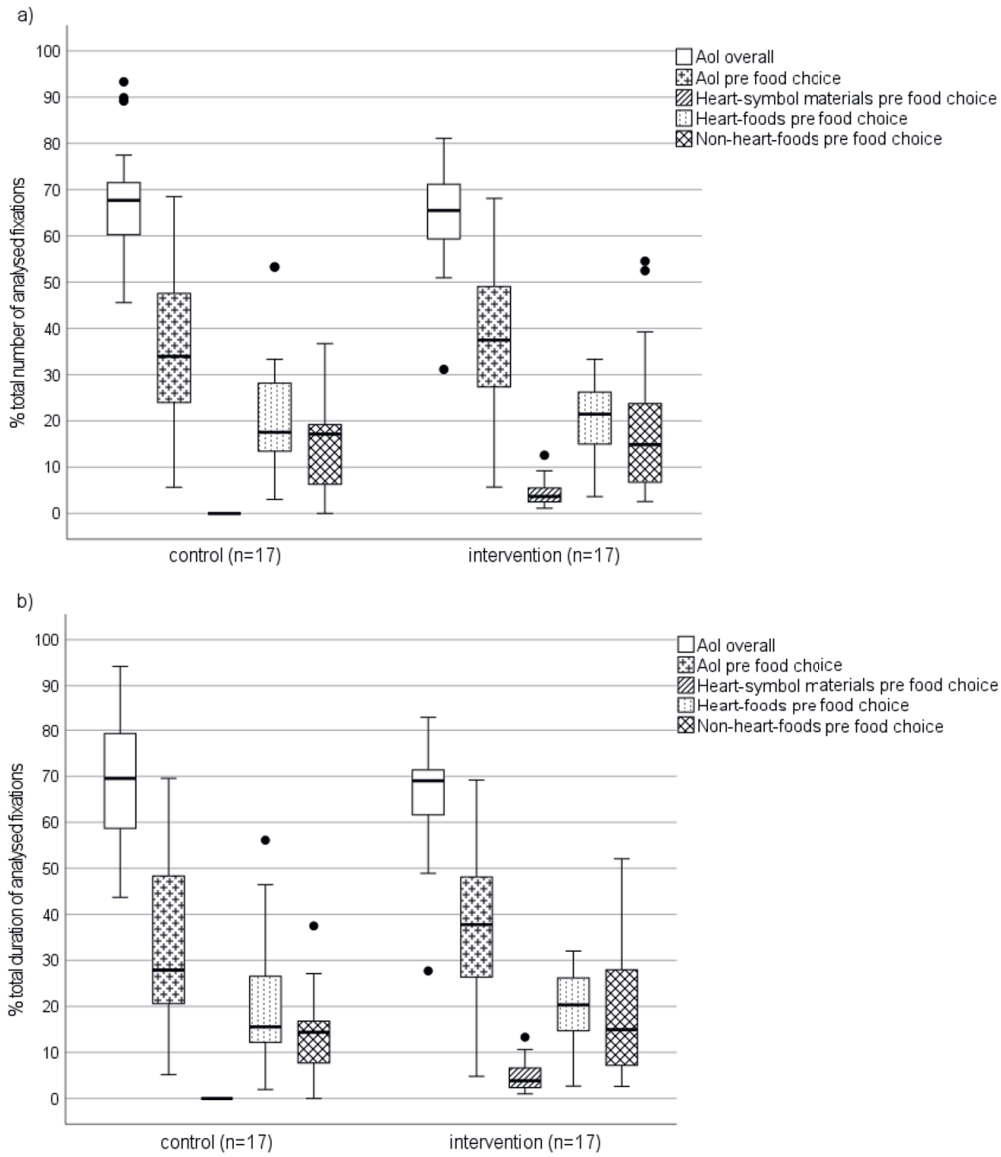

Figure 6. The distribution of (**a**) total number and (**b**) total duration of fixations on areas of interest (AoI, i.e., Heart-symbol materials, heart-foods, and/or non-heart-foods) as the percentages of total fixations accumulated at the analysed section of serving line stretch #2. Boxes extend from first to third quartile, horizontal lines across the boxes represent medians, whisker endpoints indicate minimum and maximum values, and dots represent outliers.

During the intervention, fixations on Heart-symbol materials covered on average 12.9% (SD 7.5%, range 3.8–27.3%) of the total number and 13.5% (SD 7.4%, range 4.2–27.9%) of the total duration of fixations on AoIs before food choices at serving line stretch #2 (Table 3). Regarding the percentage of fixations on heart-foods, the mean differences between intervention and control were not statistically significant for fixation number

(T_{new1} = 0.387, p = 0.702) or duration (T_{new1} = 0.406, p = 0.688). The same applied to the number (T_{new1} = −0.706, p = 0.486) and duration (T_{new1} = −0.726, p = 0.474) of fixations on non-heart-foods.

Table 3. The total number and total duration of fixations on Heart-symbol materials, heart-foods, and non-heart-foods as the percentages of total fixations on areas of interest before food choices at serving line stretch #2. Control n = 17, intervention n = 17.

