



Contents lists available at ScienceDirect

International Journal of Nursing Studies

journal homepage: www.elsevier.com/locate/ns

Effectiveness of an integrated platform-based intervention for promoting psychosocial safety climate and mental health in nursing staff: A pragmatic cluster randomised controlled trial

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ARTICLE INFO

Keywords:

Occupational health
Occupational stress
Mental health
Digital health
Internet-based intervention

ABSTRACT

Background: Organisational and individual factors cause strain in the daily lives of nurses and other healthcare professionals, who have a high prevalence of stress-related disorders. Accordingly, there is a strong need for integrated occupational health promotion interventions that include both work-directed and person-directed interventions. The psychosocial safety climate is seen as an overarching occupational health objective and can potentially be improved by implementing integrated mental health interventions.

Objective: Following an integrated approach, we developed an occupational e-mental health platform, Care4Care, which integrates both work- and person-directed interventions for promoting mental health in nurses. We evaluated the effects of the platform compared with those of an extended care-as-usual control condition.

Design: Clustered randomised controlled trial.

Setting: Healthcare service facilities in Germany nationwide.

Participants: 347 nursing staff members (intervention: 211, control: 136) from 33 healthcare service facilities.

Methods: The participants received either immediate access to the platform or access to two short subcomponents of the platform plus routine occupational health promotion offerings as well as delayed access to the whole platform after 6 months. The primary outcome was improvement in the psychosocial safety climate after 6 months. The secondary outcomes included perceived stress, depressive symptoms, and other strain-related indicators.

Results: Bayesian multilevel analyses revealed an improvement of approximately 2 points (Cohen's $d = 0.25$) in the psychosocial safety climate in the intervention group compared with the control group. Applying a 95 % credible interval, this effect contained zero ($-0.32, 4.44$), which indicated uncertainty about the effectiveness of the intervention on the psychosocial safety climate. The analyses of the secondary outcomes revealed effects in the expected direction with high credibility for a decreasing effect on perceived stress and considerable uncertainty with regard to all other secondary and tertiary outcomes. A total of 85 (40 %) participants in the intervention group used Care4Care, whereas 37 (27 %) participants in the control group used the two subcomponents of the platform.

Conclusions: This study highlights the potential of an occupational e-mental health platform that combines work- and person-directed interventions with face-to-face components for nursing staff. The findings emphasise the necessity of conducting more in-depth implementation studies to identify the factors that facilitate the successful implementation and uptake of occupational e-mental health platforms.

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<https://doi.org/10.1016/j.ijnurstu.2025.105076>

Received 5 September 2024; Received in revised form 25 March 2025; Accepted 28 March 2025

Available online 31 March 2025

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Registration: German Clinical Trials Register – DRKS (DRKS00027869). Registration date: February 23, 2022. Start of recruitment: June 21, 2022.

What is already known

- Person-directed occupational mental health interventions show promising effects in reducing mental health problems in nurses and other healthcare professionals.
- Evidence for work-directed interventions is scarce, with mixed effects on nurses' mental health.

What this paper adds

- We present an integrated intervention approach by using a web-based platform that combines assessment tools and interventions targeting both work-directed factors and individual health behaviour.
- The results showed that the intervention has the potential to improve the psychosocial safety climate in care facilities and to reduce stress in nursing staff.
- The results confirm known implementation barriers for non-digital interventions in the occupational setting, and possible facilitating factors for the implementation and uptake of digital interventions were identified.

1. Background

1.1. Work and health situation of healthcare workers

Nurses and other healthcare workers are exposed to numerous health risk factors at work, such as night shifts (Okechukwu et al., 2023), high workloads and emotional demands (Saade et al., 2022) and low levels of social support (Galanis et al., 2021; Roelen et al., 2018). Accordingly, these professionals are at high risk of developing adverse health conditions such as chronic stress (Badu et al., 2020), burnout symptoms (Woo et al., 2020), depression (Saade et al., 2022), low-quality sleep (Zeng et al., 2020) and cardiovascular disease (Gu et al., 2015). During the coronavirus disease 2019 (COVID-19) pandemic in particular, the number of work-related stressors increased, further exacerbating symptoms of depression, anxiety, and sleep problems (Al Maqbali et al., 2021).

1.2. Workplace health promotion with different intervention levels

International guidelines for workplace mental health promotion call for both work-directed interventions primarily addressing psychosocial risk factors at work and person-directed interventions aimed at building individual skills such as stress management (European Network for Workplace Health Promotion, 2018; World Health Organization, 2022). Systematic reviews and meta-analyses of randomised controlled trials of person-directed interventions have shown moderate effects on stress and stress-related outcomes amongst nurses (Kunzler et al., 2020; Melnyk et al., 2020). Work-directed interventions, such as job and task modifications (Aust et al., 2024) and work scheduling (Ruotsalainen et al., 2015), have also shown promising effects on mental health outcomes. Overall, however, the evidence for work-directed interventions is less clear due to the limited number of studies and a substantial variation in study designs (Nikunlaakso et al., 2022). Moreover, the implementation of work-directed interventions is challenging due to different frequently reported obstacles, such as low support by low and middle management, low engagement of other key stakeholders (Gray et al., 2019), insufficient information and workforce participation (Raphael et al., 2021), and misalignment between the intervention and organisational culture

(Gray et al., 2019; Raphael et al., 2021).

Hence, to create better working conditions and support employees' mental health, an integrated approach (LaMontagne et al., 2014; Rugulies et al., 2023) that combines work- and person-directed interventions with processes that ensure early participation of relevant stakeholders in the development and implementation of the intervention seems promising.

1.3. The psychosocial safety climate as a target of occupational mental health interventions

In particular, when evaluating the effect of an integrated, work- and person-directed interventional approach to mental health, improvement in the psychosocial safety climate seems to be an appropriate outcome. Loh et al. (2020) proposed that the psychosocial safety climate represents “the lead indicator of job conditions and social relational aspects at work” or “the cause of the causes of work stress”. Accordingly, the psychosocial safety climate reaches beyond single indicators of mental health and encompasses the organisational “policies, practices and procedures for the protection of worker psychological health and safety” (Dollard and Bakker, 2010). It reflects the value that management places on employee health in relation to job performance and is seen as a context factor within the work-health relationship that acts as an organisational resource (Dollard and Bakker, 2010). Evidence from systematic reviews of cross-sectional and prospective studies revealed that a better psychosocial safety climate was associated with protective working conditions in terms of lower job demands, greater job resources and less workplace abuse (Amoadu et al., 2023, 2024). For example, Owen et al. (2016) reported that a negative psychosocial safety climate was associated with an effort-reward imbalance and suggested that it precedes harmful working conditions. In terms of adverse mental health, a low psychosocial safety climate is associated with a variety of indicators, including emotional exhaustion, fatigue, stress, depression, and posttraumatic stress (Amoadu et al., 2023, 2024). For example, Zadow et al. (2021) reported that a low psychosocial safety climate predicted a threefold increase in the risk of experiencing a new episode of major depression after 12 months. Finally, a better psychosocial safety climate is positively associated with indicators of positive mental health, such as well-being or resilience, and indicators of job performance, including work engagement, job commitment and job satisfaction (Amoadu et al., 2023, 2024). Notably, most observational research on the psychosocial safety climate has been conducted with healthcare workers (Amoadu et al., 2024), demonstrating its associations with a variety of outcomes, e.g. patients' safety or depression. Research on interventions to improve the psychosocial safety climate is very scarce. A distinction can be made between two different approaches to the improvement of the psychosocial safety climate. As one approach, Dollard and Bailey (2021) have developed a new intervention that relates directly to the psychosocial safety climate framework. This involves the assessment of its dimensions at the beginning of a change process, which may include targeted interventions such as management training in mental health communication and management commitment to mental health policies. This approach could be considered direct psychosocial safety climate intervention. The second approach is based on established concepts and interventions that are part of routine care. For example, by clarifying roles and improving collective planning of work processes (Cedstrand et al., 2022), reducing workload (Rickard et al., 2012), or individual education about stress (Rasdi et al., 2018), it is assumed to foster the climate for psychological health indirectly. In line with the assumption that the psychosocial safety climate is the

'cause of causes' of mental health in the workplace, such interventions may focus on specific outcomes, such as stress reduction, but at the same time are assumed to have an indirect effect on the psychosocial safety climate. However, no one has investigated the effects of an intervention including a variety of work- and person-directed components on the psychosocial safety climate.

