Improving mental health in medical students and residents: a systematic review on interventions and their effects on burnout.

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Master of Family Medicine

Masterproef Huisartsgeneeskunde
Academiejaar: 2021 – 2024

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VOORWOORD

Het gebeurde vaak dat de olifant, na een bezoek aan de eekhoorn, van de top van de beuk naar beneden viel en enkele bulten en schrammen opliep. Op een dag maakte de eekhoorn speciaal voor de olifant een bord met de woorden NIET VALLEN dat hij naast zijn voordeur ophing. Niet lang daarna was de olifant weer eens bij hem op bezoek. Grijs en gewichtig zat hij in de luie stoel voor het raam en vertelde hij aan de eekhoorn wat hij allemaal van plan was. (…) Aan het einde van de middag zei de olifant: 'Kom, ik ga weer eens naar huis.' Hij vouwde zijn oren langs zijn hoofd, gaf de eekhoorn een hand en stapte de deur uit. 'Eerst nog even dat bord lezen,' zei de eekhoorn. De olifant draaide zich om, begon te lezen en viel toen met donderend lawaai naar beneden. Toen hij zijn ogen opsloeg zag hij de eekhoorn hoog boven zich in de top van de beuk zitten. 'Heb je het niet gelezen?' riep de eekhoorn. 'Ik had het nog niet uit,' zei de olifant. 'Wat stond er na NIET?' 'VALLEN,' riep de eekhoorn. 'Vallen??' vroeg de olifant. 'Waar slaat dát op?'

Uit 'Misschien wisten zij alles', Toon Tellegen (1995)

Dit eindwerk met als thema 'interventies ter preventie van burn-out bij studenten geneeskunde en artsen in opleiding' was voor mij een manier om het beestje te bevatten dat me tijdens mijn geneeskundestudies geplaagd heeft en me aangezet heeft mijn opleiding over een extra jaar te spreiden. Wat toen een onoverkomelijk falen leek, werd het begin van een leerschool: het probleem (h)erkennen, het voorkomen in de toekomst en het relativeren van de gevolgen. Naar analogie met bovenstaand verhaal van collega-huisarts Toon Tellegen, trok ik uit dit traject volgende conclusies:

1. Net zoals het risico bestaat om te vallen wanneer men in een hoge boom klimt, is er steeds de kans om uitgeblust te raken wanneer men kiest voor een geëngageerd carrièrepad.
2. De gevolgen van een val of burn-out kunnen heel ernstig zijn, maar net zo vaak komt men er met wat bulten en schrammen vanaf.
3. Hoewel goedbedoeld advies niet altijd effectief is, toont het betrokkenheid en bezorgdheid van mensen aan de zijlijn.

Ik zou graag mijn promotor, Prof. dr. Lode Godderis, bedanken voor zijn efficiënte opvolging en feedback tijdens dit traject. Ook wil ik mijn begeleiders, Anke Boone en Olivia Lavreysen bedanken voor hun input, beschikbaarheid en bemoedigende woorden. Verder wil ik mijn familie, vrienden en opleiders bedanken, die me behoeden om uit de boom te vallen en me helpen opstaan als het toch niet gelukt is. In het bijzonder wil ik mijn verloofde, Wouter Peere, bedanken voor zijn bemoediging en geduld, voor zijn ondersteuning bij de uitdagingen van dit eindwerk en van het leven in het algemeen. Ten laatste wil ik nog u bedanken die de tijd neemt om dit werk te lezen. Ik hoop dat het u mag verrijken met een inkijk in de interventies die artsen van morgen ondersteunen in het balanceren op de boomtop van een geëngageerd carrièrepad.

Annelore Van Heghe

Improving mental health in medical students and residents: a systematic review on interventions and their effects on burnout.

Summary:

This review investigates the impact of interventions aimed at mitigating burnout among medical students and residents. Among medical students, interventions primarily take on an individualized approach. Conversely, for residents, effective interventions rely on the collaborative support of both residents and faculty members. The voluntary nature of participation and strategic timing of interventions, during periods when residents are free from duty, emerge as pivotal factors contributing to their success.

ABSTRACT

Introduction: Medical student and resident mental health issues are a growing concern. Interventions have been developed to reduce burnout and support mental health. In previous research, different intervention types emerged, according to how they tried to bring about a reduction in burnout. Some act on an individual level, others imply organizational changes and some combine both aspects. Previous literature emphasizes the importance of study population engagement and strong program leadership to increase effectiveness.

Objective:

This review aims to collect interventions implemented to reduce burnout risk among medical students and residents. In addition, this study analyses the types of interventions, the development, and the implementation of these interventions, along with their impact on burnout outcomes.

Methods: A literature search was conducted in five databases with terms “Burnout, Psychological”, “Education, Medical, Graduate”, “Education, Medical, Undergraduate”, following PRISMA-guidelines. The inclusion criteria comprised studies focusing on medical students and residents in interventional studies with outcomes measured by the Maslach Burnout Inventory (MBI), Copenhagen Burnout Inventory (CBI) or Oldenburg Burnout Inventory (OLBI). Risk of bias was assessed with the Cochrane Risk of Bias Tool.

Results: Seventy articles were retrieved, of which ten involved medical students and sixty involved residents. Among medical students, eight interventions were individual, one organizational and one combined type. Six of ten articles showed significant burnout reduction. Effectiveness in burnout reduction was better when participation was mandatory. Among residents, thirty-six interventions

focused on individual-level interventions, seven on the organizational level and seventeen on both. Out of thirty-six individual interventions, seventeen were effective in reducing burnout, along with three out of seven organizational interventions and three out of seventeen combined type interventions. Interventions were more successful in reducing burnout when participation was voluntary and when the intervention was conducted outside of duty hours. There was a generally moderate to high risk of bias in the articles.

Conclusion: In medical student burnout research, individual type interventions are most frequently investigated, and demonstrate important effect on burnout. Mandatory interventions demonstrate highest success rates. Quantitative research is needed to analyse the optimal way to develop and implement interventions in this group. For residents, overall success rate of interventions was lower. Individual interventions demonstrated highest success rates. Organizational interventions were rather scarce and showed contrary results. Combined interventions were not as effective as presumed. Further research is needed to evaluate the time needed for an intervention to be effective. Besides resident engagement and strong program leadership, voluntary participation and implementation outside of duty-hours increased the success of interventions.

1. INTRODUCTION

Research in the field of mental health is in continuous evolution. From the need to identify prevalence, risk factors, causes and adverse effects of burnout, there is a shift towards promoting and supporting mental health, with implementation of interventions (1). Firstly introduced by Herbert Freudenberger in the 1970s, burnout was a phenomenon that occurred in healthcare personnel in addiction care (2). He identified three components of burnout: emotional exhaustion (EE), depersonalisation (DP) and the feeling of reduced personal accomplishment (PA). Based on his research, a first burnout measurement scale was developed in 1981 by Christina Maslach, the Maslach Burnout Inventory (MBI) (3). The concept of burnout found its way to other professions in the following decade, and it became a growing field of interest for research.

Burnout research in healthcare personnel revealed many disadvantages. High burnout is associated with increased absenteeism, decreased patient safety, lower quality of care and reduced patient satisfaction (4, 5). Physician burnout proved to have adverse effects for the physician himself (substance abuse, depression and suicidal ideation, poor self-care, increased risk for motor vehicle accidents), for patients (low quality of care, medical errors, poor satisfaction, longer recovery time) and for the healthcare system (reduced physician performance, increased physician turnover, lower access, higher costs) (6). During the COVID-19 pandemic, burnout prevalence in healthcare personnel increased, due to high work pressure. A multinational cross sectional study revealed a burnout prevalence of 67% in healthcare personnel in the United Kingdom (UK), Poland and Singapore during the pandemic, compared to the 31% to 51% burnout prevalence before the pandemic in respectively UK and Singapore (7-9).

In 1998 research on burnout interventions was introduced with the book 'The Burnout Companion To Study And Practice', written by Schaufeli and Enzmann (10). Interventions were categorized in individual, organizational and combined type interventions. Individual interventions are interventions acting on a personal level, such as relaxation exercises, social support, cognitive behavioural measures, aimed at enhancing job competence and personal coping skills. Organizational interventions are structural changes, duty hour restrictions, rotation changes, job evaluation and supervision, aimed at decreasing job demand and increasing job control. Combined interventions are programs comprising both individual and organizational aspects. These are programs that combine for example social activity propositions and wellbeing sessions with increased supervision and protected study time. A meta-analysis of twenty-seven interventions carried out in healthcare personnel, showed individual interventions to be more effective in reducing EE than organizational interventions (11). From all organizational interventions, job training and education were most effective in reducing overall

burnout and improving PA, however they did not show significant changes in EE. This finding was partially confirmed by the review of De Simone et al., where organizational interventions proved to be more effective in reducing DP and improving PA (12).

Medical students and residents are a population with higher burnout risk, since younger age and low experience are considered risk factors for burnout (13-16). For residents, risk factors for burnout and stress are work demands, worry about patient care, poor work-life balance, poor perceived mental and/or physical health, female sex, financial worries, low self-efficacy, isolation and worry about repercussions when searching for help (17, 18). Recent literature in the field of resident burnout interventions emphasizes the importance of the way interventions are implemented (1, 18, 19). In a review published in 2019, Ahart et al. appointed two major drivers for success to be resident engagement and strong program leadership (1). Strategies to empower resident engagement and increase their confidence in the intervention are implementing educational and theoretical aspects (for example about physical effects of mindfulness exercises) as well as engaging them in the development (1, 18, 19). Moreover, voluntary participation and implementation in existing didactic curricula may foster resident engagement (19). On the other hand, strong program leadership is needed to sustain a culture of work in which physician wellbeing can be addressed without stigma. This cultural change involves both residents and faculty and requires patience and persistence (1, 20). Previous reviews on this subject prioritized interventions that included both individual and organizational components and had broad support from both residents and faculty (1, 18, 19).