Fixation Target	Control			Intervention			Difference		
	Mean [1]	SD	Range	Mean [1]	SD	Range	Mean	95% CI	p [2]
Heart-symbol materials									
% n	na	na	na	12.89	7.46	3.77–27.27	na	na	na
% duration	na	na	na	13.48	7.39	4.18–27.86	na	na	na
Heart-foods									
% n	60.79	23.14	11.76–100	57.81	20.02	16.67–85.00	2.98	−12.88, 18.85	0.702
% duration	60.68	23.53	9.52–100	57.47	20.00	21.74–87.75	3.21	−13.06, 19.49	0.688
Non-heart-foods									
% n	41.96	23.38	0.00–88.24	47.60	23.16	12.50–100	−5.63	−22.06, 10.79	0.486
% duration	42.31	23.92	0.00–90.48	48.27	23.47	10.67–100	−5.95	−22.82, 10.92	0.474

[1] Percentages do not add up to 100% because the coding of fixations was not mutually exclusive. [2] Partially overlapping samples t-test "T_{new1}" with equal variances assumed [53,55]. p-values < 0.05 are defined as statistically significant. All reported p-values are two-tailed. na = not applicable because targeted Heart-symbol materials were in place only during intervention.

3.2. Food Choices

The food-choice analysis considered all food items chosen from serving line stretch #2. However, the results reflect nearly exclusively participants' main course and condiment choices because no participant purchased a dessert and only one participant purchased a snack to accompany their lunch. Participants chose a median of three (range 1–10) food items during control (n = 22) and three (range 1–13) items during intervention (n = 19) with no statistically significant difference between the conditions (T_{RNK1} = 0.075, p = 0.941) (Table 4). Of these choices, the median percentage of heart-food items was 33% (range 0–100%) during control and 67% (range 0–100%) during intervention. The change from control to intervention was not statistically significant (T_{RNK1} = −1.149, p = 0.261). Vice versa, the median percentage of non-heart-food items chosen was 67% (range 0–100%) during control and 33% (range 0–100%) during intervention (T_{RNK1} = 1.149, p = 0.261). The results did not change significantly after the exclusion of participants who chose the salad bar (control: n = 2, intervention: n = 3) (Table 4).

Table 4. The food items chosen at serving line stretch #2. All participants: control n = 22, intervention n = 19. Without salad-bar choosers: control n = 20, intervention n = 16.

Food Items Chosen	Control			Intervention			Difference
	Median	IQR	Range	Median	IQR	Range	p [1]
All participants							
Total n	3	2	1–10	3	3	1–13	0.941
Heart-foods n	1	3	0–9	1	2	0–13	0.582
Heart-foods % total	33.3	78.8	0–100	66.7	75.0	0–100	0.261
Non-heart-foods n	1	1	0–4	1	2	0–3	0.163
Non-heart-foods % total	66.7	78.8	0–100	33.3	75.0	0–100	0.261
Without salad-bar choosers							
Total n	3	3	1–5	3	3	1–4	0.540
Heart-foods n	1	3	0–3	1	2	0–3	0.846
Heart-foods % total	33.3	72.9	0–100	50.0	68.8	0–100	0.366
Non-heart-foods n	1.5	1	0–4	1	1	0–3	0.314
Non-heart-foods % total	66.7	72.9	0–100	50.0	68.8	0–100	0.366

[1] Partially overlapping samples "T_{RNK1}" test for non-normally distributed variables with equal variances assumed [54]. p-values < 0.05 are defined as statistically significant. All reported p-values are two-tailed. IQR = interquartile range

3.3. Cafeteria-Level Food Consumption

The cafeteria-level consumption analysis covered food items consumed from serving line stretch #2, except for snacks and desserts. Hence, similar to the food-choice results, the consumption results reflect main course and condiment consumption, corresponding to 556 meals sold during control and 589 meals sold during intervention. The overall amount of food consumed per sold meal was 15 g smaller during intervention compared to control (Figure 7a). Yet, between-condition differences in the percentages of heart-foods and non-heart-foods consumed were negligible. The percentage of heart-foods consumed was approximately 45% and the percentage of non-heart-foods approximately 55% during both study conditions (Figure 7b). Excluding the consumption of salad bar items, which corresponds to 68 (12.2%) meals sold during control and 76 (12.9%) during intervention, the overall amount of food consumed per sold meal was 24 g smaller during intervention compared to control (Figure 7c). The proportion of heart-foods consumed reduced from 40% during control to 38% during intervention, and the share of non-heart-foods consumed increased from 60% to 62% (Figure 7d).