1.4. Approach for intervention accessibility: digital interventions

Occupational e-mental health interventions have been proposed to facilitate the implementation of work- and person-directed interventions in the workplace (Lehr et al., 2016). Digital interventions fit well with the increasing digitalisation of everyday life and can be accessed anytime or anywhere. Thus, e-mental health interventions offer the advantage of reaching workers who are often excluded from traditional programmes, such as part-time workers or night-shift workers. This point is particularly important for care facilities, as shift work is common in this sector, and a lack of time is one of the main barriers to successful intervention implementation (Pollock et al., 2020).

Findings from meta-analyses have shown that person-directed e-mental health interventions—targeting individual behaviour—can effectively reduce stress, depression, and anxiety (Stratton et al., 2022) and increase well-being and work effectiveness (Carolan et al., 2017) in the general working population. A recent review indicated that the digital intervention format can also be effective for healthcare workers (Henshall et al., 2022). Nevertheless, the heterogeneity of the effects limits the generalisability of the results (Henshall et al., 2022). Notably, almost all interventions implemented and investigated were single-component interventions, each with a specific health focus such as depressive symptoms, anxiety, or general stress (Stratton et al., 2022; Carolan et al., 2017). However, mental health has multiple components and needs may vary from person to person and from organisation to organisation. Therefore, solutions that empower management and employees to choose the most appropriate intervention from a range of evidence-based interventions appear to be a promising approach to mental health promotion (Deady et al., 2024).

Ketelaar et al. (2013) were amongst the first to develop and investigate an e-mental health platform for healthcare workers, including screening with tailored feedback and corresponding self-help interventions. The screening tool aimed to raise awareness and provide support in choosing the intervention that would best fit the nurses' needs. Overall, the platform had a positive effect on psychological well-being (Bolier et al., 2014) but not on work functioning (Ketelaar et al., 2013). Havermans et al. (2018a) evaluated an e-mental health platform including information, screening and planning tools and a search engine with preselected online and onsite work- and person-directed interventions. The results revealed a significant effect on stress but no effects on any of the measured determinants of work stress.

To summarise, with the accumulating evidence of person-directed digital interventions, multicomponent platforms appear to be the logical next step in the digitalisation of occupational care. Platforms offer a unique opportunity to overcome the work- or person-directed debate in occupational healthcare by offering interventions in both domains. Such interventions can address different topics important for mental health by providing a variety of specific interventions. However, only limited evidence for their feasibility and efficacy exists, probably due to high platform complexity and appropriate study designs. To date, no study has investigated the effect of an e-mental health platform on the psychosocial safety climate.

1.5. Aims of the present study

Care4Care is an e-mental health platform for nursing staff that includes work- and person-directed assessment tools as well as a variety of interventions, each targeting specific topics in occupational care. We hypothesised that nursing staff who receive Care4Care would show an

increase in their perceived psychosocial safety climate (primary outcome) at the post-assessment in comparison to those who receive extended occupational care-as-usual. In addition, we aimed to examine the effects of Care4Care on several mental health-related secondary outcomes.

2. Methods

2.1. Design

We employed a parallel cluster randomised controlled design to compare Care4Care with an extended occupational care-as-usual control group. Randomisation took place at the organisational level, stratified by the type of organisation: hospitals, nursing/care homes or home care services. We conducted outcome assessments at the individual level via online questionnaires at baseline (T1) and six months after randomisation (T2). Recruitment took place between May and October 2022 and was stopped because of the end of project funding. The ethics committee of Leuphana University of Lüneburg approved the study design (Reference No. 202111-18-Lehr_Care4Care-02). We registered the trial at the German Clinical Trials Register (DRKS00027869; February 23, 2022). This registry is the primary registry for Germany recognised by the WHO and thus meets the requirements of the International Committee of Medical Journal Editors.

2.2. Sample size calculation

On the basis of findings from a meta-analysis on the effectiveness of e-mental health interventions (Phillips et al., 2019), we expected a between-group Cohen's *d* effect size of 0.33 for the primary outcome [a better psychosocial safety climate at post-assessment (T2)] to be realistic and practically meaningful. A priori power analysis using PASS (version 21) for a two-sided test with 90 % power and a significance level of 5 %, an intraclass correlation (ICC) of 0.05, and an average cluster size (number of participants per organisation) of 10 resulted in a target sample size of 560 to detect an effect of this size. Thus, 28 organisations (total of 56) per study arm, with an average of 10 participants were needed.

2.3. Recruitment and participants

We applied a transdisciplinary approach to facilitate the subsequent implementation of Care4Care. This included the cooperation with occupational health consultants from statutory health insurance funds who were involved in the recruitment of care facilities and participants as well as in the implementation process of Care4Care. In Germany, statutory health insurance funds are obliged to support companies in workplace health promotion regardless of whether workers are clients of the respective health insurance fund. In this study, consultants acted as implementation agents to overcome common implementation barriers identified in previous studies (Engels et al., 2024; Raphael et al., 2021). Consequently, they were involved in the recruitment of care facilities and participants as well as in the Care4Care implementation process. Before recruitment, the health consultants participated in a three-hour workshop conducted by the researchers with the aim of familiarising them with Care4Care and the study process. The main tasks of the health consultants were to a) inform the care facilities about the intervention and study participation, b) provide support in planning the implementation, c) support the organisations in using Care4Care, and d) conduct face-to-face workshops that accompanied the digital components of the intervention (see Fig. 1). Contacting companies, presenting the interventions to management and providing work-directed workshops were part of the daily work of the occupational health consultants.

For inclusion in this study, organisations had to a) be hospitals, nursing/care homes or home care services and b) have at least five employees who provide informed consent and complete the initial

