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Types and outcomes of safety interventions addressed to diverse workers: a scoping review

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ABSTRACT

The goal of this scoping review is to map the types and outcomes of interventions aimed at increasing safety and reducing workplace hazards of diverse workers. After searching Web of Science, Scopus and PsycInfo, 23 papers addressing safety interventions for diverse workers were selected. We extracted and systematized the data by filling in a form with specific information about each study. The included studies were published between 2003 and 2023. They were mainly conducted in the United States, followed by Australia, Bangladesh, Canada, Gambia, India, Qatar, and South Africa. Most of the interventions targeted immigrant and ethnic minority groups, followed by young and/or older workers, women, mixed groups (women and young/older workers) and workers from low-wage countries. Different strategies were applied to adapt the interventions to the specific needs of the diverse workers (e.g., language and cultural adaptation, provision of different stimuli during the training according to the participants' age). The intervention outcomes were measured in several ways, for instance, in terms of knowledge acquisition and transfer, hazard identification and reduction, and improvements in safety behaviors. The findings showed that safety interventions are more effective when tailored to the specific needs of diverse workers. In many cases, interventions yielded more positive results when trainers from the target group were involved. These findings can guide the design of future safety interventions, and should encourage future research to extend to other diverse workers (e.g., people with disability and LGBTQ workers), by considering their unique characteristics and needs.

1. Introduction

Due to several societal and global shifts, such as globalization, migratory flows, medical advances, and digitalization, workplace environments are, nowadays, spaces of encounter of a diversity of individuals. Because of these global trends, the composition of the workforce in the United States has changed significantly. In 2023, people older than 55 years, non-White people and Hispanic workers increased by 8%, 6.2% and 6.2% respectively, compared to 2003 (U. S. Bureau of Labor Statistics, 2024). Data available from the European Union also points in the same direction, showing a higher rate of workers from diverse backgrounds in the labor market. For instance, compared to 2013,[2] people older than 50 years increased by 5% in 2022 in work environments (CEDEFOP, 2024) and immigrant workers increased by 2% in 2023 (Eurostat, 2024).

Workers are often exposed to occupational risks and hazards, regardless of their identity. However, several studies showed that being part of a diverse or protected group might increase the likelihood of suffering workplace injuries if organizations do not consider their unique needs (Ranasinghe et al., 2023). According to the American Psychological Association, diverse groups refer to "social identities that correspond to societal differences in power and privilege and thus to the marginalization of some groups based on specific attributes" (American Psychological Association, 2023, p.4). In line with this definition, under the umbrella "protected or diverse groups", we include diverse people in terms of gender, gender identity, gender expression, sexual orientation,

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[2] 2013 was chosen as the reference year because it marks the creation of the EU-27, making it more comparable to the current composition of the EU.

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(dis)ability, health status, age, racial or ethnic origin, color, nationality or national origin, religion or belief, language and socio-economic disadvantaged status (European Union Agency for Fundamental Rights and Council of Europe, 2018)[3]. Age, for instance, is an individual characteristic that might make people more vulnerable in a specific context and that impacts prevalence and type of injuries. Although we know that the number of accidents at work decreases with age (Shooshtari et al., 2022), several studies also show that older workers are exposed to more severe injuries than young people due to the depletion of their physical health and cognitive functions (Choi, 2009; Ranasinghe et al., 2023; Stoesz et al., 2020). While several job accommodations and interventions to reduce workplace hazards for older people have been suggested, studies that implement and test their outcomes remain scarce (Stoesz et al., 2020; Truxillo et al., 2015; Wallen and Mulloy, 2006).

Immigrant workers are a group of individuals who may also be exposed to a higher number of risk factors than local workers. A recent systematic review and meta-analysis (Lau et al., 2024) showed that immigrant people are at greater risk of fatal accidents at work than their local colleagues. Several factors contribute to such a result. Immigrant people are often working in 3-D jobs; those that are described as dirty, dangerous and demanding. Thus, they are often employed in precarious jobs and with poor working conditions, which are characterized by lower pay than colleagues from the host country, even when they work for longer hours. Moreover, their working conditions are often unsafe, with no appropriate health and safety training nor protective equipment (Moyce and Schenker, 2018; Quandt et al., 2013; Williams et al., 2010). Language barriers, differing levels of formal education, and safety-related cultural norms might also explain the higher number of injuries in this diverse group (Brunette, 2005; Shepherd et al., 2021). Some researchers have also highlighted the limited findings about the outcomes of safety and injury prevention interventions addressing migrant workers (Caffaro et al., 2018). Those evaluations are scarce due to the low response rate to post-intervention questionnaires, often stemming from the challenge of locating the same participants (Williams et al., 2010).

Gender is another aspect that should be considered when we try to understand safety and injuries prevalence and their prevention at work. Although both men and women are exposed to risks in the work environment, there are some gender-specific aspects that should be taken into account. For instance, women are usually segregated in female-dominated sectors, where they often carry out fast, repetitive, and monotonous tasks and receive lower salaries than their male counterparts (Alksnis et al., 2008; EU-OSHA et al., 2016; García-Mainar et al., 2018). Moreover, physical and biological differences between men and women need to be contemplated. For instance, personal protective equipment (PPE) is often tailored to men's body measures, increasing the risk of accidents for women (EU-OSHA et al., 2016). In relation to sexual and reproductive differences, there is a paucity of research about how menopause affects women at work (Verdonk et al., 2022) and, consequently, their safety. Research in this area has shown that menopause can negatively affect concentration, memory and energy levels (Cipd, 2023; Griffiths et al., 2013; Verdonk et al., 2022), which can increase the likelihood of work accidents and may require specific safety interventions (e.g., work redesign).