Considering burnout interventions for medical students, research is rather scarce. Two recent reviews identified only two articles on this subject (21, 22). They concluded from their results that the interventions had no evident effect on burnout and that there was a tendency to decreased program participation of the students near the end of intervention. The most frequently evaluated interventions for medical students are mindfulness based (23, 24). A variety of outcomes have been analysed in the past for evaluation of mental health in students. A meta-analysis on thirty-five articles demonstrated the significant effect of mindfulness interventions to reduce stress in medical students (24).

Walsh et al. have investigated the effect of burnout interventions for both medical students and residents, with a literature search until September 2016 (22). Fourteen articles were retrieved, from which twelve evaluated resident interventions and two investigated medical student interventions. In residents, four articles reported significant improvement, whereas one article reported significant worsening of burnout. This worsened burnout score was attributed by the authors to negative bias against IOM WDH recommendations and inability to blind faculty (25). In medical students, one of two interventions demonstrated significantly lower burnout. The main conclusion of this review was the

general poor quality of the research in this field and need for rigorously designed studies in burnout prevention and reduction. Since 2016, and particularly since the COVID-19 pandemic, there has been increased attention to mental health, with implementation of a variety of new interventions. Since Walsh et al. chose to restrict burnout outcomes to MBI only, they did not include interventions evaluated with other currently used burnout measures as CBI and OLBI. Therefore, the authors found it beneficial to carry out a more recent literature review on burnout interventions in medical students and residents, including CBI and OLBI. The aim of this review is multiple. The first aim is to discuss a variety of implemented interventions in medical students and residents. Since articles on burnout interventions for medical students were proven scarce up till 2019, this review aims to see whether more interventions for medical student burnout were studied in the past three years. A second aim is to compare success of different interventions types, more specifically individual, organizational and combined type interventions, in analogy with previous reviews. A final aim is to draw attention to the development and implementation of the interventions as drivers of success or failure.

2. METHODS

2.1. Search methods

For this systematic review, the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were followed. The research question was constructed using the Population, Intervention, Comparison, Outcome (PICO) procedure: “In medical students and residents, what interventions have proven to be effective in reducing burnout?” A search string was developed with the keywords ‘medical student’, ‘medical resident’, ‘burnout’ and ‘intervention’. Full search strings are available as Supplement 1 (S1) in the supplementary data section of this article.

Five databases (PubMed, Embase, Scopus, Web of Science and Cochrane Central) were systematically searched and results were extracted from the latest fifteen years until September 26th, 2022. Secondly, all records were imported in EndNote and duplicates were automatically removed. Subsequently, the articles were uploaded in the screening program Rayyan and screened by two independent researchers (AV and AB), based on title and/or abstract. Then, full-text articles were screened by the same researchers. A third researcher (OL) was consulted in case of disagreement. Disagreements were resolved by discussion until consensus was reached.

2.2. Study selection criteria

Randomized controlled trials, controlled observational studies and pre-post analyses in English, French and Dutch, published between 2007 and September 2022 were considered eligible for inclusion in this review. Studies without baseline values or control group, conference abstracts, letters to the editor,

case reports, comments and editorials were excluded. The selected study population are undergraduate medical students and postgraduate medical residents. Articles studying other student groups or other healthcare professionals were excluded. No articles were excluded based on type of intervention.

The primary outcome measure in this review is burnout. Articles using the 22-item Maslach Burnout Inventory (MBI-HSS), the 15-item Maslach Burnout Inventory Student Survey (MBI-SS), the 19-item Copenhagen Burnout Inventory (CBI) or the 16-item Oldenburg Burnout Inventory (OLBI) were included, as these instruments are identified by the National Academy of Medicine Studies as valid and reliable to measure burnout (26). All articles using other burnout measures or abbreviated versions of the above-mentioned instruments were excluded. Burnout measurement instruments and their interpretations are listed in Table 1.

2.3. Assessment of risk of bias

Assessment of risk of bias was performed using the Cochrane risk-of-bias tool for randomized trials (RoB 2) (27) and the 'Risk Of Bias In Non-Randomized Studies - of Interventions' (ROBINS-I) tool (28). Risk of bias judgement is displayed in Figure 2.

2.4. Data collection

The following data were extracted from seventy articles: type of study, journal, publication year, publication country, study population, number of participants in intervention and control groups, inclusion- and exclusion criteria, intervention type, outcome measures, burnout-related outcomes and way of implementation. Information of general data, population, sample size, intervention type, intervention development and implementation, burnout outcome and results is listed in Table 3 for medical students and Table 2 for residents.

2.5. Statistical analysis

In this review, a qualitative analysis was made. Results were extracted from the publications with their reported values for effect size and significance. Values for effect size were for example Cohen's d, β, η^2 and Hedge's g. P-values indicate the statistical significance of an observed effect. Interventions were considered effective when at least one of the subscales of the burnout measure demonstrated a significant ($P < 0.05$) improvement.

3. RESULTS

3.1 Results of the literature search

The literature search consisted of Mesh terms “Burnout, Psychological”, “Education, Medical, Graduate”, “Education, Medical, Undergraduate”. From five databases 10.288 articles were retrieved, from which two articles had been retracted. After duplicates were removed, 5670 articles were screened by two independent researchers. Full texts of 229 articles were screened by the same researchers, from which 167 articles were excluded due to various reasons, described in Figure 1. The process of data extraction was performed on eighty articles, after which ten more articles were excluded in consensus between all researchers. When the screening process was completed, seventy articles were selected for inclusion in this review.

3.2. Risk of bias in the included studies

From all seventy articles, fifty-three were screened for bias with the ROBINS-I tool, for non-randomized studies (28). Results are displayed in Figure 2.a. There was generally high risk of bias due to confounding factors. All articles had a moderate risk of bias on measurement of the outcome. Bias due to selection of participants, classification of interventions, deviations from intended interventions and selection of reported results was generally low or moderate. Overall bias judgement for these fifty-three non-randomized articles was moderate to high, except for one article that demonstrated low overall risk of bias (29). Four articles were assessed for bias with the RoB 2 (Cluster) tool, for cluster randomized trials (27). Results are displayed in Figure 2.b. There was an overall risk of bias for all four articles. Twelve RCT’s were evaluated with the RoB 2 tool (27). Results are displayed in Figure 2.c. Highest bias risk occurred due to deviations from intended interventions and due to missing outcome data. There was a moderate overall risk of bias in all twelve articles.

3.3. Effects of interventions on burnout in medical students and residents

In this section, results from the selected articles will be discussed. Firstly, the general characteristics of the articles, such as geography, study design, population and sample size will be appointed. Subsequently, the different burnout scales used in the articles will be commented on. Then, different intervention types and their effects on burnout will be examined. Finally, the development and implementation of the evaluated interventions will be discussed.

Article characteristics

Seventy articles were selected to review. Ten articles focused on interventions for medical students and sixty on interventions for in residents. All articles and their characteristics are listed in Table 3 for medical students and Table 4 for residents. There was a remarkable geographic ascendency towards America, with forty-seven American publications compared to eleven European, nine Asian and three Australian publications.

Among medical students, four articles had a Pre-Post Interventional Design (PPID) (30-33), three were non-Randomized Controlled Trials (non-RCT) (34-36), two were Randomized Controlled Trials (RCT)(37, 38) and one was a prospective cohort study (39). In resident articles, there were 33 PPID (25, 29, 40-70), ten non-RCT (71-80), eleven RCT (81-91), three cluster Randomized Trials (RT) (92-94), one prospective cohort study (95) and two crossover trials (96, 97). Sample sizes in medical student interventions ranged from thirty to 234 participants with a mean sample size of 110 participants. For resident interventions, sample sizes varied from eight to 437 participants, with a mean sample size of sixty-eight participants.

Burnout scales

The most frequently used burnout instrument was the 22-item MBI-HSS, used in 48 articles. In five articles, only two of the three subscales (EE, DP and PA) were measured (49, 51, 54, 78, 98). Four articles reported using validated translated versions in Dutch, Spanish, Chinese and Farsi language (86, 88, 89, 91). However, this number might be underestimated, given the significant number of publications from not native English speaking countries. In students, MBI-HSS was used in seven articles (30, 31, 33-35, 38, 39) and MBI-SS was used in three articles (32, 36, 37). In residents, CBI was used in six articles (47, 50, 52, 82, 84, 87), OLBI was used in three articles (58, 66, 76) and one article used the Maslach Burnout Inventory – General Survey (MBI-GS)(57).

Intervention types

Among medical students, eight out of ten evaluated interventions focused on the individual level (30-34, 36-38), one on the organizational level (35) and one combined (39). Individual interventions comprised online or real life mindfulness-based programs (31, 33, 36), a stress management skill training (32), a wellbeing intervention course (38), sleep improvement measures (30), an electroacupuncture treatment (37) and equine assisted learning (34). From these eight individual interventions, five demonstrated a significant effect in reducing burnout in at least one subscale. Sleep improvement measures reduced burnout in all subscales ($P = 0.001$ for EE, DP and PA). However, the measure for effect size indicated a small effect ($d = 0.353$; $d = 0.411$; $d = 0.275$ respectively) (30). An equine assisted learning intervention had an important effect in increasing PA in the intervention group compared to a non-treated control group ($\beta = 3.74$, $P = 0.03$) (34). Electroacupuncture treatment reduced cynicism (C) and increased academic efficacy (AE) when compared to a non-treated control group, but there was no significant difference when compared to a sham transcutaneous electrical nerve stimulation (TENS) – treated group (37). A stress management skills training showed an important decrease in EE ($\eta^2 = 0.07$, $P = 0.04$) compared to baseline measurement (32). An eight-week online self-care program taking place during the COVID-19 pandemic demonstrated an impressive

decrease in total burnout prevalence (in this article defined as EE ≥ 36 or DP ≥ 11) from 48% to 24% in fourth-year students (P = 0.001) compared to baseline measurement (33). One organizational type intervention was a resident-student mentorship program during emergency medicine sub internship rotation, which showed a significant increase of PA after adjustment for (non-specified) confounders (P = 0.04) (35). One combined method intervention was selected, a three-component wellness program consisting of dedicated faculty mentors, annual retreats and student led programming. However, there was no significant effect on burnout outcomes (39). Four from ten studied interventions did not demonstrate a significant change in burnout (31, 36, 38, 39).