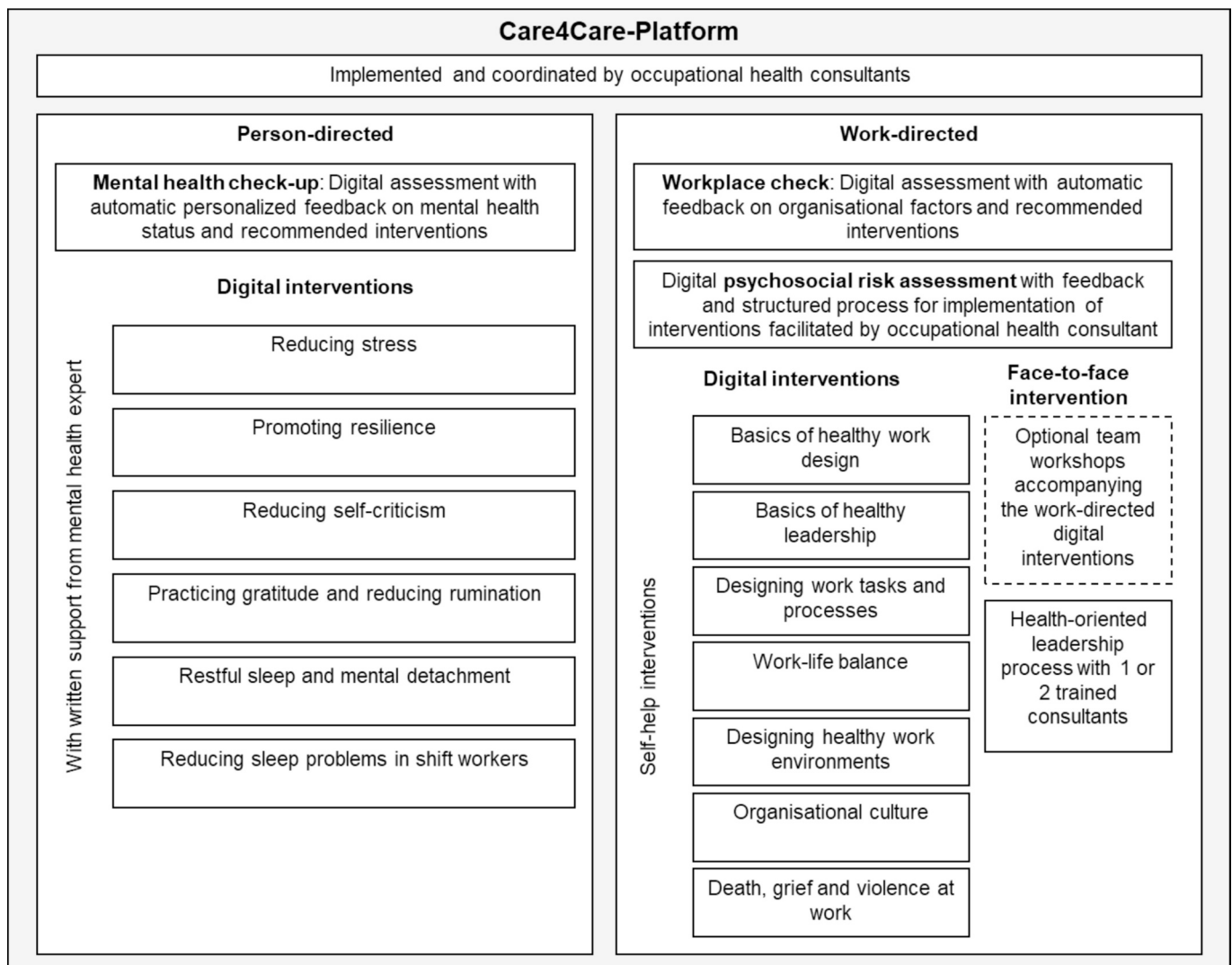


Fig. 1. Overview of the components of Care4Care.

questionnaires. Furthermore, c) study participants had to be members of the nursing staff. In Germany, nursing care is typically carried out by multi-professional teams, including registered or licenced nurses, nursing assistants, apprentice nurses, and employees with other professional training (e.g. physiotherapists). The health consultants strongly recommended that the participating companies consider their employees' use of Care4Care as working time. However, this was not a mandatory inclusion criterion.

2.4. Procedure

Upon expressing interest in participation, each organisation received a unique registration link to the web platform where both the digital intervention components and the outcome assessment were provided. Afterwards, interested organisations were asked to invite their employees to self-register within 5 weeks. Interested employees could create an individual account by using the registration link. During the registration, they were informed about the study procedures and data protection, asked to provide informed consent, and asked to complete the baseline questionnaire. Organisations with at least five employees who successfully registered were included in the study. Blinding of the organisations, participants, or health consultants was not possible. An independent researcher who was not involved in the study generated the randomisation sequence via the software Randlist (<http://randomis>

[atn.eu/](http://randomis.atn.eu/)) and conducted the randomisation at the organisational level, stratified by three types of organisations (hospital, nursing/care home, home care service). For each stratum, simple randomisation with a block size of two was conducted. Only the independent researcher knew the details of the allocation sequence and informed the study coordinator about the randomisation result, who informed the health consultants as well as the participants by email. After randomisation, the participants assigned to the intervention group received immediate access to Care4Care. The participants in the control group received the same intervention after completing the post-assessment (T2). We sent up to five e-mail reminders to increase the response rate at T2. In addition, we conducted a lottery to encourage participants to complete the post-assessment questionnaire. In this lottery, a total of 20 different cash prizes, ranging from 50 to 300 euros, were randomly awarded to participants who took part in the post-assessment.

2.5. Care4Care platform

Care4Care is a web-based platform (www.care4care-trainings.de) that targets both work-directed and person-directed factors related to mental health (Fig. 1). The platform consists of 17 different components, including 3 assessment tools, 8 different work-directed interventions and 6 person-directed interventions. The work-directed interventions were developed according to international ([European Agency for Safety](http://www.osha.europa.eu)

and Health at Work, 2018) and national (Rothe et al., 2017) guidelines on protective workplace factors. They included educational material about different workplace factors, for instance, what it takes to create a healthy working environment and how to promote a healthy culture. A three-hour face-to-face team workshop, led by health consultants, complemented the work-directed interventions and aimed to plan the implementation of changes in the work environment. The person-directed interventions were personally guided training programmes that address different mental health topics like stress-management and recovery from work. The topics of these interventions were in line with the national regulations for person-directed prevention in the area of mental health (National Association of Statutory Health Insurance Funds, 2024). Four of these training programmes have already been evaluated as single interventions in previous RCTs and shown to be effective (e.g., Nixon et al., 2022; Behrendt et al., 2020, 2023; Lehr et al., 2024). The Supplementary material 1 provides detailed information regarding the content of all the interventions. All the components were developed to suit the context of employees working in a care or nursing setting. The content of these components was presented as a combination of text-based information, interactive exercises, video and audio files, and 11 personas (Cooper et al., 2007), representing prototypical members of the nursing staff and their experiences in using the interventions (Holden et al., 2017; Serio et al., 2015). Within the platform, the personas guided the participants, beginning with using the assessment tools and ending with conducting and reflecting on the exercises of all the interventions. Although the aim of Care4Care was to digitalise as much content as possible, two components were designed for face-to-face delivery: After the work-directed interventions were delivered via the web-based platform, actions at the organisational level were planned and initiated in team workshops. Similarly, health-oriented leadership training was offered in a face-to-face format. Overall, the aim of this multicomponent approach was to give the user a high degree of freedom of choice, particularly to use the online components regardless of time and place. The principle structure of this platform, the connection between assessments and specific interventions, user navigation and user experience, and interactions between web-based and face-to-face components were piloted in a previous project (Ducki et al., 2019). Participants in both study groups had unrestricted access to regular health care (e.g., psychotherapy, medication, prevention measures).

2.6. Extended occupational care-as-usual

In Germany, statutory health insurance funds are legally mandated to spend a certain amount of their budget on employee health promotion measures in the workplace. Typically, these include healthy eating, exercise, mental health promotion, and addiction prevention. Consequently, the facilities participating in this study also had access to those occupational care-as-usual programmes. In addition, facilities in the control group received access to two specific web-based Care4Care components (i.e. extended occupational care-as-usual). With respect to the work-directed perspective, these organisations had access to the healthy work design intervention, which took approximately 45 min to complete (Fig. 1; Supplementary material 1 for details). With respect to the person-directed perspective, the participants had access to the breathing and progressive muscle relaxation exercises that were part of the stress-management intervention, complemented by information about the connections amongst stress, tension and relaxation exercises. These exercises took approximately 30 min to complete.

2.7. Measures

2.7.1. Primary outcome measure

We assessed employees' perceptions of their organisation's psychosocial safety climate with the German version of the Psychosocial Safety Climate-12 scale (Hall et al., 2010; Otto et al., 2016), adapted to the professional care and nursing context. The scale covers four dimensions

of the psychosocial safety climate: management support and commitment; management priority; communication; and employee participation and involvement in relation to mental health and safety. The participants were asked to rate 12 items related to the past six months (e.g., "Care workers are encouraged to become involved in psychological safety and health concerns") on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total score is calculated by summing the responses for all the items, with higher scores indicating a better psychosocial safety climate. Sum scores below 38 suggest that measures could be implemented to reduce health risks for employees in the organisation, values below 27 indicate that measures should be taken in the organisation (Dormann et al., 2017). The internal consistency of all outcome measures was presented in Supplementary material Table 2.