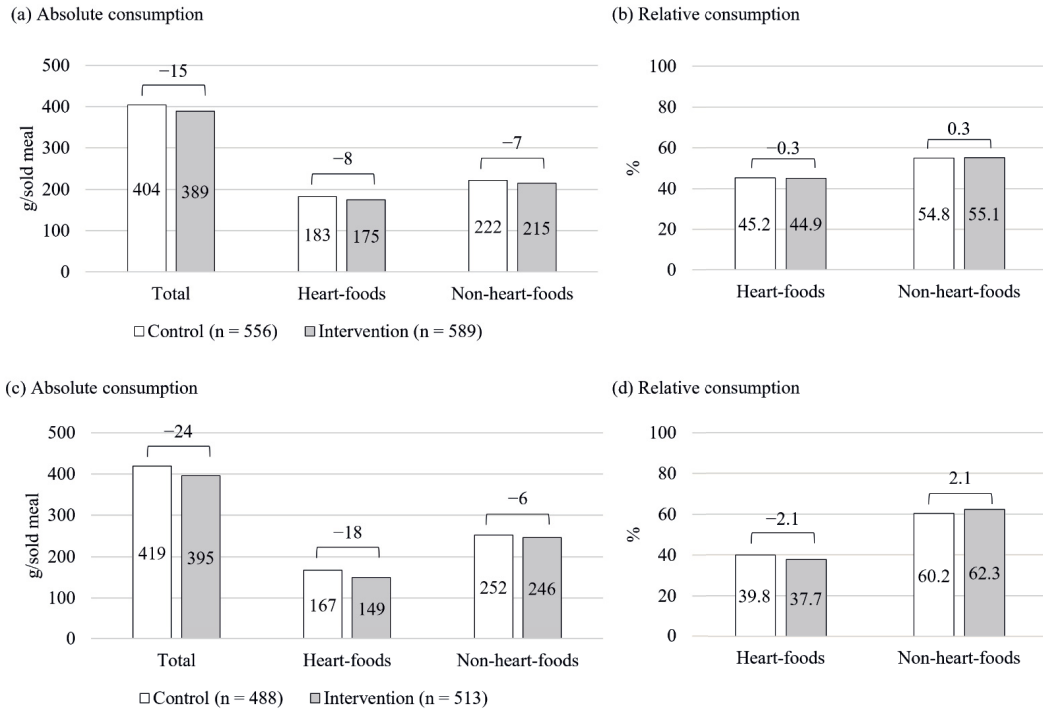

Figure 7. The cafeteria-level consumption of foods available on serving line stretch #2. (**a**,**b**) Data covers salad bar items, warm courses, and condiments; (**c**,**d**) Data covers warm courses and condiments. In graphs (**b**,**d**), numbers above the square brackets denote differences in percentage points.

3.4. Perceived Influences on Food Choices

We identified 17 factors participants perceived to influence their food choices (Table 5). The most frequently mentioned influence was sensory appeal, followed by healthiness, familiarity, and particular foods. Participants often reported multiple influences, and the decisive influence could depend on the choice task. For example, sensory appeal could determine individual food items chosen, while health considerations guided meal composition and portion size. We portray the identified influences briefly in a descending order

according to the total number of individuals that mentioned each influence. Supplementary Table S3 provides example quotes that reflect each influence.

Table 5. The number (%) of individuals that mentioned each perceived influence on food choices. Control $n = 22$, intervention $n = 19$, total $n = 34$ [1].

Influence	Control	Intervention	Total
Sensory appeal	17 (77)	11 (58)	25 (74)
Healthiness	13 (59)	9 (47)	17 (50)
Familiarity	12 (55)	8 (42)	17 (50)
Particular foods	10 (45)	9 (47)	17 (50)
Variation	6 (27)	5 (26)	11 (32)
Weight control	6 (27)	3 (16)	9 (26)
Menu	8 (36)	1 (5)	9 (26)
Satiety	6 (27)	3 (16)	7 (21)
Mood	4 (18)	4 (21)	7 (21)
Special diet	2 (9)	4 (21)	6 (18)
Food quality	3 (14)	1 (5)	4 (12)
Convenience	2 (2)	2 (11)	4 (12)
Price	1 (5)	2 (11)	3 (9)
Season	2 (9)	1 (5)	3 (9)
Social influence	1 (5)	1 (5)	2 (6)
Natural content	1 (5)	1 (5)	2 (6)
Ethical concern	1 (5)	0 (0)	1 (3)

[1] Individuals who participated both during control and during intervention and who mentioned the same influence on both times are counted in only once.

3.4.1. Sensory Appeal, Healthiness, Familiarity, and Particular Foods

Influences related to sensory appeal encompassed the look, taste, and texture of food. In addition, sensory appeal covered less-specified preferences that appeared in liking or disliking, wanting or not wanting, or finding foods tempting or not tempting. For several participants, sensory appeal was a priority that could outweigh competing influences such as healthiness. Highlighting the importance of taste, one participant said that if available foods were not appealing, they would go and eat elsewhere, even if it was more time-consuming and expensive.

Influences related to healthiness covered general, less-specified preferences for healthy choices, as well as considerations of meal composition, nutritional content, specific dietary guidelines, and the Heart symbol. Regarding meal composition, many participants focused on the proportion of vegetables and/or protein sources on the plate, and mentioned following the so-called plate model. In this model, vegetables fill half of the plate, protein-rich foods a quarter, and carbohydrate-rich foods another quarter. Considerations of nutritional content focused on protein, micronutrients, or the quality of fat. A few participants were motivated by national food-based dietary guidelines that recommend eating fish 2–3 times per week and a handful (i.e., 30 g) of nuts and seeds daily [50]. One participant was accustomed to use the Heart symbol to support their food choices.

Familiarity appeared in habitualness, in familiar choices that built on earlier experiences, and in preferences for traditional foods. Expressions that reflected habitualness included "always", "daily", "often", and "usually". Participants could, for example, "have a warm meal daily", "often choose the salad bar", or favour "foods they usually eat". Habitualness manifested itself also in principles that guided participants' choices such as an aim to include salad in the meal or a routine to choose specific courses whenever they are on the menu. Habits appeared to influence the choices of the majority of participants, as 95% of participants in the control condition and 84% in the intervention condition considered their choices on the participation day typical or somewhat typical of them.

Particular foods or food groups that drove participants' choices included vegetables, fish, meat, bread, and soup. A number of participants considered important to include vegetables in the meal, and some favoured fish courses when they were available. These

preferences relate to the healthiness- and familiarity-related influences concerning meal composition, dietary guidelines, and habitualness.

3.4.2. Variation, Weight Control, and Menu

The importance of variation related to a desire to have a wide variety of options to choose from and a desire to choose diverse foods. A wide variety of salad components in the salad bar, for example, could prompt a decision to have salad. Seeking variety appeared also in a desire to choose foods different to those eaten elsewhere, in a curiosity to try new foods, and in a motivation towards specialties rarely served.