Although the interest of researchers toward the safety of diverse workers is growing, there remains a lack of comprehensive studies on certain protected groups. For instance, research on workers with disability has focused on the experience of people that return to work after an occupational hazard or a chronic illness (Loisel and Anema, 2013) and the accommodations that should be implemented to ensure the safety of both people with disabilities and their colleagues (Bay et al., 2020). Previous research also showed that workers with disability have a higher rate of occupational injuries than their colleagues without any known disability (Price et al., 2012). To reduce these injury rates, it is therefore necessary to understand which types of safety and injury prevention interventions have been addressed to workers with disability, and what has, so far, failed. Occupational safety might also be a relevant issue for lesbian, gay, bisexual, trans and queer (LGBTQ) workers, who are more likely to be exposed to violence and discrimination at work than their cisheterosexual counterparts (Di Marco et al., 2018; McFadden, 2015), and for that reason the former may require specific health and safety training (EU-OSHA, 2022).

The unique characteristics of diverse groups described above make it necessary to develop specific interventions aimed at preventing occupational injuries and increase their safety. Some researchers have designed and tested safety and injury prevention interventions tailored to protected groups, highlighting the effectiveness of such interventions in achieving the desired outcomes. For instance, research showed that the educational approach to health and safety must be culturally and linguistically comprehensive for immigrant workers (Moure-Eraso and Friedman-Jimenez, 2005). Thus, merely translating the content of a training program might not be sufficient if it fails to take cultural differences into account, even when participants share the same language. Other studies pointed out that training for older workers needs to consider the depletion of working memory, which might pose a barrier to processing and integrating complex or multiple pieces of information (Wallen and Mulloy, 2006), and they recommend providing the same educational input both visually and verbally. Although these studies showed that tailoring is an overall useful approach, there is no comprehensive overview of which types of interventions have been addressed to diverse workers so far, and what types of outcomes they have produced. To address this gap, a scoping review was conducted to map the available evidence in this emerging field (Munn et al., 2018; Tricco et al., 2018). Therefore, the research question guiding the study was: Which types of safety and injury preventions interventions are aimed at diverse workers, and what outcomes do they yield? Thus, the goal of this scoping review was to identify those studies that focus on interventions targeting protected groups. With this scoping review, first, we aimed to identify which types of safety and injury prevention interventions have been developed and to which diverse group of workers. Second, we aimed to highlight any positive outcomes those interventions led to, as identified in each study.

2. Material and methods

This scoping review was conducted following the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review (PRISMA-ScR) guidelines (Tricco et al., 2018). To ensure transparency and replicability of the process, the protocol was registered on the Open Science Framework (reference number: https://osf.io/xqr9k).

2.1. Search strategy

Three scientific databases were searched: PubMed, Scopus, and Web of Science. To perform the search, multiple and comprehensive keywords were included in order to identify those studies focused on safety interventions directed to diverse groups at the workplace. The following keywords were included: "Protected group*" OR "diverse group*" OR minorit* OR "gender identity" OR "trans people" OR transgender* OR transsexual* OR TGNC OR "gender non-binary" OR "gender non-conforming" OR "Sexual divers*" OR "sexual minorit*" OR "gender divers*" OR "gender minorit*" OR "sexual orientation" OR "sexual identity" OR "SOGI" OR LGBT* OR LGB* OR GLB* OR GLBT* OR lesbian* OR gay* OR queer* OR bisexual* OR "gender expression" OR intersex* OR "sex diversity" OR woman OR women OR disabilit* OR "disabled people" OR

[3] In this article, we will use "diverse groups" and "protected groups" as synonymous, while acknowledging that not all diverse people fall under the category of protected people.

"chronic illness*" OR "chronic disease*" OR "health impairment*" OR "health disorder*" OR older OR elder* OR "older adult*" OR ageism* OR young* OR youth OR race OR racial OR ethnic* OR refug* OR migrant* OR immigrant* OR faith* OR religio* OR "minority language*" OR "foreign language*" OR "social class*" OR "educational level" OR "socioeconomic factors" OR "socioeconomic status" OR "socioeconomic position" OR "income" OR "housing tenure" OR "deprivation area" OR "deprivation index" OR "poverty area*" OR "area* of deprivation" AND "Workplace safety" OR "safety at work" OR "safe work environment*" OR "occupational safety" OR "workplace injur*" OR "injury at work" OR "accident* at work" OR "workplace hazard*" AND "Safety intervention*" OR "injury prevention" OR "accident prevention" OR "hazard prevention" OR "health and safety practic*". No time restrictions were applied. The first search was carried out on March 19th, 2024. It was updated on October 13th, 2024. Moreover, the reference list of the articles included in the scoping review was reviewed to identify additional articles that met our inclusion criteria that were not included in the first selection.