2.7.2. Secondary outcome measures

Given the novelty of the concept and the assessment of the psychosocial safety climate in intervention research, we aimed to analyse whether the intervention can also directly affect relevant aspects of mental health of the participants. We used established measures with robust psychometric properties as secondary outcomes that enable us to compare the results of the present study with previous findings. We used the Irritation Scale (Mohr et al., 2006) as an indicator of emotional and cognitive strain within the working environment. Total scores can be calculated for each domain by summing the responses on the respective items. Higher scores indicate a higher level of irritation. We used the German version of the Perceived Stress Scale (Cohen et al., 1983; Schneider et al., 2020) to measure the extent to which the participants experienced stress. The total score is calculated by summing the responses on all items, with higher scores indicating a higher level of perceived stress. Depressive symptoms were assessed with the widely used eight-item Patient Health Questionnaire (Kroenke et al., 2009). The participants were asked how often they had been affected by various complaints in the past two weeks. The depression thresholds can be derived from the total score as follows: 0 to 4 points (no significant depressive symptoms); 5 to 9 points (mild depressive symptoms); 10 to 14 points (moderate depressive symptoms); 15 to 19 points (moderately severe depressive symptoms); and 20 to 24 points (severe depressive symptoms).

2.7.3. Tertiary outcome measures

As the intervention contains different components (e.g. work- and person-directed interventions), we chose tertiary outcomes to explore specific effects we expected to see depending on the intervention components used by participants. Vigour describes a dynamic aspect of well-being at work and may therefore be more likely to fluctuate between the baseline and post-assessment. Vigour was measured via the three-item subscale of the short German version of the Utrecht Work Engagement Scale (Schaufeli and Bakker, 2003). We used the self-care subscale of the Health-oriented Leadership Instrument (Franke et al., 2014), which measures health awareness and health behaviour. To assess psychosocial stress at work, we used the short version of the Effort-Reward Imbalance questionnaire (Siegrist et al., 2009) with the subscales of effort and reward and the ratio of the subscales, with values greater than 1 indicating an imbalance. We used the questionnaire on healthcare consumption and productivity losses for patients with a psychiatric disorder (Bouwman et al., 2013) to assess the number of days on sick leave and the number of days working despite of health impairment, each referring to the past 4 weeks. In addition, we used three questions to assess the subjective prognosis of gainful employment (Mittag and Raspe, 2003). We used the following item to assess job satisfaction: "How satisfied are you with your work in general?" (Wanous et al., 1997). We used two self-developed questions to assess the employees' intentions to quit their current job ("Have you recently thought about changing your current job?") and to change their profession ("Have you recently thought about changing careers?"). The participants in the

intervention group evaluated Care4Care on six sub-domains (satisfaction, utility, gained knowledge, application to practice, and impact on individual or organisational performance) by an adapted version of the Questionnaire for Professional Training Evaluation (Grohmann and Kauffeld, 2013). For each subdomain, subjects rate their agreement to the presented statements from 0 % to 100 % (e.g. “The training is very beneficial to my work”) regarding their professional skills development through the intervention. Finally, we measured the satisfaction with the intervention with two items adapted from the Client Satisfaction Questionnaire for Internet-based interventions (Boß et al., 2016). One item assessed the general satisfaction (“I am satisfied with the services offered by Care4Care”) and one item assessed the participants’ desire for their employer to continue to offer the programme in the future (“I hope that my institution will continue to provide services such as Care4Care for employees in the future”).

2.8. Data analyses

The data were analysed following the intention-to-treat (ITT) principle. To account for the multilevel structure of the data and missing values, we used Bayesian multilevel modelling for nested data. Bayesian methods compute the probability of different effects values given the observed data (and some prior expectation), resulting in a distribution of possible values for the parameters, called the posterior distribution. Bayesian analysis models handle missingness by incorporating it into the probabilistic framework of inference (e.g., Ma and Chen, 2018). For missing values, the model used the observed data and prior information to infer plausible values for the missing data during the estimation process. We structured our data such that pre- and post-measures (Level 1) were nested within participants (Level 2), which, in turn, were nested within clusters (i.e., healthcare facilities; Level 3). The study group was entered as a dummy-coded predictor variable (0 = control group, 1 = intervention group). The pre- and post-measures were dummy-coded as time (0 = pre, 1 = post). We treated study group, time, and their two-way-interaction as fixed effects. To account for individual- and cluster-level variability, we treated participants and healthcare facilities as random effects. Analyses were conducted in R (R Core Team, 2023) via the brms package (Bürkner, 2017, 2018), which is based on Stan (Carpenter et al., 2017). In the brms package, we used default non or weakly informative priors, which have a negligible influence on the obtained results (Bürkner, 2017, 2018). We used two chains, with each chain containing 10,000 iterations, of which 2000 were warm-up runs. As the brms package uses the No-U-Turn (NUTS) sampler, an extension of the Hamiltonian Monte Carlo sampler (Hoffman and Gelman, 2014) that converges much more quickly, even high-dimensional models can be fitted with no more than a few thousand samples (Bürkner, 2017). The models converged with Rhats values smaller than 1.05. We summarised the posterior distributions with the median, standard deviation, and 95 % equal-tailed credible interval of the study group x time interaction. Credible intervals that do not include zero can be taken as indicators of superiority/ inferiority of the intervention over the control group, or vice versa. In addition, we report the probability of direction parameter, which provides the probability that a parameter is consistent in sign with the point estimate or the proportion of the posterior distribution of the median’s sign. The probability of direction, varying between 50 and 100 %, is a Bayesian indicator of “consistency of an effect in one particular direction, without any assumptions or conclusions as to its size, importance, relevance or meaning” (Makowski et al., 2019). We also report estimated effect sizes in terms of Cohen’s d for the average difference between the intervention and control group over time. Finally, we conducted a frequentist linear mixed model with restricted maximum likelihood estimation via the lme4 package (Bates et al., 2015) as sensitivity analysis.

2.9. Evaluation of intervention implementation

As the platform approach was entirely new to the health consultants and the participating care facilities, we decided to conduct a qualitative process evaluation alongside the RCT. The aim was to explore facilitating and hindering factors regarding the use of Care4Care in health-care facilities. We conducted post hoc interviews with the health consultants who supported the participating organisations in using the platform. From the total number of 12 consultants, 11 accepted the interview invitation. The model of process evaluation from Nielsen and Randall (Nielsen and Randall, 2013) served as a guideline for the conceptualisation of the interview. The interview questions covered three main topics: 1. the motivation and engagement of different stakeholders within the organisations, 2. information and communication about the platform within the organisation, and 3. factors facilitating and hindering the use of the platform. A translated version of the interview guide can be found in the Supplementary material 3. The results of the interviews were derived following thematic analysis (Braun and Clarke, 2006).

2.10. Ethics approval

The study was approved by the Leuphana University Research Ethics Committee (Reference No. EB-Antrag202111-18-LehrCare4Care-02, January 14, 2022). The trial was registered at the German Clinical Trials Register (DRKS-ID: DRKS00027869, February 23, 2022). Informed consent was obtained from all participants prior to participation.

3. Results

3.1. Participants

A total of 56 organisations expressed interest in taking part in the study and received a registration link (Fig. 2). Amongst these organisations, 23 did not reach the required minimum number of five participants and therefore had to be excluded. Overall, 33 organisations with a total of 347 participants met the inclusion criteria and were randomised. The number of participants per organisation ranged from 5 to 45. Seventeen organisations (5 hospitals, 10 nursing/care homes and 2 home care services) with 211 participants were allocated to the intervention group, and 16 organisations (5 hospitals, 10 nursing/care homes and 1 home care service) with 136 participants were allocated to the control group. In total, 150 participants in 28 organisations completed the post-assessment. Most of the participants were female (82.3 %), with a mean age of 42.5 years (SD = 10.7) (Table 1). On average, the participants reported having 16.7 years of job experience (SD = 10.4), most participants worked shifts (63.7 %), and nearly half of them had management responsibility (42.2 %). Regarding working conditions, 77.5 % of the participants reported an effort-reward imbalance, and 36 % showed moderate or higher depressive symptoms. The sample showed a medium technology affinity score of 3.8 (SD = 1.0) that corresponds to values that have been previously found for the German population (Franke et al., 2019).