Factors related to weight control differed from factors related to healthiness in a more pronounced focus on weight management, on lightness, and/or on the conscious regulation of portion sizes. Participants mentioned balancing their eating with energy consumption and expressed preferences for options with low energy and/or fat content. The conscious reflection of portion sizes supported attempts to downsize portions and served as a means to compensate food choices considered less favourable. For example, participants could choose hamburgers yet omit potato wedges to keep the meal light and portion sizes reasonable.

The menu, which was available online, at the cafeteria entrance, and on the serving line, could determine both the restaurant in which participants chose to have lunch and the main courses they chose to eat. Participants could make their main course choices based on the menu without looking at the foods on the serving line. The menu relates to sensory appeal and familiarity, as participants could consider menu items by imagining their sensory properties and by recalling earlier experiences on similar foods.

3.4.3. Further Factors

Further factors included considerations of satiety and mood. Prioritising satiety meant choosing foods that fill the stomach and take away the hunger. Participants could favour heartier foods, such as sausages or steak if they were very hungry or had a long day ahead. Relatedly, considerations of mood appeared in a preference for foods that help stay awake and cope with work commitments and leisure activities. Alternatively, mood could mean choosing foods based on current "vibes".

Special dietary requirements, such as gluten free or vegetarian diet guided the choices of some participants, and a few participants paid attention to food quality such as freshness. Quality appraisals relate to sensory appeal because judgements of quality often built on sensory evaluation. Convenience was important for a few participants who preferred foods that are quick to acquire or eat. A few participants valued affordable prices and prices to quality ratio. For some, the season influenced food choices, as New Year's resolutions motivated increased vegetable consumption, and cold weather prompted to choose warm foods. Social influences worked through the recommendations of the cafeteria staff or the experiences of other customers. Natural content reflected preferences for less processed foods, and ethical concerns focused on food origin.

3.5. Self-Reported Observations and Understanding of the Heart Symbol

During the intervention, two participants (11%) reported that they noticed changes in the cafeteria and correctly specified the changes as the point-of-choice Heart symbols. Both participants considered the symbols a positive add, and one of them said that the symbols influenced their choices. This person was used to paying attention to and consulting Heart symbols when choosing foods. Three additional participants (16%) remembered that they noticed the symbols after the interviewer showed them the symbol and asked whether it was familiar. No participant mentioned having noticed the priming posters or changes in the placement of foods. Nearly all participants (n = 17 [89%]) were familiar with the Heart symbol, and all participants understood the label to indicate healthier or nutritionally beneficial foods. Participants associated the label with healthy, heart-friendly, lighter, and/or nutritionally wiser foods with better salt and/or fat profile.

4. Discussion

This study used a unique mixed-methods approach to examine the effects of a multi-strategy choice-architectural intervention in a workplace cafeteria, and developed a method to analyse eye-tracking data collected in a natural choice setting. Three intervention strategies—priming posters, point-of-choice nutrition labels, and enhanced product placement—proved capable of capturing customers' visual attention to the posters and labels but had no significant effects on visual attention to foods, on food choices, or on food consumption. Although health considerations influenced the food choices of a substantial proportion of participants, health-related motives were challenged by numerous competing priorities—particularly sensory appeal and familiarity.

4.1. Fixations on Heart-Symbol Materials and Foods

While few participants recalled having noticed the Heart-symbol materials, our eye-tracking data indicated that before making their food choices all participants gazed the materials at least once. Fixations that swept Heart-symbol materials covered on average 13% of fixations that targeted defined areas of interest before food choices. These findings suggest that the materials were sufficiently prominent to catch the eye and support evidence according to which prominent display, larger size, and distinctive colours enhance the noticing of nutrition labels [42,45,70]. In addition, our findings align with the conception that self-reports may yield inaccurate estimates of visual attention [21,30,37], and that eye tracking yields more accurate estimations of visual experience [22].

Gazing the Heart-symbol materials, however, does not mean that participants consciously paid attention to the materials or internalised their message [21,33], which assumingly leads to stronger effects on behaviour [30]. While fixations give a good estimation of visual attention and cognitive processing in some situations, we acknowledge that this may not always be the case because the direction of gaze may dissociate from the focus of attention [38], and because exposures to visual cues may occur by sheer accident [21,30]. This means that participants may have looked at the Heart-symbol materials while thinking of something else. To influence behaviour, exposure to nutrition labels must be accompanied with the perception and understanding of the label information [30].

In the case of the Heart symbol, however, the message is very simple, and according to our interviews, all participants understood the symbol more or less correctly. The symbol's simple graphical layout also enables grasping the message quickly at a glance, particularly if the symbol is familiar, which was the case for nearly all participants. According to research on nutrition labels, simple graphic presentations and summary indicators are cognitively quicker and easier to process compared to numerical information and multidimensional label formats that consist of more than one piece of nutritional information [37,43,71–73]. Since familiarisation tends to reduce visual attention and response time to visual cues [35,36,74], and since visual cues can be perceived with the peripheral vision as well [38,47], our participants were likely able to perceive the Heart symbols quickly, even without looking at them directly. Hence, lack of understanding of the symbol is an unlikely explanation to the ineffectiveness of the intervention. A more presumable reason is that the message the symbol conveys was personally not relevant enough for the participants to overrule other simultaneous drivers of food choice [75], and that they chose to ignore the symbols [21]. This interpretation aligns with the finding that while many understand nutrition information, fewer actually use it, likely due to lack of motivation [76]. Consumers may consider, for example, that the Heart symbol is more relevant for individuals with or at risk of cardiovascular diseases, or that heart-foods are less tasty compared to non-heart-foods—a conception that may coexist with health consciousness [77].