2.2. Eligibility criteria

The selection process adhered to specific eligibility criteria defined a priori, based on the research question. Papers were selected if they focused on a population that included protected groups, as defined by the European Union Agency for Fundamental Rights and Council of Europe (European Union Agency for Fundamental Rights and Council of Europe, 2018). The content of the articles had to include safety interventions implemented in workplace settings and to report the outcomes of such interventions being evaluated. Only studies published in peer-reviewed journals and in English were considered. Consequently, systematic reviews, meta-analyses, editorials, commentaries, conference papers, dissertations, books, essays, and reports were excluded.

2.3. Selection process

The initial search yielded 1415 results (Fig. 1). After removing 336 duplicates, the research team screened 1079 records for eligibility, analyzing their titles and abstracts. This screening was conducted by the four authors. At the beginning, a calibration process was carried out to practice and clarify the pre-established decision rules (Kolaski et al., 2023). The selection process was facilitated using Rayyan (https://www.rayyan.ai/), a tool which allows to work in a blind mode and to identify those articles that create conflicting opinions between reviewers. During the first calibration round, all authors independently evaluated a limited number of documents ($n = 54$) and then met to resolve disagreements through discussion. In this initial round, the conflict rate was 35%, highlighting the need to refine the inclusion criteria. In the second calibration round, the authors evaluated another set of documents ($n = 54$), and the conflict rate dropped significantly to 1.8%. Given that the acceptable conflict rate at this stage is 8% (Mak and Thomas, 2022), we concluded the calibration stage. The remaining articles were divided into four blocks which were assigned to pairs of reviewers. The pairs of reviewers did not always consist of the same individuals, as the authors rotated. After finalizing the revision of one block, the full team met to discuss conflicts.

After this stage, 1022 articles were excluded for not meeting the inclusion criteria, and 57 documents were selected for the full text review by one pair of authors. The full-text screening was carried out by the first author. The research team met regularly to solve any doubts related to the decision to include or exclude articles. After reading the full text, 37 articles were excluded for different reasons: not including protected groups ($n = 7$); not including interventions ($n = 8$); not focusing on the outcomes of the intervention ($n = 7$); not being conducted in work settings ($n = 11$); and not meeting the criteria related to the type of paper (e.g., systematic review, dissertation) ($n = 4$). As a result, 20 articles were included in the scoping review. A second search was conducted in October 2024 together with a review of the reference list of the articles already included. At that time, five additional articles were selected for full text revision. However, only three met the inclusion criteria, making a total of 23 articles included in the review (Fig. 1).

2.4. Data extraction and quality assessment

Data was codified and extracted using an Excel form containing the elements described in Table 1. Thus, we extracted data related to authors, year of publication, the sample size, the country where the intervention was implemented, and the specific diverse group of workers targeted. Moreover, we identified data about the characteristics of the research design, in terms of the type of intervention and the presence or not of a control group. The characteristics of the intervention design were also extracted, focusing on the delivery method (e.g. training developed with the guide of an instructor, use of new technologies, provision of work tools, etc.), the delivery mode (resources provided during the training and the mode of the intervention – e.g., in presence vs online), the tailoring strategies applied, and the content and the length of the intervention. Lastly, the main outcomes of the intervention were extracted as well (see Table 1). A quality assessment of the eligible articles was conducted using the JBI critical appraisal tools (Barker et al., 2023; Barker et al., 2024; Gomersall et al., 2015). These instruments are tailored to different types of research design, and evaluate the validity and quality of the studies by answering a set of questions related with different dimensions (e.g., bias related to administration of intervention/exposure; bias related to assessment, detection, and measurement of the outcome). Each item can be scored as met, unmet, unclear, or not applicable (Barker et al., 2024). Authors two, three and four independently assessed the quality of the studies. Disagreements were solved through discussions between all the authors.

3. Results

3.1. Study characteristics

The articles included were published between 2003 and 2023. Of the 23 studies, $n = 16$ were conducted in the United States, followed by Australia, Bangladesh, Canada and United States, Gambia, India, Qatar, and South Africa ($n = 1$). Nineteen were quasi-experimental studies (eight studies used one-group pre–post design; seven studies used between-groups design; two used crossover designs, and two used one-group post-only design), three were randomized control trials, and one was an observational study. Twelve interventions were developed in the farm industry and four in the construction sector, followed by electronic manufacturing, fishing industry, forestry, mining industry, and shipbuilding industry ($n = 1$). Two articles did not report the sector because they were developed with immigrant laborers working in different fields.

The quality assessment was carried out using different JBI tools, depending on the research design of each study analyzed. Specifically, the tools for quasi-experimental studies, randomized controlled trials, and economic evaluations[4] were applied. The quality assessment of the quasi-experimental studies showed that all clearly identified temporal precedence. However, only three studies included a control group. Another significant weakness of the included studies was the lack of clarity in determining the reliability of the measures used.

All of the randomized controlled trials employed random assignment of participants to the treatment group and demonstrated consistency and reliability in measuring outcomes across all groups involved in the experiments. Moreover, all of them conducted appropriate statistical

[4] The economic evaluation tool was applied to Thiede and Thiede's study (*Thiede and Thiede, 2015) which analyze the costs and benefits of occupational safety interventions at a Bangladesh shipbuilding company.