3.2. Intervention effects

3.2.1. Effects on the primary outcome

We found a time x group interaction effect in the expected direction (Median of the posterior distribution = 2.04), but the 95 %-credible interval contained zero [-0.32, 4.44] (Table 2). The probability of direction parameter was high, indicating that 95.4 % of the effects summarised by the posterior distribution were positive in sign. This means that for the majority of possible effects (95.4 %) estimated by the Bayesian model, the nursing staff would benefit from Care4Care compared to an extended occupational care-as-usual in terms of an increase of the psychosocial safety climate score. However, the 95

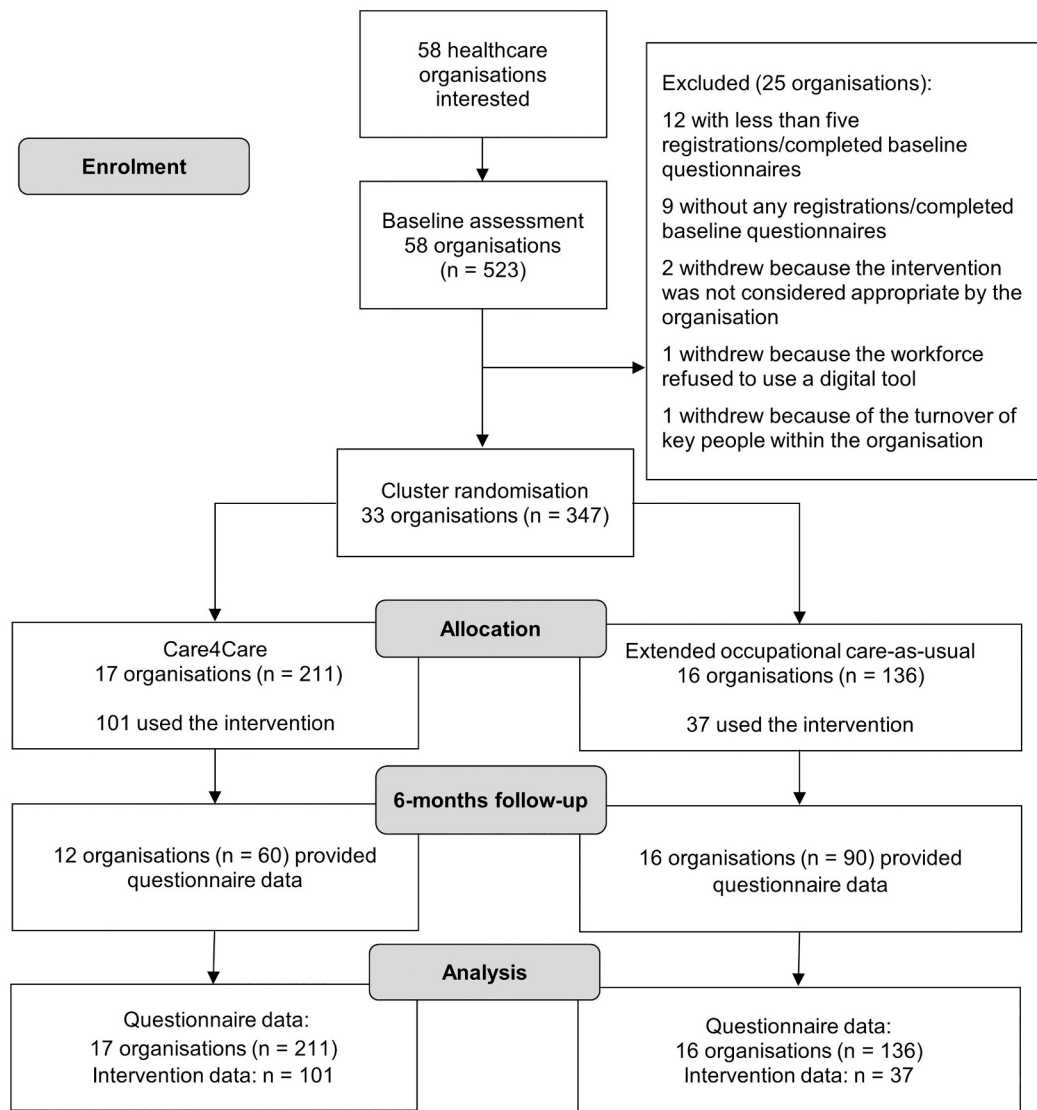


Fig. 2. Study flow of the participating organisations and individuals.

%-credible interval indicates that the possible effects include very small effects near zero and even worse effects with the intervention compared to the control. The median effect corresponds to an improvement of approximately 2 points (Cohen's $d = 0.25$) on the Psychosocial Safety Climate Scale with Care4Care compared to extended care-as-usual. Results for all fixed and random effect parameters are available in the Supplementary material Table 4. The sensitivity analysis confirmed these findings (Supplementary material Table 5).

3.2.2. Effects on the secondary outcomes

The analysis demonstrated a clear reduction in perceived stress with Care4Care compared to the extended care-as-usual, as described by the median of the posterior distribution and its credible interval that was fully below zero (Median = -2.44 , 95 %-credible interval [-4.35 , -0.48], probability of direction = 99.3 %, $d = -0.33$). Compared with participants who received extended care-as-usual, those with access to Care4Care showed a tendency to benefit in terms of reductions of cognitive strain, emotional strain, and depressive symptoms. However, the credibility intervals for the effects of all the secondary outcomes except for perceived stress included zero (Table 2). This suggests that the possibility of irrelevant or even detrimental effects cannot be ruled out.

3.2.3. Effects on the tertiary outcomes

Finally, the Care4Care participants showed also a tendency to benefit in terms of increased self-care and a decreased number of days working despite of health impairment. There were no substantial differences between the study groups regarding individual characteristics, such as vigour, job satisfaction, days of absenteeism, nor in characteristics of the working environment, such as effort-reward imbalance. For all the tertiary outcomes, the credible intervals of the intervention effect contained zero (Table 2).

3.3. Engagement and satisfaction with the intervention

Amongst all the subjects with access to Care4Care, 101 (48 %) used at least one of the 17 intervention components. Regarding the two branches of Care4Care, 41 subjects used only person-directed interventions, 16 used only work-directed interventions, and 28 used interventions from both branches. Supplementary material Table 6 shows which interventions and assessment tools the participants used. The e-coaches who provided guidance as part of the person-directed interventions sent 78 feedback messages to 54 participants.

In the extended care-as-usual group, 37 participants (27 %) logged into the web-based platform, with 13 (10 %) using the 'Breathing and relaxation' intervention, 6 (4 %) using the 'Basics of a healthy work

Table 1
Baseline characteristics.