Considering resident interventions, thirty-six individual (25, 29, 41, 44, 46-48, 50, 51, 54, 55, 58-61, 64-69, 73, 75, 76, 79-84, 87-89, 91, 92, 95, 97), seven organizational (25, 49, 70, 74, 85, 93, 96) and seventeen combined type (40, 42, 43, 45, 52, 53, 56, 57, 62, 63, 71, 72, 77, 78, 86, 90, 94) interventions were included. Individual interventions were mindfulness trainings offline (44, 47, 50, 55, 60, 61, 66, 75, 84, 87, 91, 92, 95) and online (59, 67, 83, 95), stress management and resiliency trainings (46, 48, 51, 58, 73, 79-81, 88, 89), psychotherapy workshops (65, 68, 69), personal coaching (29, 54), extracurricular social activities with residents and faculty (41), communication training (81), well-being text messages (82), gratitude journaling (76), group meetings (64), and virtual reality based meditation (97). Organizational interventions included personal mentoring (49, 70), duty-hour changes (25, 93), a day of rest after 24-hours shift (74), debriefing sessions (85) and protected non-clinical time (96). Combined type interventions included Balint seminars (42, 43, 62, 63, 77, 78, 86), multi-component programs (40, 45, 52, 71, 72), inclusion of wellbeing sessions in formal education program (56, 57, 94), preparatory course (90) and continuous quality improvement model (53). Among individual interventions, seventeen out of thirty-six articles described significant improvement of at least one burnout subscale. In these articles, burnout was measured twelve times with MBI-HSS, twice by CBI and three times by OLBI. Ten articles described a decreased exhaustion or EE (41, 58, 59, 65-67, 73, 76, 83, 97), eight described decreased disengagement or DP (58-60, 66, 67, 73, 89, 95), four reported increased PA (41, 60, 65, 91) and four reported significant burnout reduction with other measures (50, 59, 84, 88). Three articles noted significantly worsened scores on burnout subscales (41, 46, 59). From the seven organizational interventions, three demonstrated significant improvement of burnout scores. One intervention showed impressive improvement in all subscales (70), one intervention reduced EE only (96) and the other reduced DP only (74). However, one organizational intervention demonstrated significantly worsened DP score (25). From the seventeen combined type interventions, only three report significant decrease in burnout. Two interventions demonstrated significant reduction in both EE and DP (78, 86). The third intervention reduced only EE (57). Another combined type intervention reduced burnout on all subscales in the subgroup of internal medicine residents,

comprising 23% of all participants (53). One article reported worsened DP after implementation of a combined type intervention (94).

Development and implementation

In this paragraph, four aspects of development and implementation will be discussed, based on suggestions in previous literature. Firstly the initiator of the intervention will be discussed, making subdivisions in (university or other) study groups (external to the student or residency program), large-scale initiatives (for example law changes or large multi-centre studies), program directors, or students or residents themselves. Secondly, the engagement of the study population and/or program direction in the development of an intervention will be reviewed. The third variable that will be assessed is the voluntary or mandatory participation of students and residents. Finally, the implementation of interventions will be evaluated, more specifically whether or not they take place as part of the formal curriculum.

Considering medical students, five out of ten interventions were initiated by external study groups (30, 31, 34, 37, 38). From these, two were co-developed with students (31, 38). Remarkably, the three interventions not involving students for development showed significant improvements of burnout outcomes, whereas the interventions that were co-developed with students did not show significant effect in burnout. Five interventions were implemented by program directors (32, 33, 35, 36, 39), from which three interventions improved burnout outcomes significantly (32, 33, 35), whereas two did not (36, 39). For eight interventions, participation was voluntary (30, 31, 34-39), from which four improved burnout significantly (30, 34, 35, 37). The two mandatory interventions both showed a significant improvement of burnout scores (32, 33). Considering curriculum implementation, six interventions were implemented as part of the formal curriculum (32-36, 39), from which four demonstrated a significant improvement of burnout scores (32-35). Four interventions took place external to the formal curriculum (30, 31, 37, 38), from which two demonstrated a significantly favourable effect on burnout and two did not (31, 38).

Considering resident interventions, seventeen interventions were initiated by study groups external to the residency program (47, 50, 58, 59, 65, 66, 69, 75, 76, 81-84, 88, 89, 91, 95), from which four articles report co-development with residents or faculty (47, 65, 69, 84). From these seventeen interventions, twelve reported significant decrease in burnout on at least one subscale (50, 58, 59, 65, 66, 76, 83, 84, 88, 89, 91, 95). However, this significant decrease of burnout was seen only after two of the interventions that were co-developed with residents or faculty (65, 84). Large-scale initiatives were described in five articles (25, 29, 74, 80, 92). From these, one intervention demonstrated significant improvement of burnout by reducing DP (74). However, another intervention elicited a

significant worsening of burnout by increasing DP (25). Two of the five large-scale implemented interventions did not show significant effect on burnout (80, 92) and the fifth intervention did not report p-values (29). Interventions implemented by program directors (PD) were described in thirty-six articles (40-46, 48, 49, 51-57, 61-64, 67, 68, 70-73, 77-79, 85-87, 90, 93, 94, 96), from which nine demonstrated significant improvement of at least one burnout subscale (41, 53, 57, 67, 70, 73, 78, 86, 96). Nine articles provided information about co-development with residents for implementation of intervention (40, 41, 43, 46, 52, 53, 62, 63, 90), and from these only two demonstrated significant decrease in burnout (41, 53). However, burnout deterioration was seen in two PD-implemented interventions (46, 94). Lastly, two interventions were implemented by residents themselves, which were both successful in reducing burnout significantly (60, 97). Participation was voluntary in forty-six and mandatory or strongly encouraged in fourteen interventions. From the forty-six voluntary interventions, nineteen appeared successful in reducing burnout significantly (50, 58-60, 65, 66, 76, 83, 84, 88, 89, 91, 95, 97) (41, 53, 67, 70, 86). From the fourteen mandatory or strongly encouraged interventions, five elicited a significant decrease in burnout (57, 73, 74, 78, 96). Regarding implementation of interventions in residency curricula, interventions taking place during duty hours were considered embedded in the formal residency curriculum, whereas interventions outside of duty hours were considered not embedded in residency curriculum. Twenty-five interventions were reported to take place during duty hours (25, 42, 46, 49, 50, 53, 55-57, 61, 65, 68-70, 73-75, 78-80, 82, 93-96), whereas sixteen were reported to take place outside of duty hours (41, 47, 58, 59, 66, 67, 76, 81, 83-85, 87, 88, 90, 91, 97). Nine interventions consisted of components taking place both during and outside of duty hours (40, 45, 52, 62-64, 71, 72, 77). For remaining interventions, timing was not clearly reported. From the twenty-five interventions taking place during duty hours, ten articles demonstrated decreased burnout in at least one of the subscales (50, 53, 57, 65, 70, 73, 74, 78, 95, 96), whereas three showed increased burnout in at least one of the subscales (25, 46, 94). From the sixteen interventions taking place outside of duty hours, eleven demonstrated reduced burnout on at least one of the subscales (41, 58, 59, 66, 67, 76, 83, 84, 88, 91, 97). From the interventions with components both during and outside of duty hours, none demonstrated significant effect on burnout.

4. DISCUSSION

The purpose of this review was multiple: to discuss a variety of implemented interventions in medical students and residents, to compare success of different interventions types (individual, organizational and combined type interventions) and to draw attention to the development and implementation of the interventions as drivers of success or failure. From the literature search, ten articles describing interventions in medical students and sixty describing interventions in residents were identified. This

confirms previous findings that medical student interventions on burnout are studied less frequently than resident interventions (22). A hypothesis for this finding is that residents are more dispersed than medical students, and hence a larger number of small-scale initiatives is investigated. This hypothesis is supported by the finding that the mean sample size of medical student articles (n = 110) is higher than the mean sample size of residents (n = 68). A second hypothesis to explain this finding is that in university institutions, research on student wellbeing is often generalized to all university students. Since this literature search and selection process was performed specifically for medical students, articles examining medical students as a subgroup of a larger population were not retrieved. A remarkable geographic ascendency towards America in the selected articles can be explained by the origin of mental health research in general (99), and more specifically of the phenomenon 'burnout'. Burnout was firstly introduced by the American psychotherapist Herbert Freudenberger in 1974 (2) and further promoted with the development of the Maslach Burnout Inventory by the American Christina Maslach (3). Other explanations for this finding are resources, cultural interests and access to populations.

This review retrieved ten articles on burnout interventions for medical students, which provided further knowledge into the effectiveness of interventions for medical students. In this review a variety of interventions were investigated specifically on burnout outcomes, such as an equine assisted learning curriculum (34), sleep improvement measures (30), an electroacupuncture treatment (37), a stress management skill training (32), a mindfulness-based self-care program (33) and a resident-student mentorship program (35). The identified interventions were predominantly (eight from ten) individual interventions. One organizational intervention was identified, a resident-student mentorship program during emergency medicine rotation that demonstrated significant increase of PA (35). One combined type intervention was identified as well, a three component program consisting of dedicated faculty mentors, annual retreats and student led programming, however not affecting burnout outcomes (39). Considering development and implementation of the medical student interventions, attention was drawn on the developers, voluntary or mandatory participation and implementation in the formal curriculum. Five of ten interventions were developed by external study groups and the other five by program directors. There was no difference in effectiveness on burnout. Participation was voluntary for eight interventions and mandatory for two interventions. Half of the voluntary interventions were effective in reducing burnout, whereas all mandatory interventions reduced burnout significantly. Six interventions were embedded in the formal curriculum, from which four were effective in reducing burnout. Four interventions took place external to the formal curriculum, from which two demonstrated significant burnout reduction. These results can be summarized stating that in medical students, mandatory interventions appear to be more effective in

reducing burnout and implementation in the formal curriculum fosters this result. However, considering these limited data, this statement must be interpreted with caution. There is a need for further investigation to substantiate or refute this conclusion.