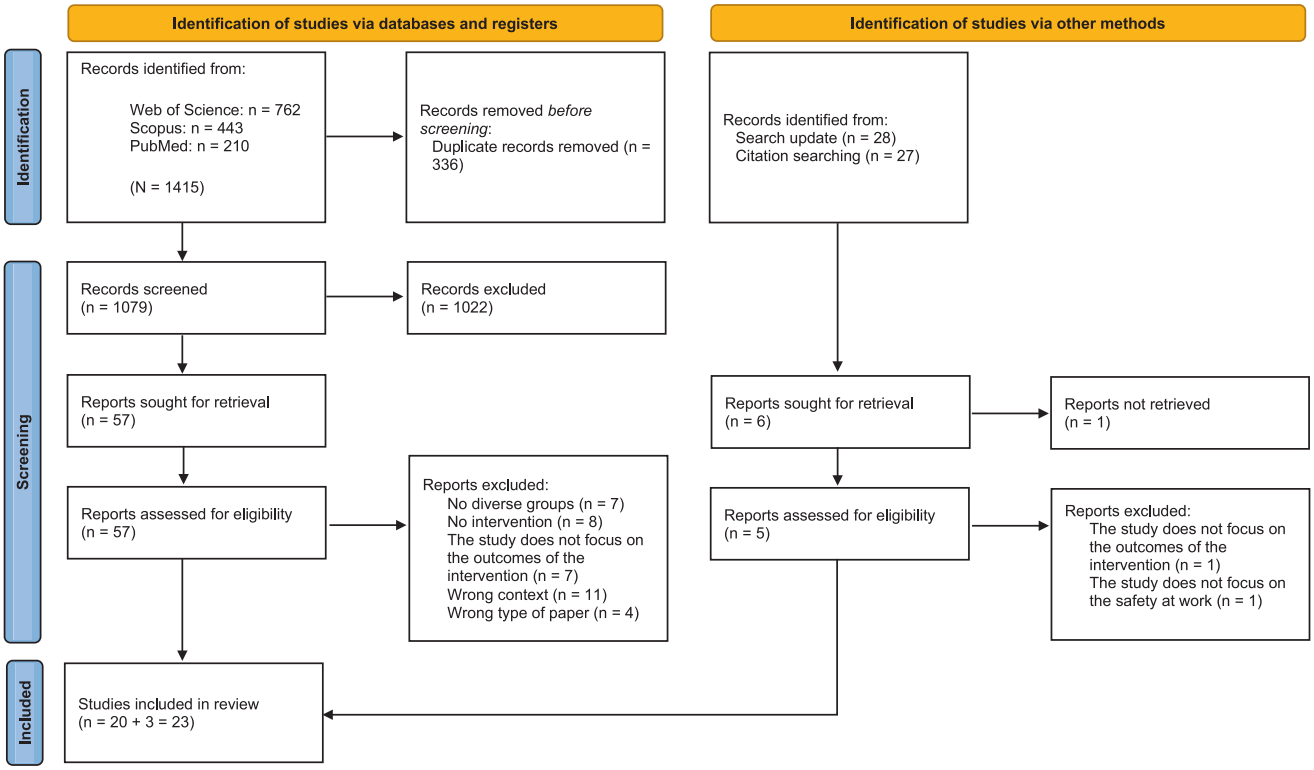

Fig. 1. PRISMA flow diagram summarizing the search process.

analyses. However, the main weakness was related to the administration of the intervention. In fact, it was unclear whether people who delivered the treatment and assessed the outcomes were blinded to the treatment assignment.

Finally, although the observational study focused on cost-benefit analysis and presented a clearly defined research question and a clear incremental evaluation of costs and consequences, all other dimensions considered in the quality assessment were either unmet or unclear (the results of the quality assessment are included in the Supplemental Materials).

Although the quality of the studies was not always very high, following Barker et al.'s recommendations (Barker et al., 2023), we decided to include all the studies. In fact, according to Barker et al., authors should not necessarily exclude studies after critical appraisal. Although keeping only high-quality studies may appear to strengthen the evidence base, doing so can reduce the reviewer's ability to comprehensively examine all relevant data and present a complete picture of the available evidence in relation to the research question. Therefore, to provide a comprehensive overview of this understudied topic, we decided to include all the studies.

3.2. Diverse groups included

The diverse groups targeted by the interventions were limited. As presented in Table 1, most of them were addressed to immigrant and ethnic/racial minority groups ($n = 12$), followed by young and/or older workers ($n = 6$), women ($n = 3$), mixed groups (women and young/older workers; $n = 1$) and workers from low-income countries ($n = 1$).

The majority of interventions targeting immigrant populations were conducted in the United States, with a particular focus on the safety of immigrant Latino workers (De Souza et al., 2012; Evia, 2011; Fernández-Esquer et al., 2022; Forst et al., 2013; Juárez-Carrillo et al., 2017; Liebman et al., 2014; Vela-Acosta et al., 2005, 2009; Williams et al., 2010). In contrast, only one study addressed the safety of immigrant people from other countries, specifically from Vietnam (Levin et al., 2016) and Qatar (Hussain et al., 2020). Regarding ethnicity, one intervention focused on American Indian farmers (Helitzer et al., 2014).

Age was another diverse group considered in the articles included in the scoping review. Three articles addressed the implementation of safety interventions among young people. All of the three were completed in the agricultural industry, but only two implemented and tested the intervention directly on young workers (Kidd et al., 2003; Namkoong et al., 2023). A third study (Rohlman et al., 2021) aimed instead to increase the safety of young workers by training their supervisors. With regard to older workers, only one article addressed older people exclusively (McCallum et al., 2022). Two articles instead compared the interventions outcomes between older and younger workers (Wallen and Mulloy, 2006; Sammarco et al., 2012).