4.2. Food Choices and Consumption

Our results mirror the findings of some point-of-choice labelling interventions that encouraged healthier food choices in workplace and university cafeterias with symbol-type nutrition labels and supporting communications material [26,27,29]. The Choices nutrition

logo had negligible effects on the sales of fruit, healthier sandwiches, and soups in two workplace cafeterias [29], and a star-rating intervention proved ineffective in improving meal choices and nutrient intake in a university cafeteria [26]. Similarly, a lightning bolt symbol accompanied with calorie, fat, and cholesterol information had no effect on the sales of low-fat main courses in a military dining facility [27].

On the other hand, a communications campaign that was tailored to customers' motivations was able to increase moderately healthy food choices and the total number of meal components chosen per participant in a military dining facility [25]. This intervention employed point-of-choice labels, posters, and floor stickers with slogans, such as "GO LEAN" and "GO FRESH" that reflected the military personnel's desire to eat well to support performance. Complementing the intervention with a placement strategy that moved healthy options to more prominent and convenient places further improved the results [25]. Similarly, another intervention with point-of-choice nutrition labels, related communications material, and enhanced placement succeeded in increasing the sales of healthier items and in decreasing the sales of less healthy items in a hospital cafeteria [18]. In this study, the health-focused context may have supported intervention effectiveness, since hospital staff and patients might be particularly responsive to messages that encourage healthy eating. In summary, these findings suggest that a tailored approach is advisable in choice-architectural interventions. The conclusion receives support also from other recent studies [78,79].

The ineffectiveness of our placement intervention may be due to relatively minor changes in the order and physical distance of healthier options. Despite the rearrangement, all food items that our analyses covered remained fairly effortless to access and stayed on participant's route to the cash desk. Although a field study in a university cafeteria found as small reductions in distance as 25 cm to result in 9–13% greater consumption of salads [20], the overall impact of placement strategies appears dependent on the magnitude of manipulation [14]. With minor manipulations that cause trivial changes in convenience and accessibility, effects on food choices may remain negligible [13]. For example, placement on the top versus bottom shelf of an 89 cm high display at the checkout counter had no effect on snack sales in a hospital canteen [28]. On the contrary, the selection of targeted foods increased significantly in a military dining facility along with changes to cafeteria layout that brought healthy options on more prominent and convenient places [25].

4.3. Perceived Influences on Food Choices

Our results regarding perceived influences on food choices demonstrate the multitude of factors individuals consider when choosing foods. Sensory appeal and healthiness seem to drive people's food choices across cultures and populations [27,67,78,80]. The importance of familiarity, in turn, was likely pronounced because the cafeteria was a habitual food choice context for the majority of our participants, and because we grouped factors that reflected habitual choices to the familiarity domain.

Regarding behaviour change interventions, habitual environments have advantages and disadvantages. While consistent contexts and recurring behaviours provide fruitful elements for forming new habits, they can also strengthen already established habits and make them more resistant to change regardless of motivation and intentions [81,82]. Similar to many choice-architectural interventions, habits work through automatic, often unconscious and uncontrollable cognitive processes that mediate the effects of contextual cues on behaviour [10]. The shared working mechanism has raised a question about the capability of choice-architectural interventions to override habitual food choices [78]. Emerging evidence suggests that habits may indeed create barriers to the effectiveness of choice-architectural interventions [79]. This issue might concern particularly cognitively oriented interventions such as nutrition labels, as they require visual attention and aim to influence what people know [9]. Consumers have reported greater interest in nutrition labels and greater likelihood of using the labels when they buy products for the first time and when their need for nutrition information is higher [22,30]. On the contrary, the effects

of interventions that influence behaviour more directly, even without noticing, might be more immune to established routines. Such behaviourally oriented interventions include, for example, default options and alterations to portion or tableware size [9].

Closely related to habits, many of our participants expressed detailed preferences or principles that guided their food choices. According to a recent review, people with strong preferences may be least susceptible to the effects of choice-architectural interventions [31]. Similarly, priming literature suggests that the effects of health-related primes on healthy choices could be dependent on the liking of targeted foods [15]. Supporting these claims, a field study found the use of nutrition labels more likely among individuals who are open to change and less bound to familiar meal choices [26]. These findings suggest that efforts to enhance the nutrition of individuals with strong preferences should employ strategies that target their preferred foods, for example, with gradual improvements to nutrient composition.

While evidence suggests that health primes and nutrition labels work for people with healthy preferences and intentions to eat healthy food [15,17,26,29,42], our results indicate that people may ignore such health-related cues despite health motivations. Potential explanations are many. First, people may consider foods served in workplace cafeterias generally healthy. This conception might reduce the need to seek for additional nutritional information [30]. Compared to meals in fast-food and full-service restaurants, meals in workplace cafeterias have proven to contain less energy [83]. Relatedly, eating in workplace cafeterias has been associated with healthier dietary habits [84–86]. Second, for many participants of our study, health-related motives did not focus on individual foods but rather targeted meal composition or remained less-specified higher-level goals. In addition, for several of our participants, healthiness appeared a relatively less important factor compared to sensory appeal. Prior research suggests that compared to specific health goals such as an attempt to reduce salt intake, general health goals may be too vague to trigger healthier food choices, particularly when challenged with competing motives such as taste [72,77] or hedonism [32]. A third remark relates to compensation. Our interviews indicated that participants could compensate the selection of less healthy food items by including or omitting other meal components or by regulating portion sizes. Such compensatory behaviours illustrate how the making of healthy choices can take various forms.