		Total (N = 347)		Intervention (n = 211)		Control (n = 136)	
		n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)
Age			42.5 (10.7)		42.9 (10.5)		41.9 (11.1)
Relationship	Single/unmarried	73 (21)		43 (20.4)		30 (22.1)	
	Married or in a partnership	240 (69.2)		150 (71.1)		90 (66.2)	
Sex	Divorced or widowed	34 (9.8)		18 (8.5)		16 (11.8)	
	Male	60 (17.4)		41 (19.4)		19 (14.0)	
	Female	286 (82.3)		170 (80.6)		116 (85.3)	
Education	Other	1 (0.3)		0		1 (0.7)	
	None	1 (0.3)		1 (0.5)		0	
	Secondary school	51 (14.7)		30 (14.2)		21 (15.4)	
	Middle school	149 (42.9)		83 (39.3)		66 (48.5)	
	High school	146 (42.1)		97 (46.0)		49 (36.0)	
Employment	Years working in the care sector		16.7 (10.4)		16.4 (10.4)		17.1 (10.5)
	Years working in the current care facility		10.7 (9.3)		10.0 (9.1)		11.8 (9.6)
	Working hours per week according to the employment contract		34.0 (6.8)		33.5 (6.8)		34.9 (6.7)
	Actual hours worked per week		36.8 (8.8)		36.3 (8.9)		37.9 (8.4)
	Working shifts	221 (63.7)		139 (65.9)		84 (61.8)	
	Management responsibility	148 (42.2)		86 (40.8)		60 (44.1)	
Subjective threat to gainful employment	believe that they will work until the regular retirement age (reference) ^a	101 (29.1)		57 (27.0)		44 (32.4)	
	one and a half times greater risk of early retirement	130 (37.5)		75 (35.5)		55 (40.4)	
	two times greater risk of early retirement	91 (26.2)		61 (28.9)		30 (22.1)	
Intentions to quit	eight times greater risk of early retirement	25 (7.2)		18 (8.5)		7 (5.1)	
	Intention to change careers (yes)	46 (13.3)		27 (12.8)		19 (14.0)	
Psychosocial safety climate	Intention to quit the job (yes)	28 (8.1)		19 (9.0)		9 (6.6)	
	> 38 (good)	8 (24.2)		4 (23.5)		4 (25.0)	
Mental health	27–38 (moderate)	23 (69.7)		12 (70.6)		11 (68.8)	
	< 27 (low)	2 (6.1)		1 (5.9)		1 (6.3)	
	Effort-Reward-Imbalance (yes)	269 (77.5)		162 (76.8)		107 (78.7)	
Mental health services used	Moderate or severe depressive symptoms (yes)	125 (36.0)		77 (36.5)		48 (35.3)	
	Other occupational health promotion (yes)	22 (6.3)		14 (6.6)		8 (5.9)	
	Medication (yes)	16 (4.6)		9 (4.3)		7 (5.1)	
Technology affinity ^b	Psychotherapy (yes)	40 (11.5)		22 (10.4)		18 (13.2)	
	Other mental health prevention (yes)	73 (21.0)		41 (19.4)		32 (23.5)	
			3.7 (1.0)		3.7 (1.0)		3.8 (1.1)

Notes: SD = standard deviation.

^a Increased risk of early retirement due to ill health compared to the reference group (risk = 1; Mittag and Raspe, 2003).

^b Technology affinity was assessed using the Affinity for Technology Interaction Scale (Franke et al., 2019). It consists of nine items and uses a 6-point Likert scale from 'completely disagree' (1) to 'completely agree' (6). The mean score presented is calculated over all nine item scores.

design' intervention, and 18 (13 %) using both interventions. Owing to communication issues, one organisation started health-oriented leadership training shortly before this study began and therefore deviated from the study protocol. The number of subjects who used other mental health services before and during the study period did not differ substantially between the two groups (Supplementary material Table 7).

The participants have made moderate positive experiences with the intervention regarding the professional skills development indicated by an average score of 48 % on the Questionnaire for Professional Training Evaluation. Looking at the satisfaction with the training, 47 of 58 participants (81 %) were satisfied with Care4Care in general and 50 (86 %) expressed the desire that their employer would continue to provide platforms such as Care4Care for their colleagues in the future.

3.4. Intervention implementation

After the study ended, we conducted 11 interviews with the occupational health consultants who were responsible for 15 of the 17 organisations in the Care4Care group. The most important insights are

presented along the main themes from the interviews (Table 3).

4. Discussion

4.1. Principal findings

The aim of the present study was to investigate the effectiveness of the newly developed e-mental health platform, Care4Care, in improving the psychosocial safety climate in care facilities. The statistical analysis could not establish with certainty the superiority of Care4Care over extended occupational care as usual, despite the improvements in the psychosocial safety climate observed for the intervention on a descriptive level. We found mixed results for the secondary and tertiary outcomes, ranging from a clear and clinically meaningful effect on stress reduction and tendencies towards improving several work-related mental health outcomes to no effects regarding occupational outcomes such as vigour and job satisfaction.

Table 2

Means and standard deviations of the outcome variables of all available cases and effect estimators based on Bayesian multilevel models.

Outcome	T1				T2				Effect			
	Intervention (n = 211)		Control (n = 136)		Intervention (n = 60)		Control (n = 90)		d	Median	95%-CrI	pd
	Mean	SD	Mean	SD	Mean	SD	Mean	SD				
Psychosocial safety climate	34.1	10.1	33.1	9.1	36.3	11.0	32.9	9.6	0.25	2.04	-0.32, 4.44	95.38
Stress	20.1	6.2	19.7	6.2	16.6	5.5	18.9	5.7	-0.33	-2.43	-4.35, 1.58	99.30
Depressive symptoms	8.1	5.0	7.9	4.9	6.5	4.6	7.7	5.2	-0.14	-0.69	-2.14, 0.71	83.50
Cognitive strain	13.0	5.0	12.1	5.1	11.4	4.3	11.8	5.0	-0.21	-0.86	-2.09, 0.35	91.65
Emotional strain	16.2	7.5	15.7	7.3	14.9	7.0	15.6	8.2	-0.19	-1.39	-3.51, 0.72	90.26
Vigour	9.2	3.7	9.2	3.8	9.0	3.3	9.1	3.7	0.02	0.07	-0.50, 0.63	56.09
Self-care	3.5	0.7	3.4	0.7	3.7	0.6	3.4	0.7	0.20	0.11	-0.05, 0.28	90.49
Reward	18.2	3.5	17.6	3.3	18.3	3.8	17.4	3.5	0.04	0.13	-0.80, 1.08	60.82
Effort	9.8	2.0	10.0	1.7	9.2	1.9	9.7	1.6	-0.02	-0.05	-0.49, 0.39	58.42
Days on sick leave during the past 4 weeks	2.4	3.8	1.9	3.6	3.0	4.8	2.8	5.2	-0.03	-0.32	-1.97, 1.30	64.95
Days working despite health impairment during the past 4 weeks	4.7	5.5	4.1	5.0	4.3	4.7	4.3	5.2	-0.09	-0.71	-2.59, 1.20	76.71
Job satisfaction	4.6	1.0	4.6	1.1	4.6	1.0	4.5	1.0	0.01	0.02	-0.30, 0.35	54.89
Intention to quit current contract (n/%)	27	12.8	19	14.0	11	18.3	11	12.2	Na	Na	Na	Na
Intention to quit the job (n/%)	19	9.0	9	6.6	6	10.0	4	4.4	Na	Na	Na	Na

Notes: SD = standard deviation; d = standardised mean difference between the groups based on frequentist multilevel-model estimations; Median = the point estimate of the time x group interaction derived from the posterior distribution; 95%-CrI = the 95%-credible interval of the point estimate; Pd = probability of direction: the probability that a parameter, described by the posterior distribution, is consistent in sign with the point estimate; Na = no effect estimation due to the low number in cells.

Table 3

Interview results about intervention implementation.

Main theme	Findings
Contact initiation	(a) Most of the health consultants had been in contact with the care facilities prior to the start of the acquisition for Care4Care and provided occupational health promotion; (b) some care facilities have heard about the project through press releases and actively asked to participate, whilst most were invited to participate by a health consultant
Motivation to adopt the digital platform	(c) The management searched for help to reduce the high level of sickness absence (d) Digital approach seemed promising for the management (e.g. because of expected lower costs or as innovative health promoting measure)
Facilitating conditions for the implementation	(e) Support was provided by management (e.g., by internal information campaigns) (f) Most organisations allowed participation to be counted as working time
Barriers associated with the implementation	(g) It was not possible in all organisations for the occupational health consultants to inform the nursing staff about Care4Care on site (e.g., due to the COVID-19 pandemic's aftermath). (h) Whilst official representatives of the nursing facilities were regularly informed about the upcoming implementation, the nursing staff themselves were rarely directly involved in the decision to implement the intervention. (i) In some cases, exceptional circumstances occurred, such as filing bankruptcy during the study, the turnover of occupational health staff and the parent company insisting that some branches participate.