Three studies analyzed the impact of interventions targeting women (Brumby et al., 2009; Mehta et al., 2012; Vanderwal et al., 2011). However, only one of them was specifically addressed to them (Vanderwal et al., 2011). In contrast, the other two included gender as a variable to compare the differential effects of the intervention between men and women (Brumby et al., 2009; Mehta et al., 2012). In addition, one study analyzed the outcomes of the intervention in the forestry industry taking into account age and gender (Nkomo et al., 2018). Lastly, one article targeted workers in the shipbuilding industry from a low-income country and with low wages (Thiede and Thiede, 2015).

3.3. Types and interventions delivery characteristics

As presented in Table 1, the most widespread delivery method was the instructor-led training (12 interventions). Such method entails the presence of one or more professional trainers who increase safety knowledge and retention through several types of tools, such as written material, scenarios, simulation exercises, games, etc. This delivery method was chosen mostly when the target group was composed by immigrant people. The duration of this type of interventions ranged from 60 minutes to 4 days. However, two articles did not specify the duration of the intervention (Mehta et al., 2012; Nkomo et al., 2018).

Table 1
Overview of the included safety intervention studies.

N.	Authors and year	Title	Sample size	Country	Industry	Diverse groups
1	Brumby et al., 2009	The Sustainable Farm Families Project: changing attitudes to health	N = 321 farm families	Australia	Farm industry	Gender - Women
2	De Souza et al., 2012	Novel approaches to development, delivery and evaluation of a peer-led occupational safety training for Latino day laborers.	N = 125	United States	Laborers (e.g., jobs in construction, landscaping, and home cleaning)	Immigrant workers (Latino workers – countries of origin were not specified)
3	Evia, 2011	Localizing and designing computer-based safety training solutions for Hispanic construction workers.	N = 9	United States	Construction	Immigrant workers (Hispanic workers from Mexico)
4	Fernández-Esquer et al., 2022	Vales+ Tú: a cluster-randomized pilot study to reduce workplace injuries among US Latino day laborers.	N_experimental_problem solving = 25 N_experimental_brief motivational interview = 25N_control = 25	United States	Laborers (e.g., jobs in construction, landscaping, and home cleaning)	Immigrant workers (Latino workers from Mexico, Honduras, El Salvador, USA, Guatemala, South America, and Cuba
5	Forst et al., 2013	More Than Training: Community-Based Participatory Research to Reduce Injuries Among Hispanic Construction Workers	N = 446 workers	United States	Construction	Immigrant workers (Hispanic workers from Mexico)
6	Helitzer et al., 2014	Culturally Relevant Model Program to Prevent and Reduce Agricultural Injuries	N_expermental = 60 farm families N_control = 60 farm families (803 farms) N = 6 model farmers	United States	Farm industry	American Indian farmers
7	Hussain et al., 2020	Impact of safety training and interventions on training-transfer: targeting migrant construction workers	N_traditional_training = 10 N_contemporary_training = 10N_training_with_intervention = 10	Qatar	Construction	Immigrant workers (Countries of origin were not specified)
8	Juárez-Carrillo et al., 2017	Applying Learning Theory to Safety and Health Training for Hispanic Immigrant Dairy Workers	N = 836	United States	Farm industry	Immigrant workers (Hispanic workers from Mexico, Central America and United States)
9	Kidd et al., 2003	The transtheoretical model of change in adolescents: Implications for injury prevention	N_experimental = 373 N_control = 417	United States	Farm industry	Age-Young workers
10	Levin et al., 2016	Workplace Safety Interventions for Commercial Fishermen of the Gulf	N_fatigue = 72 N_machinery/which safety = 92N_hearing/noise = 53	United States	Fishing industry	Immigrant workers (Vietnamese people)
11	Liebman et al., 2014	A Model Health and Safety Intervention for Hispanic Immigrants Working in the Dairy Industry	N = 161	United States	Farm industry	Immigrant workers (Hispanic workers – countries of origin were not specified)
12	McCallum et al., 2022	Farm Dinner Theater: Testing an innovative health and safety intervention among older farmers and their families	N_experiment = 553N_control = 317	United States	Farm industry	Age - Older workers
13	Mehta et al., 2012	Intervention of drudgery reducing technologies in agriculture and impact evaluation	N = 15 menN = 15 women	India	Farm industry	Gender - Women
14	Namkoong et al., 2023	Virtual reality for public health: a study on a VR intervention to enhance occupational injury prevention	N = 291 (including control groups. Number of people in each group is not specified)	United States	Farm industry	Age - Young workers
15	Nkomo et al., 2018	Effectiveness of Health and Safety Training in Reducing Occupational Injuries Among Harvesting Forestry Contractors in KwaZulu-Natal	N = 300	South Africa	Forestry	Age – younger and older workers Gender - women
16	Rohlman et al., 2021	Evaluation of an Online Training for Supervisors of Young Agricultural Workers.	N= 185 supervisors (who completed three times of data collection)	United States and Canada	Farm industry	Age-Young workers (Supervisors of)
17	Sammarco et al., 2012	A visual warning system to reduce struck-by or pinning accidents involving mobile mining equipment.	N= 36	United States	Mining Industry	Age – Young, middle and older workers
18	Thiede & Thiede, 2015	Quantifying the costs and benefits of occupational health and safety interventions at a Bangladesh shipbuilding company	Not specified	Bangladesh	Shipbuilding industry	People from low-income countries (and low wage)
19	Vanderwal et al., 2011	Evaluation of long- and short-handled hand hoes for land preparation, developed in a participatory manner among women vegetable farmers in The Gambia.	N= 48	Gambia	Farm industry	Gender - Women
20	Vela-Acosta et al., 2005	Measuring success in a pesticide risk reduction program among migrant farmworkers in Colorado	N = 152 total N_experimental = 77N_control = 75	United States	Farm industry	Immigrant workers (Hispanic workers from Mexico and USA)