4.4. Strengths and Limitations

The strengths of this study included the real-world setting that guaranteed high external validity of study outcomes, the mixed-methods approach that drew a rich, multidimensional view of the studied phenomenon, and the study design that involved a control condition. Moreover, we demonstrated that eye tracking is a feasible data collection method in a natural cafeteria setting, and developed a method for analysing eye-tracking data collected in this context. This method enabled us to verify that the intervention was prominent enough to catch the eye, and allowed a systematic and rigorous tracking of intervention effects on visual attention and food choices. Eye-tracking outcomes were complemented by food-consumption data that provided objective evidence on the volume of foods consumed at the cafeteria level. Interviews, in turn, increased our understanding of the study population and supported the interpretation of eye-tracking and consumption results. The adopted mixed-methods design serves as an example of ways to combine objective, technology-driven data with self-reports to obtain more accurate, reliable, and meaningful outcomes than would be possible with any of the methods alone [87]. Additionally, the design answers a call for studies that examine the effects of nutrition labels on visual attention and food choices in real-world settings, considering person- and context-related factors [42].

The main limitation of this study is its small size. The small sample might lack statistical power to demonstrate significant effects even if they existed, particularly if true effect sizes are small and inter-individual dispersions large. For a larger sample, we

would have needed a cafeteria with a larger customer base or several smaller cafeterias, longer data-collection period, and/or multiple eye-tracking glasses. Our study cafeteria served approximately 150 customers per day, but a substantial proportion of the clientele were regular visitors that ate in the cafeteria several times per week; thus, limiting the number of individuals that were eligible to participate during each study condition. During both control and intervention, recruiting new participants proved increasingly challenging towards the end of the week because customers keen to participate had already taken part, and customers unwilling to participate remained uninterested. In addition, most customers visited the cafeteria during a one-hour window from 11 a.m. to 12 p.m. With one pair of eye-tracking glasses, we could have only one participant at a time and were hence unable to make use of the peak hours. Including several cafeterias or extending the data collection period were not feasible, however, due to labour-intensive data-collection and -analysis methods. Resource issues are characteristic to mixed-methods studies that produce large volumes of data [48] and to studies that collect technology-driven data that need manual data-handling processes [46,87].

Another limitation of this study is its short duration, which may have influenced our findings because repeated exposures to nutrition labels are expected to enhance their noticing, understanding, and impact [70]. However, the label we used was familiar and understood, and the eye-tracking data demonstrated that the labels were seen. We thus doubt that a longer intervention would have substantially changed the results.

The study population in this study represented predominantly working population who valued food healthiness. Considering the location of the cafeteria in an office building, we assume that the majority of participants were office workers, who additionally may have represented a relatively highly educated and healthy-eating share of the workforce. In Finland, workers with higher education more commonly use workplace cafeterias compared to workers with lower education [4], and the use of workplace cafeterias is associated with healthier dietary habits [84–86]. The study cafeteria, in turn, likely had an offering with a relatively high nutritional quality—compared to full-service and fast-food restaurants at least [83]. Our results may not generalise to other occupational groups with different food choice motives or to other types of restaurants with diverse food offering.

When interpreting the outcomes of this study, a few methodological matters warrant consideration. Regarding eye tracking, we encourage keeping in mind that eye trackers are not mind-reading machines but produce approximate estimates of visual attention and cognitive processing. In a real-world setting, factors that can influence visual attention are myriad. For example, a queue at the serving line may have forced participants to kill time by viewing available foods, even without any intention to choose them. On the other hand, due to the reflexive tendency of eyes to follow sensed motion, participants' gazes may have been drawn to foods that other customers were portioning, regardless of participants' interest in these foods. Another remark relates to the accuracy of the eye-tracking measurement. In mobile eye tracking, the distance between participants and gazed objects varies and often differs from the distance used in calibration. This may compromise calibration accuracy and reduce the reliability of results [33]. A further consideration pertains to the proneness of manual data handling to researcher-originated errors [46]. In the present study, this issue concerns all collected data. Despite repeated and careful checks at all phases, the risk of random errors is evident due to the substantial manual work that our data collection, management, and analysis required. This uncertainty, however, concerns control and intervention data equally.

4.5. Recommendations

While nutrition labels typically receive support from the public [11,22,27,30,37,71] and in principle allow consumers to make informed healthy choices, we should not expect them to automatically trigger healthier eating. The labels and the nutritional criteria they build upon might be greater incentives for food manufacturers to improve the nutritional quality of food products [12,17], particularly when label use is mandatory. Similarly, labelling

schemes could serve as standards for public food procurement. To increase healthier food choices, we recommend combining measures that ease the recognition and enhance the visibility of recommended options with measures that are less reliant on the provision of information and reflective cognitive processing, since such measures tend to yield greater effects [9]. Acknowledging the decisive influence that sensory appeal and habits have on food choices, efforts appear advisable that improve the nutritional profile of foods consumers prefer and that increase the attractiveness of foods with high nutritional quality. Regarding placement interventions, we encourage measures that substantially reduce the physical effort that healthy choices require. Additionally, in line with prior literature [79,88], we recommend future research to design interventions in collaboration with cafeteria staff, management, and clientele. Such approach facilitates the identification of factors that drive target groups' food choices and the development of feasible interventions that tap into these factors. For multi-dimensional, more complete and meaningful effects evaluations of choice-architectural interventions, we recommend mixed-methods designs that combine objective and subjective measurements. Interventions that work through eyesight could benefit from eye-tracking measurements because they enable detecting the capabilities of interventions to capture visual attention, and allow monitoring food choices more accurately and reliably than self-reports or cashier data do. Future studies could follow the procedure developed in the current study to confirm our findings in different types of restaurants with diverse populations. To ensure larger study samples, researchers should strive for recruiting restaurants with large customer bases.