Regarding resident interventions, sixty articles have been retrieved. Residents are dispersed in different services and hospitals, which encourages small-scale initiatives to improve mental health in specific groups of residents. Sources of inspiration for of the implemented interventions were among others the ACGME AWARE Well-Being Resources, the books 'I Dare You' by Danford and 'Square One: A Simple Guide to a Balanced Life' by Maroon and Kennedy, the Stress Management and Resiliency Training: Relaxation Response Resiliency Program (SMART-3RP), the web-based group coaching program 'Better Together Physician Coaching', 'The Happiness Practice'-program, Balint groups, 'Gratitude and three good things journaling', the 'Fish!'-principles… In this review, attention was drawn to different intervention types, more precisely individual, organizational and combined method interventions, as based on previous literature. Seventeen from thirty-six individual interventions demonstrated burnout reduction, mostly in exhaustion and depersonalization subscales. These findings are consistent with previous literature suggesting that individual interventions impact mainly the emotional exhaustion subscale (11). It is however important to note that OLBI does not have an accomplishment subscale and that CBI uses completely other subscales, which might affect the total result by an underestimation of the impact of individual interventions on personal accomplishment and to a lesser extent on emotional exhaustion and depersonalization. Three from seven organizational interventions demonstrated significant burnout improvement; one reduced EE, a second reduced DP and the third had a favorable effect on all three subscales. However, considering these limited data, no conclusions can be made about the effect of organizational interventions on specific subscale scores. Combined interventions show significant burnout reduction in only three from seventeen articles. This is a remarkable finding, since literature increasingly emphasizes the importance of multimodal interventions, supported by both faculty and residents (1, 18). A possible hypothesis to explain this contrary finding could be the time needed for accomplishment of a 'cultural change' leading to better burnout scores. It seems a plausible assumption that new programs have childhood diseases that hinder a significant improvement of mental health outcomes. However, this findings suggests that intervention type is not the only important variable to take into account when developing an intervention.

In this review, other variables were addressed, such as development, timing and the best way to implement an intervention. These results demonstrate that most interventions – namely thirty-six – are implemented by program directors. Study groups (university or private) external to the program

have the second largest share – seventeen – in implementing interventions. Five interventions are implemented after institutional changes or for multi-center studies, and two interventions were implemented by the residents themselves. It is remarkable that the amount of successful interventions is higher in the interventions implemented by the external study groups (twelve from seventeen) and by the residents themselves (two from two), than compared to the rather low success of PD-implemented interventions (nine from thirty-six) and institutional implemented interventions (one from five). A possible explanation for this finding is given by intrinsic motivation from residents and medical students to participate in an intervention. In study group and resident implemented interventions participation is voluntary, whereas in PD-implemented and institutional implemented interventions, respectively twelve and two interventions were mandatory. From these fourteen mandatory interventions, three demonstrated even significant worsening in burnout. One was explained by the authors by faculty bias against IOM WDH recommendations (25). Explanation for worsened burnout in another study was the mandatory participation (and thus lower initial motivation of participants), the inability to completely free participants from work and educational duties and the fact that group facilitators were psychotherapists (not physicians) (94). In the third article, authors explained the setback by the unfortunate timing of the surveys, which were distributed in July and six months later, in January (46). The last evaluated variable was the moment of implementation of interventions, namely during or outside of duty-hours. From twenty-five interventions taking place during duty hours, ten articles demonstrated decreased burnout in at least one of the subscales, whereas from the sixteen interventions taking place outside of duty hours, eleven demonstrated reduced burnout on at least one of the subscales. To assume by these results that interventions outside of duty hours are more successful than during duty hours seems to be a rather precarious statement. This finding could be explained once more by the intrinsic motivation of residents to participate in activities after duty-hours, and thus to benefit from mental health promoting interventions. Another contributing factor could be the strict separation from work, which induces a different mindset and might provide a safer space to open up about difficult themes. And a final not unimportant explanation could be bias due to the inability to blind participants or lacking data. Further research is needed to investigate the best timing of mental health interventions for residents.

Evaluation with the Cochrane risk of bias tool demonstrated important risk of bias in the selected articles. All except one of the retrieved articles had moderate or high risk of bias. In these interventions, there is inability to blind participants, which leads to bias. Also, participation was voluntary in a large share of implemented interventions, which increases risk of selection bias. In addition, intervention studies often demonstrate dropout or incomplete survey response, which increases the risk of reporting bias. This high bias risk was previously addressed by Walsh et al. in a systematic review in

2019 (22). Another remarkable and troubling finding is the lack of reported P-values in some articles. This reaffirms the statement that there is an urgent need for more streamlined research and reporting in the field of mental health.

This review is distinguished from the review of Walsh et al. by including CBI and OLBI as burnout measurement instrument besides the most widely used MBI (22). Walsh et al. included fourteen articles up till September 2016 with interventions in medical students and residents. They identified only two articles on interventions in medical students, which were both excluded from our review due to inclusion of psychology students and publication date before 2007. Nevertheless, this review demonstrated new research being performed in this field since 2016, with ten additional articles about burnout interventions among medical students. Other reviews evaluated the effect of mindfulness interventions only, or they had other mental health related outcomes (23, 24). This review is the first to include more than three articles about medical student interventions to reduce burnout. Considering resident interventions, there is an overlap of five articles with Walsh et al. (25, 54, 61, 85, 93). The other seven articles were not included because of their publication date, the study type or inclusion of other than only residents.

Compared to the more recent review of Ahart et al. in 2022, we additionally searched Embase and Cochrane Central (1). This review included a multiplicity of interventions, which allows a wide view over existing literature in the field, to test different hypotheses.

A limitation of this review is the general poor quality of the existing research in the field of mental health, as mentioned before (22, 100). Burnout is a difficult measure to quantify, which makes quantitative research very challenging. Various scales are used for burnout measurement and different cutoffs are used in research to define burnout. Hence, data requires cautious interpretation. A second challenge is the diverse population. Undergraduate medical students face different challenges than medical residents. Residents from different specialties or different hospital centres have other professional demands and different support and supervision. Most research is performed on a rather small population sample, therefore critical reflection is required before the generalization of conclusions.

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2019 (22). Another remarkable and troubling finding is the lack of reported P-values in some articles. This reaffirms the statement that there is an urgent need for more streamlined research and reporting in the field of mental health.

In this review, there is an impetus for future research. Firstly, in the past, attention has been drawn to combined type interventions, such as multifactorial wellness programs. However, this review was unable to confirm the effectiveness of these combined type interventions. Future research should investigate long-term effects from combined type interventions, which had time to evolve to increase its response to specific needs and challenges of medical students and residents. Secondly, there is a growing interest in other indicators of mental health, more specifically in positive indicators such as flourishing, wellbeing, job satisfaction and resilience (101). Future research is needed to know how negative and positive indicators of mental health relate to unfavourable outcomes such as long-term illness and job dissertation. A third subject for future research can build on the effectiveness of voluntary and mandatory mental health interventions in medical students. This review suggests mandatory interventions to be more effective in reducing burnout than voluntary interventions. However, these findings need to be confirmed with quantitative data. Finally, this review confirms that there is an urgent need for more streamlined reporting in the field of mental health interventions. This would allow any recently suggested assumptions about interventions in medical students and residents to be supported by quantitative research.

5. CONCLUSION

Research in mental health is a very broad and heterogenous theme. In medical students, investigated burnout interventions are most often on an individual level. Successful burnout interventions were an equine assisted learning curriculum, two-week sleep improvement measures, an electroacupuncture treatment, a resident-student mentorship program, a stress management skill training and a mindfulness based self-care program. Mandatory interventions appear to be more effective in reducing burnout than voluntary interventions. More research is needed for the best way to develop and implement interventions in this population.

In residents, a third of the articles reported significant improvements in at least one of the burnout subscales. Emotional exhaustion and depersonalization were most subject to effect of intervention. Individual interventions were most effective in residents. Contrary to expectations, the effectiveness of combined type interventions appeared to be rather low. Further research is needed to investigate whether combined type interventions need more time to demonstrate an effect. Besides the previously emphasized importance of resident engagement and strong program leadership, interventions seem to be more successful when participation is voluntary. The risk of mandatory

participation is worsening of burnout, due to additional obligations. Interventions taking place outside of duty hours showed better effect on burnout, however this finding must be interpreted cautiously because of bias risk.

A returning finding is the poor quality and heterogeneity of burnout research. There is a need for a protocol to implement, evaluate and report mental health interventions, to allow quantitative evaluation and meta-analysis.

DECLARATIONS

Funding

No sources of funding were used to conduct this study or prepare this manuscript.

Conflicts of interest

There are no conflicts of interest.

Ethics approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Authors' contributions

All authors have made substantial contributions to the conception and design, and/or acquisition of data, and/or analysis and interpretation of data for this review. All authors have participated in drafting the article or revising it critically for important intellectual content. All authors have given final approval of the version to be submitted and any revised version.

TABLES

Table 1 : Burnout measurement instruments.