(*continued on next page*)

Table 1 (*continued*)

N.	Authors and year	Title	Sample size	Country	Industry	Diverse groups
21	Vela-Acosta et al., 2009	Farmworkers at the border: a bilingual initiative for occupational health and safety.	N_experimental = 18 N_control = 31	United States	Farm industry	Immigrant workers (Hispanic workers – countries of origin were not specified)
22	Wallen & Mulloy, 2006	Computer-based training for safety: Comparing methods with older and younger workers.	N_text (TXT) = 16 N_text with picture (TAP) = 20N_text_picture_audio (NAP) = 14	United States	Electronic manufacturing	Age – younger and older workers
23	Williams et al., 2010	The impact of a peer-led participatory health and safety training program for Latino day laborers in construction	N = 313	United States	Construction	Immigrant workers (Latino workers from Mexico, Honduras, Guatemala, Ecuador, El Salvador, and other countries)

	Research design characteristics		Intervention design characteristics				
N.	Research design (intervention type)	Control group	Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
1	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In person Resource manualVideos Graphs statistics	No information provided about the use of tailoring strategies.	**Content**: the state of rural health, cardiovascular disease, cancer including bowel and skin, farm health and safety, stress and stress management, diet and nutrition – supermarket tour, gender related topics delivered in separate groups, for example prostate cancer, impotence, women's health and breast cancer. **Length**: The program consists of a structured two-day workshop in year 1 and a one-day workshop in years 2 and 3.	**Knowledge acquisition.** In year 1, women's level of knowledge from pre- to post intervention was evident in 88% of questions. The same results for men revealed a significant improvement in 67% of questions. **Knowledge retention.** Knowledge was reassessed at year 3 in the broadacre program. Women answered correctly to 86% of questions while men answered correctly to 85% of questions.
2	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In person Physical materials - Personal Protective Equipment Group discussions Written materialsVideos	Training delivered by peer educators.	**Content**: PPE familiarity, correct PPE use, hazard identification, workers' rights. **Length**: The final training was four hours in length with one hour allotted for each training theme.	**Knowledge acquisition.** It was measured through clip art pictures and pictograms. Out of 96, 38 participants (40%) improved their scores in the post-test, while an equal number showed no change. 18 participants scored perfectly on pre- and post-tests, and 20 participants had a decrease in scores. Overall, there was a small but statistically significant improvement in scores. **Knowledge transfer.** They were measured with face-to-face interviews. Out of 125 participants, only 10 were interviewed. Only 60% used appropriate PPE. While some participants applied their safety knowledge to real work situations, others still faced challenges in consistently adopting safe practices.
3	Quasi-experimental one-group pre–post design	Absent	E-learning	In person Audio and written materialsVideos	Participatory design of a Spanish and culturally appropriate computer-based course for low-literacy users.	**Content**: Fall safety basics, scaffolds, working and walking surfaces, and stairways and ladders. **Length**: Stop-motion animated video: 4 min.	**Knowledge acquisition.** Workers scored an average of 4.75 on a scale of 1–5 points (5 was the highest for content comprehension). The qualitative post-test interview showed that all participants were able to summarize the module.

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Table 1 (*continued*)

N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
4	Randomized controlled trial (cluster)	Present-active	Mixed method: Self-learning (control group) Group discussion (group problem solving)One-on-one conversation with trained promotor (brief motivational interview)	In personWritten materials	Spanish-speaking Latino facilitator who leads brief small group discussions or one-to-one conversations (brief motivational interview).	**Content**: advantages and disadvantages of workplace dangers. **Length**: Groups problem solving: 30 minutesBrief motivational interview: 30-45 minutes.	**Hazard exposure reduction.** It was observed for the entire sample and for the Brief Motivational Interview. **Risk-reduction practices.** The Brief Motivational Interview group and the sample as a whole reduced significantly risky practices. **Workplace dangers.** The entire sample reported improved behaviors toward reducing workplace dangers. **Social support.** It improved significantly among participants in the Brief Motivational Interview and Group Problem Solving arms, as well as in the sample as a whole. **Improved self-efficacy.** It was only observed in the control group.
5	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In personWritten materials (Spanish and English), Diagram Exercises	Training delivered by a Spanish speaker peer educator appropriate for low-literacy workers.	**Content***:* OSHA curriculum and training adapted for variable literacy Spanish speaking construction workers. **Length**: 10h. Training took place on the weekends, over 2 days.	**Knowledge acquisition.** Knowledge regarding the best way to prevent fall and on the impact of ‘‘grounding’’ on the risk of electrical shock also improved. **Hazard recognition.** Results showed an increase of recognition of hazards from the pre-training responses to the post-training responses. **Hazard communication.** It increased in the post-training survey. In the 3-month follow-up telephone survey participants said to be more aware of **hazards** at work. Increased confidence to **communicate hazard** to supervisors and to realize **safety practices** (e.g., using PPE - **knowledge transfer)**.
6	Randomized controlled trial	Present-waiting list	Instructor-led training	In person.Written materials	Participative and culturally appropriate training that includes community model farmers.	**Content**: chemicals and their uses, sprayer calibration, pesticide safety, fertilizer application, and pesticide rates, pesticide safety, integrated pest management, weed identification, insect identification. **Length**: Three-hour training session.	**Safety storage and behaviors.** In both groups, the number of farm families who owned pesticides increased across years. There was significant improvement in keeping pesticides out of children in both groups. They were stored in a ventilated room only in Group 2. In both groups, the number of farm families who owned some **standard pesticide safety equipment** increased, in particular chemical-resistant gloves, sand, chemical-resistant boots, and protective clothing. **Maintenance of practices** between 2010 and 2011 (group 1). Pesticide safety