4.2. Comparison with previous research

The observed effect size for psychosocial safety climate was slightly smaller than expected, but the estimate was subject to uncertainty, probably because of the sample size. Nevertheless, considering the implementation of the intervention within a universal prevention approach and by taking a public health perspective (Cook et al., 2018), even smaller effect sizes for universal interventions in the workplace were regarded as practically meaningful (Tan et al., 2014). Whilst previous research emphasised the general importance of the psychosocial

safety climate on the basis of descriptive, cross-sectional or prospective studies (Amoadu et al., 2023, 2024), the present pragmatic cluster RCT demonstrated that the psychosocial safety climate can be improved.

Several factors must be considered when interpreting the results on the primary outcome. First, none of the participating care facilities presented a critical value for the psychosocial safety climate, as defined by Dormann et al. (2017). From a methodological perspective, a moderately good psychosocial safety climate at baseline, however, leaves little room for further improvement. Second, most studies on occupational e-mental health have employed nonactive comparators (Phillips et al., 2019), leading to large differences in outcomes across the study groups. In contrast, the present study employed an active comparator. Offering interventions to a control group can prevent participants from becoming frustrated and experiencing even more stress (Havermans et al., 2018b) but can also reduce differences between groups. Third, it should be noted that the care facilities in the control group knew that they would have access to Care4Care after the 6-month waiting period. Thus, the planned implementation of Care4Care in the control group may have already influenced the assessment of the psychosocial safety climate by the nursing staff before the actual implementation. The planned implementation could have been a sign that management was planning to prioritise mental health. Accordingly, the anticipated implementation may have reduced the differences between the groups. Finally, there was no indication of differences in the uptake of further mental health co-interventions, such as medication, psychotherapy or preventive services, which could have biased the effects.

With respect to the secondary outcomes, the effect for perceived stress can also be regarded as practically meaningful (Boß et al., 2021). A meta-analysis on e-mental health interventions demonstrated average effects on stress (between $g = 0.25$ and $g = 0.28$) (Stratton et al., 2022). In studies with similar characteristics in terms of active comparators or universal prevention, the effects on stress were $g = 0.17$ and $g = 0.18$, respectively. We also observed effects of Care4Care on reducing work-related strain, self-care, and depressive symptoms. The effects on work-related strain and self-care appeared rather small compared to person-directed digital interventions with a focus on these factors (Behrendt et al., 2023, 2020). For all other secondary and tertiary outcomes, the effect sizes in the present study were comparable to findings from meta-analyses for universal interventions on depressive symptoms (Tan et al., 2014), and to those of e-mental health interventions

delivered in the workplace (Phillips et al., 2019). Tan et al. (2014) argued that so-called small effect sizes for universal interventions could have a considerable impact at the population level, as “universal interventions are never likely to produce large individual effect sizes, but when translated to an entire workforce, the overall impact can be substantial”. However, the comparability of our results is restricted, as previous meta-analyses investigated single-component, person-directed interventions (Phillips et al., 2019; Stratton et al., 2022).

The novelty of Care4Care is that it combines a variety of work- and person-directed components integrated into an e-mental health platform. However, only a few studies have investigated similar interventions. Ketelaar et al. (2013) evaluated an e-mental health platform consisting of five person-directed interventions for common mental health issues. They found no significant effect on any of the outcomes. Interestingly, the platform was also implemented in the workplace. One difference was that all intervention components were offered as self-help, whereas Care4Care used a form of personalised support that previous studies have shown to increase adherence and effectiveness (Zarski et al., 2016). Havermans et al. (2018a) also adopted a digital platform approach. After six months, the control group, which received no intervention, presented an increase in stress, whereas that in the intervention group remained stable, leading to a significant difference in stress between the groups ($d = 0.23$) that diminished after 12 months. In contrast, the interventions of the platform in the study by Ketelaar et al. (2013) were evaluated as stand-alone interventions in previous RCTs, and at least some of the interventions included in Care4Care were also found to be effective in separate RCTs (Behrendt et al., 2023, 2020; Lehr et al., 2024; Nixon et al., 2022). There are only a few evaluation studies on health-oriented leadership interventions (Felfe et al., 2019; Stuber et al., 2020; Vonderlin et al., 2021), and none of them has been combined with an occupational e-mental health platform so far.

Overall, these findings suggest that the impact of an intervention may vary depending on the context in which it is implemented. One relevant context factor may be the recruitment strategy. For instance, the meta-analysis of Phillips et al. (2019) revealed that person-directed interventions implemented by the employer were significantly less effective than were interventions for which employees were recruited directly by researchers. Future studies should investigate why the same interventions seem to be less effective when implemented in the workplace by the employer and what measures could mitigate that effect. For instance, the efficacy of person-directed components, which deal with most personal issues, may be contingent upon the employee's trust in the employer or the presence of a sufficient psychosocial safety climate. Another contextual factor refers to the availability of personalised support, that may not only be needed for the person-directed components but also for the work-directed components to increase adherence and effectiveness.

Regarding the direct evaluation of Care4Care two directions appeared. First, participants expressed only moderate positive feedback regarding their professional skills development. This result may indicate a need to optimise the intervention or could be explained by the fact that such skills are only addressed in the work-directed intervention components, which were not used by all participants. Secondly, regarding satisfaction with the intervention, the majority reported overall favourable satisfaction and expressed a desire for the intervention to be available to all staff in the future. The satisfaction rates of in the present study are in line with results from other digital, but solely person-directed mental health interventions (e.g. Behrendt et al., 2020; Heckendorf et al., 2022).

The consideration of usage behaviour revealed that the proportion of non-users was higher in comparison to person-directed interventions recruited outside the workplace (Behrendt et al., 2023, 2020; Lehr et al., 2024; Nixon et al., 2022). However, similar low uptake rates were reported in the studies by Ketelaar et al. (2013), Havermans et al. (2018b), and Tsantila et al. (2023a, 2023b), all of which offered a variety of different digital interventions through the workplace. Therefore,

Havermans et al. (2018a) emphasised that not only interventions but also strategies to implement interventions should be investigated. The results of our evaluation suggest that the following conditions facilitate the implementation of the platform: (a) care facilities actively seeking support to promote mental health, (b) inviting health consultants to introduce the platform personally to the nursing staff, (c) allowing staff to count the use of the platform as working time, (d) and both management and staff supporting the implementation through their actions. This is largely in line with recently published recommendations for the implementation of occupational e-mental health interventions (Raggi et al., 2024). Furthermore, it appears particularly important for researchers or external healthcare providers to engage with key stakeholders who possess a direct, well-established and trusted relationship with the workforce. Such involvement could facilitate the reduction of barriers to the adoption of mental health interventions.

4.3. Strengths and limitations

This study contributes to the knowledge about the psychosocial safety climate and occupational e-mental health in several ways. First, the study went beyond the investigation of stand-alone person-directed internet interventions by following a platform approach that included a variety of interventions addressing common topics in occupational care. Most importantly, work- and person-directed interventions were weighted equally in terms of number and intensity, thereby aiming to overcome the neglect of work-directed interventions (Nikunlaakso et al., 2022). Second, this pragmatic cluster RCT showed that the psychosocial safety climate can be changed even in care facilities, an occupational setting that has been repeatedly found to be highly stressful (Okechukwu et al., 2023; Saade et al., 2022). Third, this is one of the first studies in occupational mental health research to employ a Bayesian approach for analysing interventions (Brückner et al., 2024). Bayesian methods are widely adopted because they expand the range of testable hypotheses and offer computational advantages, particularly in small-sample studies (Zyphur and Oswald, 2015). Investigations of organisational outcomes in real-world settings, where small effects are likely and large sample sizes are needed, are highly challenging and therefore rare. Consequently, even large studies are likely to be underpowered. Since the frequentist approach often focuses on a single threshold value (alpha level) to decide whether to accept or reject a hypothesis, even promising interventions are at high risk of being prematurely rejected as ineffective. By weighing the certainty and importance of the desired positive outcome by the costs of implementation and uptake, employers, care providers or policy makers might consider the intervention worthwhile even at a lower probability for a beneficial effect. Finally, the use of a transdisciplinary research approach, in which occupational health consultants played an important role in implementing the platform, reflected real-world conditions. Thus, cooperation between researchers and health consultants has the potential to bridge the research-to-practice gap and facilitate subsequent implementation in routine care.