Burnout scale	Subscales	Items	Scores and interpretation
22-item MBI-HSS (3)	Emotional exhaustion (EE)	8	Range 0-54, high score indicates burnout
	Depersonalization (DP)	5	Range 0-30, high score indicates burnout
	Personal accomplishment (PA)	7	Range 0-48, low score indicates burnout
15-item MBI-SS (102)	Emotional exhaustion (EE)	5	0-6 Likert scale, high score indicates burnout
	Cynicism (C)	4	0-6 Likert scale, high score indicates burnout
	Academic efficacy (AE)	6	0-6 Likert scale, low score indicates burnout
19-item CBI (103)	Personal	6	Range 0-100, high score indicates burnout
	Work-related	7	Range 0-100, high score indicates burnout
	Client-related	6	Range 0-100, high score indicates burnout
16-item OLBI (104)	Exhaustion	8	Range 1-4, score ≥ 2.25 indicates exhausted
	Disengagement	8	Range 1-4, score ≥ 2.1 indicates disengaged
	Total burnout	16	Both exhausted and disengaged

Table 2 : Articles studying interventions to reduce burnout in residents.

Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Acevedo, 2021 (40)	PPID	USA	20 ORL residents.	Combined. Multiple social and psychological components with both episodic and continuous initiatives.	Wellness committee with residents and faculty. Voluntary participation.	22-item MBI-HSS	Trend towards less burnout 1 year after intervention. More participants scored good on all subscales (from 40 to 50%) and less scored bad on all subscales (from 10 to 5%). No p-values reported.
Aghaei, 2022 (41)	PPID	Iran	16 PGY-2 psychiatry residents. 7 active, 9 non-active members.	Individual. Interest groups focusing on extracurricular activities with residents and faculty.	PD-implemented, after consulting focus group. Voluntary participation.	22-item MBI-HSS	Active members demonstrated increased PA ($P < 0.05$). Non-active members demonstrated reduced EE ($P < 0.01$), but decreased PA as well ($P < 0.05$).
Antoun, 2020 (42)	PPID	Lebanon	27 IM residents.	Combined. Biweekly Balint seminars, 10 sessions.	PD-implemented. Mandatory participation.	22-item MBI-HSS	No significant effects.
Ares, 2019 (71)	Non-RCT	USA	28 neurosurgery residents, 28 historical control	Combined. Bimonthly wellness lectures, access to hospital gym, group gym visits, renewed focus on mentorship.	PD-implemented. Voluntary participation.	22-item MBI-HSS	21 and 25 completed surveys before and after intervention respectively. Trend towards better EE, DP and PA scores. Not significant.
Bar-Sela, 2012 (43)	PPID	Israel	15 oncology residents. 8 junior, 7 senior residents.	Combined. Monthly Balint seminars during 1 year.	PD-implemented. After expectations questionnaire. Voluntary participation.	22-item MBI-HSS	Slightly increased PA and reduced DP in junior residents. Worsened scores in all subscales in senior residents. No p-values reported.
Bentley, 2018 (44)	PPID	USA	7 PGY-1 psychiatry residents	Individual. 8-week pilot mindfulness and empathy training program.	PD-implemented, extern course leaders. Voluntary participation, gift card reward.	22-item MBI-HSS	No significant effects.
Bisgaard, 2021 (72)	Non-RCT	USA	59 GS residents, historical control.	Combined. Multiple interventions: healthy snacks, allowing for doctors' visits during work week, residency events…	PD-implemented. Voluntary survey completion.	22-item MBI-HSS	31, 33 and 27 completed surveys at baseline, 6 months and 24 months respectively. No significant effects.
Bragard, 2010 (81)	RCT	Belgium	96 oncology residents. 49 intervention, 47 control.	Individual. 40 hours communication and stress management skills training.	Implemented by study group. Voluntary participation.	22-item MBI-HSS	No significant effects.
Brainard, 2019 (45)	PPID	USA	39 PGY-2 to PGY-4 anaesthesia residents.	Combined. Multiple interventions: lectures, mindfulness sessions, peer-mentoring, wellness education mails…	PD-implemented. Voluntary participation and survey completion.	22-item MBI-HSS	39, 16 and 28 completed surveys at baseline, half-time and end of intervention. No significant overall effect on burnout. PA increased by time ($P = 0.036$). Reduced DP was associated with participation in wellness group dinners ($P = 0.001$).
Brazier, 2022 (82)	RCT	UK	279 anaesthesia residents. 139 intervention, 140 control.	Individual. Well-being text messages.	Implemented by study group. Voluntary participation and survey completion.	CBI – work-related	74 and 79 residents completed both surveys in intervention and control group respectively. No significant effect.

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PD-implemented: program direction implemented, BG: Balint Groups
DP: depersonalisation, EE: emotional exhaustion, PA: personal accomplishment, C: cynicism, AE: academic efficacy

Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Brennan, 2019 (73)	Non-RCT	USA	32 FM residents. 19 intervention, 13 control.	Individual. 8-hour interactive resiliency sessions (intervention) versus training videos (control).	PD-implemented. Mandatory educational sessions. Voluntary survey completion.	22-item MBI-HSS	18 and 10 completed surveys in intervention and control group respectively. Immediately after program, intervention showed better EE and DP scores than control ($P < 0.05$), but no remaining effect after 1 and 2 years.
Burgos, 2018 (74)	Non-RCT	Argentina	25 cardiovascular surgery residents, 25 historical control.	Organizational. Day of rest after 24-hours shift.	Law change for residency programs. Voluntary survey completion.	22-item MBI-HSS	23 and 19 completed surveys in intervention and control group respectively. Reduced DP ($P = 0.023$), no difference in EE and PA.
Chaukos, 2018 (46)	PPID	USA	85 medicine and psychiatry residents.	Individual. 6 hours stress management and resiliency training program, based on SMART-3RP.	PD-implemented, after needs assessment. Embedded in required didactic curricula. Voluntary survey completion.	22-item MBI-HSS	31 residents completed both surveys, baseline and 6 months. Increased EE (Cohen's $d = -0.92$, $P < 0.0001$) and DP scores (Cohen's $d = -0.64$, $P < 0.00001$). No significant effect on PA.
Clarkson, 2019 (75)	Non-RCT	UK	14 radiotherapy-oncology residents. 8 intervention, 6 control.	Individual. 5-week mindfulness program with experienced mindfulness teacher.	Implemented by study group. Voluntary participation.	15-item MBI-SS	Survey completion at baseline, 5 weeks, 3 months and 12 months. Increased AE at each timepoint versus control. No consistent findings for C and EE. No p-values reported.
Fainstad, 2022 (83)	RCT	USA	101 female residents of all specialties. 50 intervention, 51 control.	Individual. 6-month online mindfulness-based program 'Better Together Physician Coaching'.	External to residency program. No protected time to participate.	22-item MBI-HSS	34 and 45 surveys completed in intervention and control respectively. Reduced EE in intervention versus control (-4.33, $P = 0.01$). No significant effect in DP and PA.
Fendel, 2020 (47)	PPID	Germany	9 residents from all stages and specialties of residency.	Individual. 8-week mindfulness-based stress reduction program and 6-hour silent retreat.	Existing program, adapted by experienced psychiatrists-psychotherapists after needs assessment. Voluntary participation.	19-item CBI	Small-to-medium improvement of work-related burnout (Cohen's $d = 0.32$). No effect on personal and client-related burnout. No p-values reported.
Fendel, 2021 (84)	RCT	Germany	147 residents of all specialties. 76 intervention, 71 control.	Individual. 8-week mindfulness-based stress reduction program and 6-hour silent retreat (intervention) versus coursebook for self-study (control).	Existing program, adapted by experienced psychiatrists-psychotherapists after needs assessment. Voluntary participation.	19-item CBI	Total burnout improved at 6 months (Cohen's $d = 0.32$, $P = 0.046$), but not at 2 or 12 months. No significant effect on subscales.
Fraiman, 2022 (92)	Cluster RT	USA	359 paediatric residents. 204 intervention, 155 control.	Individual. Monthly mindfulness curriculum (intervention) versus monthly social lunches (control).	National multi-centre implemented program. Voluntary participation.	22-item MBI-HSS	194 and 146 surveys completed in intervention and control respectively. No significant effect on burnout at 6 and 15 months.
Gunasingam, 2015 (85)	RCT	Australia	31 PGY-1 residents of all specialties. 13 intervention, 18 control.	Organizational. 4 1-hour debriefing sessions.	PD-implemented. Voluntary participation. 1 hour after work.	22-item MBI-HSS	No significant effects.
Hart, 2019 (48)	PPID	USA	46 EM residents.	Individual. Resiliency program 'The happiness practice' with 6 monthly didactic sessions.	PD-implemented with external support. Voluntary participation.	22-item MBI-HSS	34 and 24 surveys completed before and after intervention respectively. No significant effects.