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Table 1 (*continued*)

N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
							and storage practices were maintained between 2010 and 2011. The practice of washing protective clothing separately declined between 2010 and 2011, as well as the number of farm families who had pesticide application equipment. **Maintenance of practices** between 2010 and 2011 (group 2). No significant differences were observed between 2010 and 2011 in pesticide ownership and storage, pesticide safety equipment, or pesticide application equipment. **Knowledge acquisition** on integrated pest management. It improved significantly across the years for both groups. **Attitudes about Integrated Pest Management.** Both groups showed changes in attitudes. **Agricultural Yield.** The yield of corn was significantly higher on treatment group than on control one for number of ears but not ear length. The yield of alfalfa was 41.2% greater on treatment plots than on control group.
7	Quasi-experimental between-groups design	Present-active	Mixed method: Instructor-led training (Control group - WG1) Instructor-led training and feedback (Experimental group 1 - WG2) Instructor-led training with feedback and other activities (e.g. cross-cultural training) (Experimental group 2 - WG3)	In person. English and/or written information Posters Pictures Tests Site activities	Proactive bilingual training; mentoring and feedback provision; knowledge delivered through multiple means and styles; development of site activities.	**Content**: Safety related to scaffolding **Length**: 2-h training sessions with each group over a 2-day period.	**Hazard identification.** It increased in the experimental groups. Among the immigrant workers, WG-3 participants recognized the most hazards followed by WG-2 ones. WG-1 with the traditional approach identified less hazards. **Knowledge transfer.** It is considerably higher for WG-3 than for other groups. The group with the temporary approach (WG-2) also achieved satisfactory performance, while the group with the traditional approach (WG-1) showed less interest in implementing safety rules that they had learned during training sessions.
8	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In person Bilingual written materials Group discussion ExercisesGames	Bilingual (Spanish/English) and culturally sensitive training with no literacy skills required for participants.	**Content**: Working safely in diary, working safely with cattle, staying safe with equipment and machinery, workers' rights and responsibilities and working safely around chemicals, confined spaces and silos. E **Length**: Five 1-hour lesson modules in English and Spanish.	**Knowledge acquisition and transfer.** It increased after training. An analysis of the open-ended questions and feedback from workers indicates that nearly 100% of the training met the learning objectives. Participants were able to note at least one key concept they learned, at least one behavior they felt

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N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
							comfortable incorporating into their work, and the intention to request meetings with management to communicate their safety concerns.
9	Quasi-experimental crossover design	Present. Inactive	Instructor-led training	In personPhysical and narrative simulation exercises	Experiential learning through interactive techniques such as physical and narrative simulation.	**Content**: A series of physical and narrative simulations (safety training exercises) were developed with a focus on preventing amputation, spinal cord injury, hypersensitivity pneumonitis, and noise-induced hearing loss. **Length**: Each of the four units was delivered in 15–30-min.	**Safety awareness.** Students considered engaging in safer behaviors. **Safety practices.** Students' safety practices increased (e.g. using protective equipment). **Safety behaviors change.** One year after the intervention, they increased in the farm work (e.g. equipment modification, installation of roll bars on tractors, use of hearing protection, respirators, communication devices, vision protection, and safety checks).
10	Quasi-experimental between-groups design	Absent	Self-learning	In person Vietnamite written materials Images T-shirts	Provision of safety messaging using universally recognized images/colors; adoption of culturally adapted Vietnamise messages on durable signage and bright T-shirts.	**Content**: Safety messaging about hearing/noise conservation or machinery safety or fatigue awareness. **Length**: 2010-2011.	**Changes aimed to include behavioral beliefs, normative beliefs, and control beliefs.** All three belief areas changed significantly in the hearing/noise group, as well as in the fatigue one. There was an absence of statistically significant changes in most of the belief categories for machinery/winch safety.
11	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In personSpanish materials	Spanish train-the-trainer curriculum, designed for workers with lower literacy levels.	**Content**: Introduction to health and safety in dairy, Identifying and controlling hazards, Animal handling, Machinery and equipment, Workers' rights and responsibilities, Chemicals and confined spaces.	**Knowledge acquisition.** After each module/lesson, knowledge increased.
12	Quasi-experimental between-groups design	Present-active	Mixed Method: Didactic readers' theater (experimental group) Written educational packet (control group)	In personWritten materials	Readers' theater interpreted by local farmers; and their family and didactic theater to foster social interaction and discussion among peers.	**Content**: health and safety topics important for older farmers, such as fatigue, falls, and skin cancer. **Length**: 2 hours.	**Health and safety-related changes - knowledge transfer.** Participants made changes in their personal behavior or their farm operations. The intervention group was more likely than control one to report having made any changes, having made more changes, having made any substantive changes, and having made more substantive changes. The likelihood of making any changes and the number of changes realized increased from the 2-week to 2-month interview.
13	Quasi-experimental between-groups design	Absent	Instructor-led training	In person	No specific information provided about the skill training provided to men and women separately.	**Content**: field level skill training for proper use of the ergonomically improved farm technologies were given to men and women in separate groups. Drudgery reducing technologies viz. cot bag (for cotton picking	**Awareness on drudgery reducing technologies.** A significant increase in awareness was observed in both men and women. However, it was higher among farm women. **Knowledge acquisition.** A significant increase was