However, several limitations should be considered. First, the final sample size was smaller than planned and the response rate at the 6-month follow-up was low. Both factors contribute to uncertainty in the data and may explain that the effect was smaller than expected. We therefore have chosen a Bayesian model of analysis, which provides a more robust framework for dealing with limited data than frequentist approaches (Ma and Chen, 2018). The high degree of study drop-out was, however, not unique to the present study, as similar rates have been reported by Ketelaar et al. (2013), Havermans et al. (2018b), and Tsantila et al. (2023a, 2023b). Several methods to increase response rates, such as reminders and lotteries, have been developed according to the recommendations of Edwards et al. (2023) but have failed. This points to a general challenge in establishing commitment to research in occupational health, especially when interventions are introduced in the workplace and by non-research stakeholders.

Second, owing to the complexity of Care4Care and the limited

sample size, it was not possible to identify effect mediators in terms of the “active ingredients” of the intervention.

Third, the multitude of interventions may have caused an overload of options. High complexity has been shown to hinder digital intervention implementation (Graham et al., 2020). Although workplace and mental health checks were designed to support the choice of intervention, there may still have been too many options given the 6-month study period. This may have limited the rate of active use of the platform. A gradual launch of a platform with an information campaign on a specific topic for a certain period could be an alternative method of implementation.

Fourth, given the novelty and complexity of the digital platform, it would have been advisable to conduct a feasibility trial in advance to test the implementation process in greater detail (Tsantila et al., 2023a, 2023b). However, Havermans et al. (2018b) thoroughly developed an implementation strategy for their digital platform and reported similar low uptake and engagement.

Finally, although the study employed an experimental design and revealed that the psychosocial safety climate can improve, whereas levels of stress decrease, the results do not support the theoretical assumption that the psychosocial safety climate is the “cause of the causes of work stress” (Loh et al., 2020). Mediation analyses demonstrating that the change in the psychosocial safety climate precedes the change in stress are needed to confirm the assumed mechanism of action (Domhardt et al., 2021). Moreover, the dose–response relationships between psychosocial safety climate change and mental health outcomes and the onset of action, i.e., the length of time it takes for the psychosocial safety climate to have an effect, are both unknown. Therefore, it could be argued that the 6-month period may be too short for an organisational characteristic such as the psychosocial safety climate to have an effect on later depression or absenteeism.

4.4. Future directions

The present study illustrates the challenges encountered by research when investigating digital interventions that extend beyond the level of the individual worker. In comparison to the substantial body of evidence for person-directed occupational e-mental health interventions, there is a need to expand the limited evidence base for combined person- and work-directed interventions using (cluster) randomised trials. Such research on effectiveness should be accompanied by in-depth implementation studies to identify facilitators and barriers of successful implementation, as suggested by Engels et al. (2022). In the light of the present study, the following topics emerged as priorities.

First, the evaluation of the implementation process revealed facilitating factors that may influence uptake and engagement with the intervention. For example, the present results underscore the need to develop indicators of “occupational e-mental health readiness” (Graham et al., 2020; Raggi et al., 2024) that cover both the perspectives of the organisation and the respective staff. From a health economic perspective, validated readiness scores could help to allocate limited resources in the most efficient way (van Dongen et al., 2014).

Second, more research is needed on the acceptance of digital interventions (Apolinário-Hagen et al., 2024), particularly by investigating activities such as communication strategies that target users' expectations and potential reservations towards digital interventions (Philippi et al., 2021).

Third, to effectively implement digital platforms in occupational health care, we need to better understand how to integrate digital and non-digital components. In the present study, for example, the digital work-oriented interventions were intended as a starting point to work on a specific topic. The results were then discussed in more detail in later face-to-face workshops. It is unclear whether blended formats enhance both worlds or simply combine their drawbacks, potentially alienating individuals with strong digital affinity or those who prefer personal contact (Boß et al., 2021).

Finally, it seems worthwhile to compare direct psychosocial safety

climate interventions, designed around its theoretical framework and targeting management (Dollard and Bailey, 2021), with the Care4Care platform, which represents an indirect psychosocial safety climate intervention, including components for management and nursing staff, based on concepts that are part of usual occupational mental health care.

4.5. Conclusions

Overall, the integration of work- and person-directed interventions as part of a broad and universal prevention approach to mental health promotion in the workplace was accepted, feasible, and promising. This is an important finding, as it suggests that isolated measures focusing on either the workplace or the individual need to be overcome via an integrated approach such as occupational e-mental health platforms. Although there are reasons for a potential underestimation of the effects of the studied intervention owing to the study design, its effects should be interpreted with caution owing to the limited sample size and low response rates. Occupational e-mental health platforms should deliver services in manageable parts and create engaging interfaces between digital and face-to-face components. Further research is needed to understand the uptake of these interventions from the perspective of both end users and those responsible for implementation in the workplace. Implementation readiness should be established before occupational e-mental health platforms are implemented. Care4Care showed the potential to improve the psychosocial safety climate in care facilities, demonstrating that an integrated intervention can be a valuable intervention for mental health promotion in the workplace.

CRedit authorship contribution statement

Leif Boß: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Jennifer Ross:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Conceptualization. **Dorota Reis:** Writing – review & editing, Formal analysis. **Sarah Pischel:** Writing – review & editing, Investigation. **Tim Mallwitz:** Writing – review & editing, Software, Conceptualization. **Hanna Brückner:** Writing – review & editing, Investigation, Data curation. **Grit Tanner:** Writing – original draft, Conceptualization. **Helge Nissen:** Writing – review & editing, Software. **Lina Kalon:** Writing – review & editing, Writing – original draft, Investigation. **Marlies Schümann:** Writing – original draft, Conceptualization. **Thomas Lennefer:** Writing – review & editing, Resources. **Monique Janneck:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Jörg Felfe:** Writing – review & editing, Supervision, Funding acquisition. **Antje Ducki:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Dirk Lehr:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Funding

This study was part of a research project called Care4Care that was financed by the statutory health insurance fund federal association of AOK. As part of the transdisciplinary approach, the funder was involved in the recruitment of the participating institutions, but not in the collection, analysis or reporting of the data.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Leif Boss, Jennifer Ross, Sarah Pischel, Tim Mallwitz, Hanna Brueckner, Grit Tanner, Helge Nissen, Lina Kalon, Marlies Schuemann, Thomas Lennefer reports financial support was provided by Federal Association of AOK. Thomas Lennefer reports a relationship with Federal association of AOK that includes: employment. If there are other authors, they

declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank all the health consultants from the AOK for their efforts in recruiting and supporting the participating healthcare organisations. We further thank Maie Stein and Danièle Wittkopf for their contributions in developing the intervention; Katja Debelan for her support in managing the data and performing the literature review; and Hannah Heimes, who provided support as an e-coach.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnurstu.2025.105076>.

Data availability

The outcome data and variable description will be available for non-commercial use: [doi:10.48548/pubdata-1371](https://doi.org/10.48548/pubdata-1371). For those interested in further details on the analysis or use of the web-based platform can contact the corresponding author.

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