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Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Huang, 2019 (86)	RCT	China	36 PGY-1 residents. 18 intervention, 18 control	Combined. 2 lectures and 10 Balint groups during 6 months.	Standardized Balint program. Voluntary participation.	MBI-HSS, Chinese	Intervention demonstrated reducing EE (t = -2.662, P = 0.013) and DP (t = -2.433, P = 0.020). No significant effect on PA.
Ireland, 2017 (87)	RCT	Australia	44 residents during EM rotation. 23 intervention, 21 control.	Individual. 10-week mindfulness training (intervention) versus 1 hour extra break per week (control).	PD-implemented. Voluntary participation.	CBI – personal, work-related	No significant effects.
Kakarala, 2018 (49)	PPID	USA	12 IM residents.	Organizational. 4 individual mentoring sessions with trained faculty.	PD-implemented with external support. Voluntary survey completion.	MBI-HSS – EE, PA	10 and 9 completed surveys at baseline and after intervention. No significant effect on burnout.
Kalani, 2021 (88)	RCT	Iran	72 EM, IM and OB-GYN residents. 36 intervention and 36 control.	Individual. 9 hours acceptance and commitment training.	Implemented by study group, voluntary participation.	MBI, Farsi	Intervention reduced burnout (P < 0.001). Personality traits (neuroticism and extraversion) had significant impact on effectiveness of the training (P < 0.001).
Kang, 2019 (50)	PPID	Australia	16 psychiatry residents.	Individual. 8-week mindfulness-based intervention program.	External program, implemented during work-hours. Voluntary participation.	19-item CBI	Decrease of personal burnout (Hedge's g = -0.64, P = 0.03). No effect on work- and client-related or total burnout.
Kratzke, 2022 (51)	PPID	USA	95 surgical residents.	Individual. 6-week self-compassion program.	Based on existing program, yearly adaptations based on focus groups. Voluntary survey completion.	MBI-HSS – EE, DP	86 residents completed surveys, 40 completed both surveys. Decreased DP (42% in 2018 and 43% in 2020) and EE (58% in 2018 and 71% in 2020). No p-values reported.
Lisann-Goldman, 2022 (95)	Prospective cohort study	USA	38 PGY-2 and PGY-3 anaesthesia residents. 20 intervention, 18 control.	Individual. 2 years biweekly mindfulness and cognitive behavioural therapy course versus application-based control.	Existing program. Implemented by study group. During morning lecture time. Voluntary participation.	22-item MBI-HSS	Early discontinuation due to low attendance. No significant effect on EE and PA after 1 year. DP score was lower in intervention group (P = 0.040).
Mari, 2019 (52)	PPID	USA	39 psychiatry residents – 23 residents over two-year period.	Combined. 4 organizational initiatives developed by a wellness action team.	After needs assessment. Co-developed by residents and direction.	19-item CBI	14 and 12 completed surveys before and after intervention. Trend towards less burnout on all subscales, not significant.
Martins, 2011 (89)	RCT	Argentina	74 paediatric resident. 37 intervention, 37 control.	Individual. Two 2.5-hour self-care workshops.	Workshops given by mental health professionals. Voluntary participation.	MBI-HSS, Spanish	Reduced DP in intervention (P = 0.031). No other significant effects.
McGinness, 2022 (76)	Non-RCT	USA	41 paediatric residents. 20 intervention, 21 control.	Individual. App-based 3 good things and gratitude journaling program.	Voluntary participation with gift card reward.	16-item OLBI	Reduced exhaustion (Cohen's d = 0.72, P = 0.025). No other significant effect
Monteith, 2022 (90)	RCT	Ireland	11 PGY-2 OB-GYN residents. 4 intervention, 7 control.	Combined. Preparatory course flipped classroom design (intervention) versus online study material (control).	Based on user needs survey. Pilot. Voluntary participation.	22-item MBI-HSS	No significant effects.

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Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Ogunyemi, 2022 (53)	PPID	USA	271 residents from different specialties	Combined. Continuous quality Model for improvement and serial Plan, Do, Study, Act (PDSA) cycles.	PD-implemented. Evaluating interventions, adapting them according resident feedback.	22-item MBI-HSS	Survey response on 5 timepoints: 130-131-126-133-121 completed surveys. Positive trends in all subscales, not significant. In the IM program (23% of all residents), improvements were significant for EE, DP and PA (P < 0.001).
Palamara, 2021 (29)	PPID	USA	272 IM residents	Individual. Personal coaching by faculty member of other specialty.	Multicentre study. Voluntary participation and survey.	MBI-HSS – EE, DP	129 residents completed both surveys. Mean EE (-0.92) and total burnout (-0.73) decreased. Mean DP increased slightly (0.22). No p-values reported.
Palamara, 2015 (54)	PPID	USA	72 IM residents	Individual. Personal coaching by faculty member of other specialty.	Coaches participated on voluntary basis. Voluntary survey reply.	MBI-HSS – EE, PA	59 and 48 completed surveys before and after intervention respectively. No significant effects.
Parshuram, 2015 (93)	Cluster RCT	USA	47 residents during intensive care rotation in 3 different schedules.	Organizational. In-house overnight schedules of 24, 16 or 12 hours.	Organizational change. Voluntary survey reply.	22-item MBI-HSS	15 in 24h schedule, 15 in 16h schedule, 17 in 12h schedule. 13, 14 and 14 completed surveys respectively. No significant effects.
Peterson, 2022 (55)	PPID	USA	14 PGY-1 OB-GYN residents from 2 cohorts.	Individual. 12-hour mindfulness-based wellness curriculum.	PD-implemented. External therapist. Voluntary program and survey participation.	22-item MBI-HSS	14, 13 and 12 completed surveys before, after and 6-9 months after intervention respectively. No significant effects.
Quinn, 2020 (56)	PPID	USA	28 IM residents.	Combined. 6-month multimodal selfcare and compassion curriculum.	PD-implemented. Strongly encouraged participation. Voluntary survey reply.	22-item MBI-HSS	27 completed surveys. No significant effect on burnout. Reduced EE and improved PA were correlated with attendance (β = -3.65, P = 0.007 ; β = 2.69, P = 0.001).
Riall, 2018 (57)	PPID	USA	49 GS residents.	Combined. Monthly interactive wellbeing sessions.	PD-implemented. Mandatory participation, voluntary survey reply.	16-item MBI-GS	39 completed MBI-surveys. Reduced EE (P = 0.04). No other significant effects.
Rich, 2020 (58)	PPID	UK	22 residents of all specialties.	Individual. 1 interactive self-care and wellbeing workshop.	After work-hours. Voluntary participation.	16-item OLBI	18 completed both surveys. Exhaustion and disengagement decreased 1 month after workshop (P = 0.049, P = 0.02).
Ricker, 2021 (59)	PPID	USA	53 PGY-1 residents of all specialties.	Individual. Online physician well-being course, self-selected daily 10-minute resiliency activity for 14 days.	After work-hours. Voluntary participation.	22-item MBI-HSS	52 completed surveys. Reduced EE (P = 0.021), DP (P = 0.002) and total burnout (P < 0.001). Worsened PA (P = 0.028).
Ripp, 2016 (94)	Cluster RCT	USA	51 PGY-1 IM residents. 27 intervention, 26 control.	Combined. Twice-monthly theme based discussion sessions.	Facilitated discussion group led by psychotherapist. Voluntary survey completion.	22-item MBI-HSS	21 and 17 completed surveys in intervention and control respectively. Post-intervention DP worsened in intervention versus control (P = 0.04). Other burnout outcomes were similar in both groups.
Romcevich, 2018 (60)	PPID	USA	10 paediatric residents.	Individual. 4 90-minute mind-body skills training sessions, 8 online modules, optional maintenance sessions.	Led by co-resident. Voluntary participation and survey completion.	22-item MBI-HSS	7 and 8 completed surveys post-intervention and at follow up respectively. Increased PA post-intervention (P = 0.002) and reduced DP at follow-up (P = 0.014).
Runyan, 2016 (61)	PPID	USA	12 PGY-2 FM residents.	Individual. 4 2-hour selfcare and mindfulness sessions, monthly emails the following 3 months.	PD-implemented. Mandatory participation. Voluntary survey completion.	22-item MBI-HSS	9 completed surveys. No significant effects.

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Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Salles, 2017 (77)	Non-RCT	USA	76 surgical residents, historical control.	Combined. Multiple individual and organizational interventions.	PD-implemented. Voluntary use and survey reply on fixed meeting or by email.	22-item MBI-HSS	50 completed MBI surveys. No significant effects.
Schmeusser, 2022 (62)	PPID	USA	24 OB-GYN residents.	Combined. Wellness sessions in different themes. Monthly 1 hour to freely spend for physician wellness.	Implemented by wellness leadership team (three residents and faculty advisor). Voluntary survey reply.	22-item MBI-HSS	19, 13 and 18 completed surveys at baseline, 6 months and 12 months respectively. No significant effects.
Schuh, 2011 (25)	PPID	USA	34 neurology residents.	Organizational. 1 month pilot of limiting shifts according to IOM WDH recommendations.	Organizational change. Voluntary survey responding.	22-item MBI-HSS	24 and 23 completed surveys before and 1 month after adaptations. Worsened DP (P = 0.03). No other significant effects.
Sheer, 2021 (63)	PPID	USA	122 IM residents participated in grassroots interventions. 87 IM residents and 35 students in formal program	Combined. Grassroots intervention curriculum by 10 resident-volunteers. Formal program-driven wellness curriculum by 12 faculty experts.	Resident-led versus expert-led. Voluntary survey completion.	22-item MBI-HSS	Grassroots evaluation at baseline (38 surveys), 6 months (20 surveys) and 11 months (64 surveys) did not show significant effect. Formal program evaluation before (64 surveys) and after (53 surveys) had no significant effect either.
Slavin, 2017 (78)	Non-RCT	USA	17 PGY-1 paediatric residents. 18 historical control.	Combined. 1 year program with individual and communication-enhancing components.	PD-implemented, sessions led by faculty. Mandatory and voluntary sessions.	MBI-HSS – EE, DP	Reduced EE (P < 0.05) and DP (P < 0.01) in intervention versus control. Residents with overall burnout decreased from 14 to 5 (P < 0.01).
Stevens, 2020 (96)	Crossover study	USA	19 ORL residents	Organizational. 2 hours per week of protected non-clinical time.	PD-implemented.	22-item MBI-HSS	Significant decrease in EE at 32 weeks (P < 0.05). No other significant effects.
Tan-Lim, 2022 (64)	PPID	Philippines	59 paediatric residents	Individual. Twice monthly group meetings and possibility for one-on-one sessions with psychologist.	Voluntary participation and survey completion.	22-item MBI-HSS	59 and 17 completed surveys before and after intervention. No significant effect on burnout.
Tjasink, 2019 (65)	PPID	UK	14 residents from medical oncology and palliative care.	Individual. Six art therapy sessions.	Designed by art therapist and resident. During duty hours. Voluntary participation.	22-item MBI-HSS	Reduced EE (P < 0.001) and increased PA (P = 0.011). No effect on DP.
Ungerman, 2020 (79)	Non-RCT	USA	16 PGY-1 anaesthesiology residents (intervention), 16 PGY-2 residents (control)	Individual. Wellness course with 1h didactic lecture and wellness workshop about Fish!-principles.	PD-implemented. Mandatory sessions. Voluntary participation to Fish!-principles.	22-item MBI-HSS	15 and 13 completed surveys in intervention and control. No significant effect on burnout.
Verweij, 2018 (91)	RCT	Netherlands	148 residents from all medical, surgical and FM specialties. 80 intervention, 68 control.	Individual. 8-week 2.5 hour mindfulness-based group sessions and 6-hour silent retreat.	After duty hours. Voluntary participation.	MBI-HSS, Dutch	71 and 67 completed surveys in intervention and control. Significant increase in PA (Cohen's d = 0.23, P = 0.028). No significant effect on EE and DP.