5. Conclusions

This study employed a mixed-methods approach and evaluated the effects of a real-world choice-architecture intervention that promoted nutritionally beneficial foods in a workplace cafeteria with priming posters, point-of-choice nutrition labels, and enhanced product placement. Additionally, the study developed a method for analysing eye-tracking data collected in a natural choice setting. The intervention proved capable of capturing visual attention to the posters and labels, yet ineffective in increasing healthier food choices or consumption among working-age consumers who prioritised sensory appeal and had established food-choice routines. While it is important to provide people with nutrition information in a quick-to-read and easy-to-grasp form, researchers, policy-makers, and practitioners should acknowledge the limited impact such information has on people's food choices. To boost the effectiveness of health messages and visibility enhancements, we recommend complementing interventions with components that (1) address the determinants of target populations' food choices, (2) enhance the sensory attractiveness of nutritionally favourable options, and (3) improve the nutritional quality of popular foods.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu14183731/s1, Table S1: Objects of interest on serving line stretches #1–2; Table S2: Definitions for the areas of interest (AoI) of the objects of interest on serving line stretches #1–2; Table S3: Perceived influences on food choices with example quotes from interview data.

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Supplementary material

Heart-food = food items that met the product category-specific nutrition criteria of the Heart symbol.

Supplementary Table S1. Objects of interest on serving line stretches #1–2. During the intervention, heart-food items featured Heart symbols that were considered objects of interest per se.

Serving line	Weekday	Category	Object of interest	Heart-food
Stretch #1	all	Heart-symbol material [1]	"Follow the heart"-poster (A3), front of pillar	not applicable
	all	Heart-symbol material [1]	Heart label on a salad bar notice (A4), front of pillar	not applicable
Stretch #2	all	Heart-symbol material [1]	"A sign of good food"-poster (A3), back of pillar	not applicable
	all	Heart-symbol material [1]	Heart label on a salad bar notice (A4), back of pillar	not applicable
	all	Heart-symbol material [1]	Salad bar sign (A6) with Heart label, back of pillar	not applicable
	all	snack	Fruits	Yes
	all	snack	Blueberry quark	Yes
	all	snack	Sandwiches	No
	all	snack	Yoghurts	No
	all	snack	Muesli bars	No
	all	snack	Nut and dried fruit mix	No
	all	salad bar	Salad components as a whole (n = 18–19 per day)	Yes [2]
	all	salad bar	Salad dressings	Yes and no
	Monday	warm course	Steamed vegetables	Yes
	Monday	warm course	Boiled potatoes	No [3]
	Monday	warm course	Wholegrain rice	No [3]
	Monday	warm course	Chicken rissoles	Yes
	Monday	warm course	Curry sauce for chicken rissoles	Yes
	Monday	warm course	Bean and vegetable sauce	Yes
	Monday	warm course	Pureed vegetable soup with cheese	Yes
	Monday	warm course	Beef wok	No
	Tuesday	warm course	Steamed vegetables	Yes
	Tuesday	warm course	Boiled potatoes	Yes
	Tuesday	warm course	Beetroot croquettes	Yes
	Tuesday	warm course	Potato wedges	No
	Tuesday	warm course	Hamburgers	No
	Tuesday	condiment	Chilli-mayonnaise	No
	Tuesday	warm course	Salmon soup	No [4]
	Tuesday	dessert	Lingonberry quark	No
	Wednesday	warm course	Steamed vegetables	Yes
	Wednesday	warm course	Boiled potatoes	Yes
	Wednesday	warm course	Wholegrain rice	Yes
	Wednesday	warm course	Fish cutlets with Cheddar cheese	Yes
	Wednesday	condiment	Yoghurt dressing and lemon for fish	No
	Wednesday	warm course	Vegetarian curry	Yes
	Wednesday	warm course	Chorizo casserole	No
	Wednesday	warm course	Spinach soup and boiled eggs	No
	Thursday	warm course	Steamed vegetables	Yes
	Thursday	warm course	Broad bean and pasta casserole	Yes
	Thursday	warm course	Pureed sweet potato soup with chilli	Yes
	Thursday	warm course	Mashed potatoes	No
	Thursday	warm course	Oven-baked sausages with grated cheese	No
	Thursday	warm course	Chicken tortillas	No
	Thursday	condiment	Taco sauce for tortillas	No
	Thursday	condiment	Salsa for tortillas	No
	Thursday	condiment	Sour cream for tortillas	No
	Thursday	dessert	White chocolate mousse	No
	Friday	warm course	Steamed vegetables	Yes
	Friday	warm course	Boiled potatoes	Yes
	Friday	warm course	Fish sauce with lemon	Yes
	Friday	warm course	Vegetarian moussaka	Yes
	Friday	warm course	Beef burgers filled with pepper sauce	No
	Friday	warm course/condiment	Gravy/sour cream for beef burgers	No
	Friday	warm course	Blue cheese soup	No
	Friday	dessert	Fruit salad and vanilla sauce	No

[1] In place only during intervention. [2] All salad components were considered heart-food items because the implementation of Heart labels and the analysis of eye-tracking data were not feasible at the level of individual salad components. [3] Boiled potatoes and wholegrain rice met the nutritional criteria of the Heart symbol but received no symbols on intervention week's Monday. Hence, on Mondays these foods were categorised as non-heart-foods and on other days as heart-foods. [4] Salmon soup met the criteria of the Heart symbol only during the control condition. Hence, the soup received no Heart symbol during intervention and was categorised as non-heart-food.