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Reference	Study design	Country	Participants	Intervention	Implementation	Scale	Results
Villarreal, 2021 (66)	PPID	UK	17 PGY-2 and PGY-3 FM residents.	Individual. Mindful practice curriculum with 6 weekly sessions.	Recruitment by email. Sessions during lunchtime. Voluntary participation.	16-item OLBI	17 residents completed both surveys. Decrease in both exhaustion ($P < 0.001$) and disengagement ($P = 0.001$).
Wang, 2021 (67)	PPID	China	63 medical residents from different specialties with MBI score 50 to 75.	Individual. Online mindfulness intervention with videos and psycho-education platform.	Developed by psychologists and department leaders. After duty hours. Voluntary participation.	22-item MBI-HSS	Significant reduction in EE and DP in all different specialties ($P < 0.05$ for both). No significant effect on PA.
Weitzman, 2021 (97)	Randomized crossover study	USA	18 ORL residents.	Individual. 8-week 10-minute virtual reality based meditation.	Resident-implemented. Voluntary participation.	22-item MBI-HSS	18 and 14 completed surveys before and after intervention. Reduced EE after intervention ($P = 0.009$). No significant effect on DP or PA.
Williamson, 2019 (80)	Non-RCT	USA	437 PGY-1 to PGY-4 EM residents.	Individual. 1 year wellness curriculum with didactic elements, individualized interactive instruction assignments.	Multi-centre study, PD-approved. Voluntary survey participation.	22-item MBI-HSS	285, 247 and 228 completed surveys at baseline, 6 months and 12 months. No significant effect on burnout.
Winkel, 2016 (68)	PPID	USA	66 OB-GYN residents.	Individual. 15 1-hour narrative medicine workshops.	Designed by faculty. During duty hours. Strongly encouraged participation.	22-item MBI-HSS	43 completed both surveys. No significant effect on burnout after 1 year. High attendance was associated with reduced EE scores (Cohen's $d = 0.65$, $P = 0.02$).
Winkel, 2010 (69)	PPID	USA	20 OB-GYN residents. 10 participants, 8 non-participants.	Individual. 6 1-hour reflective writing workshops.	Designed by educational psychologist. Topics suggested by residents. During duty hours. Voluntary participation.	22-item MBI-HSS	18 completed both surveys. 8 residents participated in ≤ 1 workshops (non-participants). No significant effect on burnout scores.
Zhang, 2017 (70)	PPID	Canada	8 PGY-1 to PGY-4 ORL and head and neck surgery residents.	Organizational. Residents chose a main mentor with whom they met every 3 months.	PD-implemented. Involvement of staff. Voluntary participation.	22-item MBI-HSS	Decrease of burnout in all subscales ($P < 0.0001$ for EE, DP and PA).

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Table 3 : Articles studying interventions to reduce burnout in students.

Reference	Design	Country	Participants	Intervention	Implementation	Scale	Results
Artz, 2021 (34)	Non-RCT	USA	27 third year students: 15 intervention, 12 control. 3 internal medicine residents: all intervention.	Individual. Equine assisted learning.	Implemented by study group. Voluntary participation. As part of clerkship rotation.	22-item MBI-HSS	Assessment at baseline, post-course and 3 months post-course. PA improved in intervention group ($\beta = 3.74$, P = 0.03). No significant effect on EE or DP.
Brubaker, 2020 (30)	PPID	USA	57 first and second year students. 55 completed surveys.	Individual. Two-week sleep improvement measures.	Implemented by study group. Voluntary participation. Gift card reward.	22-item MBI-HSS	Improvement in EE (Cohen's d = 0.353, P = 0.001), DP (Cohen's d = 0.411, P = 0.001) and PA (Cohen's d = 0.275, P = 0.001).
Danilewitz, 2018 (31)	PPID	Canada	52 students. 37 completed surveys.	Individual. 7-module online mindfulness program.	Program built by students and clinical researches. Voluntary participation.	22-item MBI-HSS	No significant effect on burnout.
Dias, 2014 (37)	RCT	Brazil	82 second year students with sleep quality disturbance. 30 electroacupuncture (EA), 18 sham TENS, 34 untreated control.	Individual. Electroacupuncture (EA) treatment versus sham TENS and untreated control.	Implemented by study group. Voluntary participation.	15-item MBI-SS	EA was effective in reducing C compared to control (P=0.001), but not to sham TENS. There were significant baseline differences in AE. Post-intervention AE ### Post-intervention significant difference between EA and sham TENS (P=0.009), EA and control (P=0.032) and sham TENS and control (P=0.0002).
Jordan, 2019 (35)	Non-RCT	USA	135 fourth year students during emergency medicine sub internship. 51 intervention, 84 control.	Individual. Resident-student mentorship program.	Implemented by program directors. Voluntary participation.	22-item MBI-HSS	Survey completion is not mentioned in article. No significant effect on EE, DP or PA. After adjustment for confounders: significant improvement of PA (P=0.04) in intervention group.
Nebhinani, 2021 (32)	PPID	India	100 first year students. All completed surveys.	Individual. Stress management skills training	Delivered by a team of a psychiatrist and a nurse. Included in formal education.	15-item MBI-SS	Assessment at baseline, 1 month and 3 months. Improvement of EE (η^2=0.07, P=0.04). No significant effect on DP or PA.
Oró, 2021 (36)	Non-RCT	Spain	143 second to fifth year students. 68 intervention, 75 control.	Individual. Mindfulness based program.	Implemented as elective course. Voluntary participation.	15-item MBI-SS	Baseline significant difference in AE (P < 0.005). No significant effect of intervention.
Real, 2015 (39)	Prospective cohort study	USA	234 first to fourth year students.	Combined. Vanderbilt wellness initiative.	School sponsored initiative. Partially faculty-led, partially student-led.	22-item MBI-HSS	104 students met criteria for burnout (high DP and high EE score). No effect of intervention.
Rong, 2021 (38)	RCT	China	146 third and fourth year students. 74 intervention, 72 control.	Individual. Lecture-guided discussions versus non-structured discussions.	Development consulting student focus group. After regular medical courses.	22-item MBI-HSS	Baseline assessment and 1 month post-course. No significant effect on burnout.
Zúñiga, 2021 (33)	PPID	Chile	123 fourth-year students. 102 completed surveys.	Individual. Self-care program.	Implemented in formal education as mandatory course.	22-item MBI-HSS	Burnout prevalence (defined as EE scores ≥ 36 or DP ≥ 11) decreased from 48% to 24% after the program (P=0.001).

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MBI-HSS: Maslach burnout inventory human services survey, MBI-SS: Maslach burnout inventory student survey
DP: depersonalisation, EE: emotional exhaustion, PA: personal accomplishment, C: cynicism, AE: academic efficacy

FIGURES

Figure 1 : PRISMA 2020 flow diagram for new systematic reviews which included searches of databases.

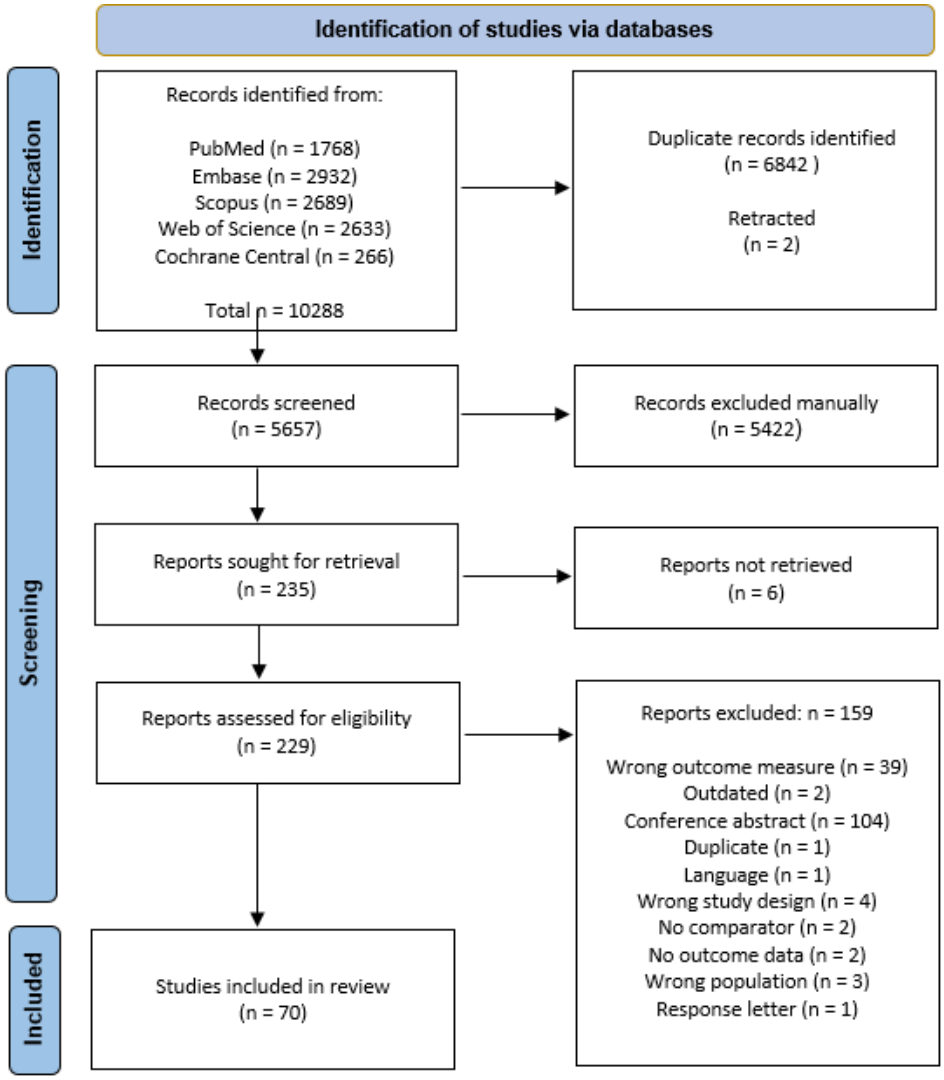
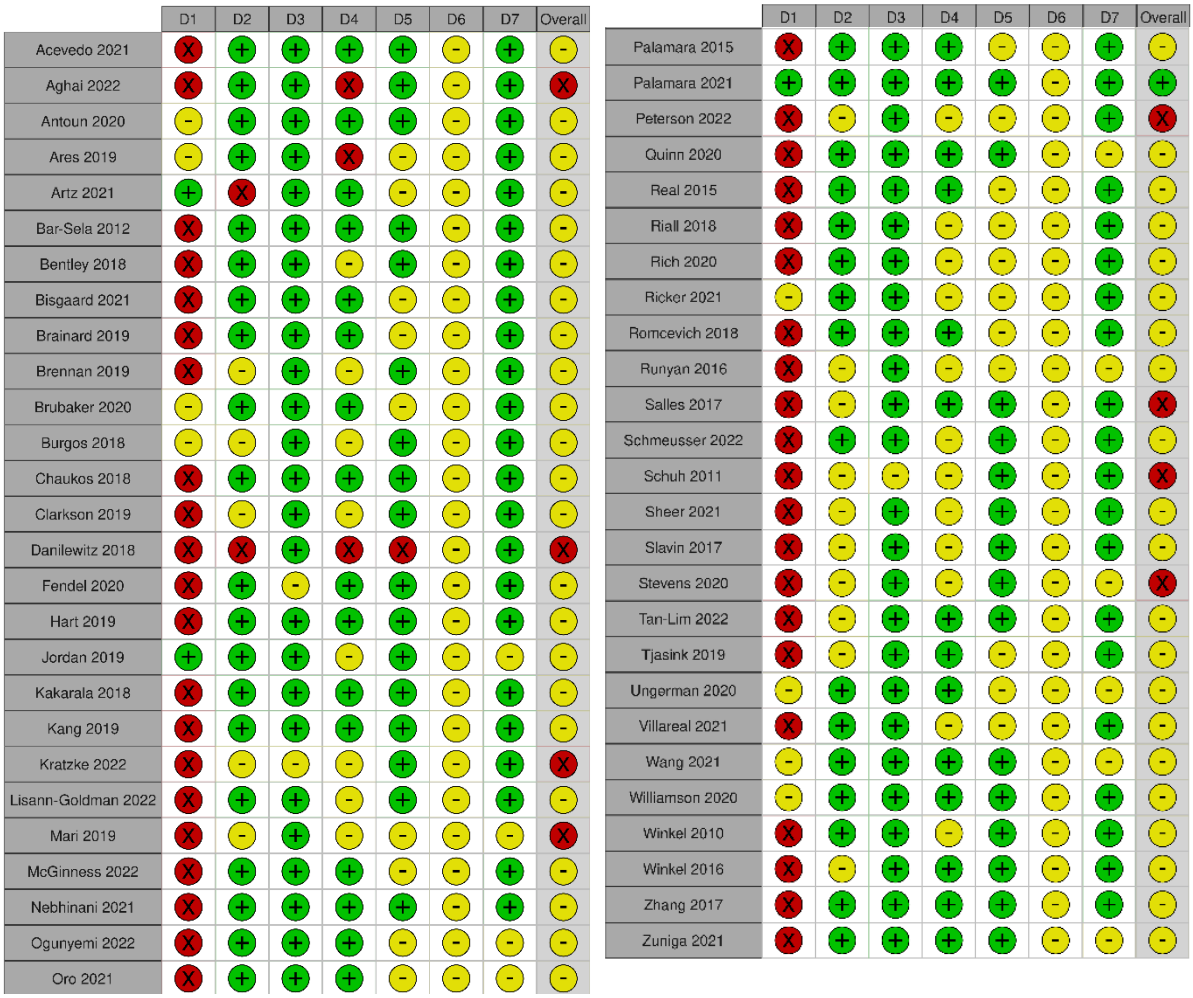


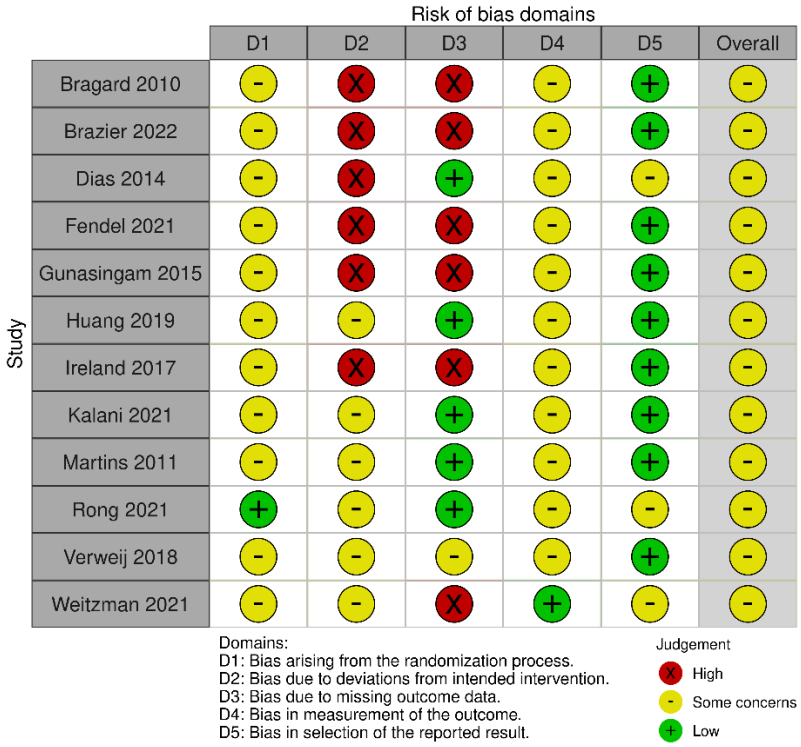
Figure 2 : Risk of bias assessment.
2.a. Risk of bias assessment of non-randomized trials using ROBINS-I tool.



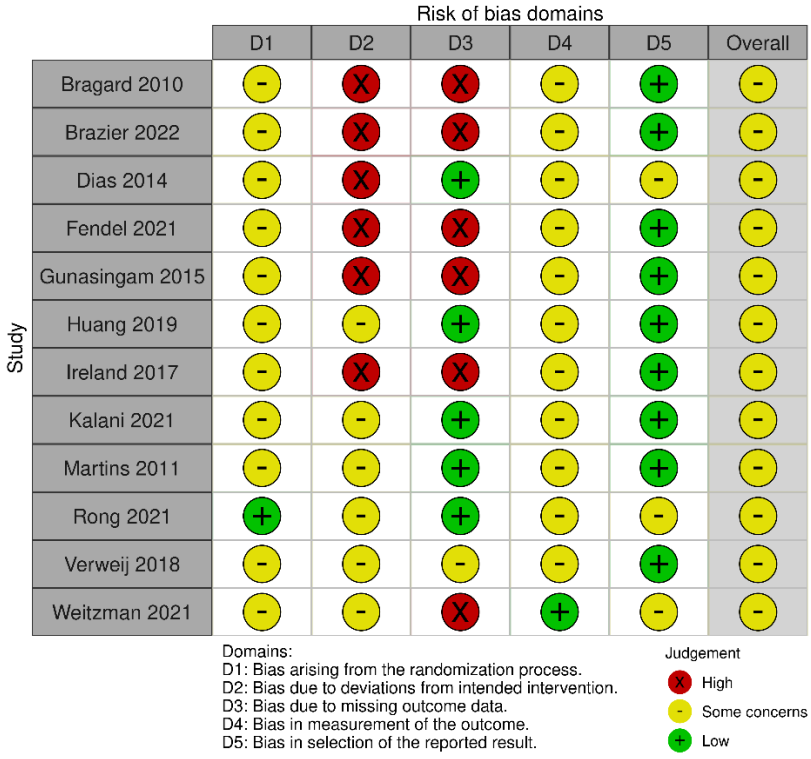
Domains:
D1: Bias due to confounding.
D2: Bias due to selection of participants.
D3: Bias in classification of interventions.
D4: Bias due to deviations from intended interventions.
D5: Bias due to missing data.
D6: Bias in measurement of outcomes.
D7: Bias in selection of the reported result.

Judgement
X Serious
\- Moderate
\+ Low

2.b. Risk of bias assessment of cluster randomized trials using RoB2 (Cluster) tool.



2.c. Risk of bias assessment of randomized controlled trials using ROB2 tool.



SUPPLEMENTARY DATA

S1 : Search strings. Databases consulted 26th of September 2022.

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EMBASE : 2932 hits

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WEB OF SCIENCE : 2633 hits

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COCHRANE CENTRAL : 266 hits

Search builder was completed with above-mentioned terms.

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