Supplementary Table S2. Definitions for the areas of interest (AoI) of the objects of interest on serving line stretches #1–2.

Category	Object of interest	Area of interest
Heart-symbol material [1]	Posters, notices, stickers, and signs	Outlines of Heart-symbol posters, notices, stickers, or signs added on the serving line
Snack	Fruit	Outlines of fruit and their serving platter
Snack	Sandwiches, blueberry quark, yoghurts, muesli bars, nut and dried fruit mix	Outlines of food packages, including possible serving platters
Salad bar	Salad components	Combined outlines of the serving dishes of available salad components, including spaces between adjacent serving dishes. These outlines defined the AoI also when the serving dishes had only little food left and the bottoms and/or insides of the dishes were exposed. If food items rose above the tops of the serving dishes, the foods themselves defined the top of the AoI.
Salad bar	Salad dressings	Outlines of salad dressing bottle.
Warm course	Warm courses	Outlines of the serving dishes of individual warm course items, excluding lids and hoods and spaces between adjacent serving dishes. These outlines defined the AoIs also when the serving dishes had only little food left and the bottoms and/or insides of the dishes were exposed. If food items rose above the tops of the serving dishes, the foods themselves defined the tops of the AoIs.
Condiment	Sauces for warm courses	Outlines of serving dishes
Dessert	Dessert items	Outlines of serving dishes

[1] In place only during intervention.

Supplementary Table S3. Perceived influences on food choices with example quotes from interview data. The influences are presented in a descending order according to the total number of individuals that mentioned each influence.

Influence	Description	Example quotes
Sensory appeal	The look, taste, or texture of food; less-specified preferences	The appearance of food; attractiveness matters. Mental image of flavour. If there is a choice after that, I choose the healthier option. Flavour is nevertheless the most important thing. Rye bread is important, but if it is too hard, I don't take it. Other options were not pleasant.
Healthiness	Healthiness in general, meal composition, nutritional content, specific dietary guidelines, the Heart symbol	Healthiness. That there are vegetable, protein, and carbohydrate sources to form a healthy plate model. Rich in protein. I aim to eat fish when it is available, due to guidelines. Sometimes I use the Heart symbol to support my choices. For example, now I took milk instead of juice due to the Heart symbol.
Familiarity	Habitual, familiar, or traditional choices	What I chose is basic food I usually eat. Tortillas have not always been very good. I considered this a safer choice. I prefer rather traditional foods.
Particular foods	Particular food, food group, or meal component	Salad table, fresh produce. I favour fish when it's available.
Variation	The importance of having a wide variety of options to choose from, desire to choose diverse foods or foods different to those eaten elsewhere, curiosity to try new foods, motivation towards specialties rarely served	Variety; that there are diverse options. A balanced meal. No red meat, I eat it otherwise so much that I try to avoid it. Seemed interesting. What is mifu *(a dairy-based meat alternative)* like? Rarely served. I planned to have salad but noticed the hamburgers and changed my mind in the nick of time.
Weight control	Weight management, lightness, conscious regulation of portion sizes	I look at what I eat in relation to *(energy)* consumption. With heavy workout, it's ok to eat more heavily. That the food is not very fatty. I may have taken a bit too much of the carbohydrate accompaniment, I paid attention to that after portioning. I considered whether to take two fish cutlets. I took one.
Menu	The menu online or at the restaurant.	I checked the menu at the entrance and practically made my decision there. I still compared the main courses at the serving line, yet kept my original choice.

Influence	Description	Example quotes
Satiety	Foods that fill the stomach and take away the hunger	That the food is filling. I often take the Heart label option but chose sausage today because I'm very hungry.
Mood	Foods that help to cope with work/personal life commitments, choices made based on a feeling.	I try to choose a fairly light lunch that doesn't make me tired in the afternoon. Soup would have been enough, but I have a long and physically active day ahead. *(I made my choice)* based on vibes, what I fancied today.
Special diet	Special dietary requirements	I need gluten free food. I'm a vegetarian.
Food quality	The type of food or ingredients	The quality of food. On the bread table, *(I checked)* whether there was fresh bread.
Convenience	Focus on time needed to acquire or eat food.	*(It is important)* to get the food rather quickly. *(I made my choice)* based on which food is quick to eat.
Price	Affordable prices, price-quality ratio	Affordable price is important as well as getting healthy food at a reasonable price. Price-quality ratio.
Season	New Years' resolutions, weather outside	The choice was based on a New Year's lifestyle change; the proportion of salad is greater than before. The soup was tempting due to the cold weather.
Social influence	Recommendations of the cafeteria staff, experiences of other customers	Sometimes I ask recommendations from the restaurant staff. I happened to hear that the steaks are very peppery. That's why I chose the fish.
Natural content	Processing	In principle, I do not eat highly processed food.
Ethical concern	Food origin	With the side dish, I pay attention to whether it is local.

EEVA RANTALA

Choice architecture (aka “nudge”) is a framework developed for designing choice environments that facilitate favourable behaviours. The framework holds potential for population-level health promotion, but limited evidence exists of its implementation, acceptability, and effectiveness in real-world settings. Transfer from research to practice is thus challenging. This dissertation contributed to filling this knowledge gap with four empirical studies conducted in the workplace context.

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