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N.	Research design characteristics: Research design (intervention type)	Control group	Intervention design characteristics: Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
						and vegetable picking), capron (protective face mask), improved sickle (serrated self harpening blade), wheel hand hoe (for weeding) and protective gloves (used during harvesting).	observed in knowledge of men and women regarding drudgery reducing technologies. However, the gain in knowledge was more among men than women. **Drudgery reduction.** The technology introduction diminished drudgery in both men and women. However, women preferred to use their traditional technology.
14	Randomized control trial	Present-inactive Present-active	E-learning	In person Virtual simulations	Safety education through a virtual reality immersion system.	**Content**: Virtual Realty Intervention for Safety Education (VRISE) included several rollover hazards, such as a pond hidden by a hill or sloping terrain and uneven roads. **Length**: A VRISE trial episode in this study took about 2.5 minutes.	**Perceived threat - hazard recognition.** People who used VRISE had significantly higher levels of perceived threat of tractor rollover accidents than participants who did not use the Virtual Reality (VR) intervention. However, there was no difference in perceived threat between the two treatment groups (people who intervention with VR headsets and on a 2D TV screen). The VR condition (versus no treatment) had a significant impact on perceived threat. **Safety behaviors intention.** The perceived threat increased participants' behavioral intention to manage tractors safely. The VR condition (versus 2D screen) increased the Safety behaviors intention through **experience of immersion** and perceived threat.
15	Quasi-experimental one-group post-only design	Absent	Instructor-led training	In person	No information provided about the use of tailoring strategies.	**Content**: Hazard identification, prevention and control, use of PPE, chemical handling, signaling and signal equipment, first aid and emergency preparedness, lockout procedures, hazard communication, and the OHS Act.	**Work-related injuries between 2009-2013**. Employees with less work experience and youngers reported more injuries than more experienced workers. **Knowledge transfer.** Women were more likely to use PPE while working compared with men.
16	Quasi-experimental one-group pre–post design	Absent	E-learning	Online	Provision of information about specific threats to young workers in agriculture (e.g., developmental differences, risky behaviors, specific needs); training in health communication skills.	**Content**: Online training course. In the training module, they completed a 25-item knowledge pre-test prior to beginning the training. **Length**: The training took approximately 45 min to complete and included knowledge checks throughout.	**Knowledge acquisition.** Significant improvement immediately following the training. However, knowledge scores decreased at the 3-month follow-up. **Changes in beliefs.** Supervisors' beliefs regarding training and other behaviors they can utilize to protect younger workers increased from pre-test to immediate post-test and changes were sustained at the 3-month follow-up. **Supervisors' Communication Behavior Changes.** The number of supervisors talking to young workers about safety issues

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N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
							at various timepoints increased from pre-test to 3-month post-test. More supervisors reported discussions about safety occurring every day or once a week.
17	Quasi-experimental one-group post-only design	Absent	E-learning	In person	Provision of different types of visual warning stimuli.	**Content**: Detection of a visual warning light or Continuous Mining Machine (CMM) movement. Scenes containing visual warning modes and CMM movement combinations (no visual warning; static visual warning system -VWS; flash VWS; directional VWS; progressive VWS). **Length**: 30 unique video scenes. Each test scene was approximately 10–15 s long.	**Reaction time.** Age didn't have a significant effect on the reaction time to detect machine motion. However, the differences between no visual warning and any type of visual warning were dramatic (VWS were detected faster). Moreover, results showed that dynamic lighting patterns increase motion detection time to a greater extent than a simple static light.
18	Observational	Absent	Mixed method: TrainingOHS service provision	In person	No information provided about the use of tailoring strategies.	**Content**: The intervention included investments in workplace and environmental safety, personal protective equipment (PPE), OHS training for all employees and a new clinic that also serves the community. **Length**: 2011-2015.	Benefits of OHS interventions: **Injury rates.** They dropped from over 500 (and in some cases 1000+) injuries per month before the introduction of OHS measures to nearly zero within a few months after the beginning of implementation. Total monthly **worker injury treatment costs** diminished. Benefits of community healthcare facilities: **Fewer missed workdays** These results increased **annual labor cost savings**
19	Quasi-experimental crossover design	Absent	Work tools provision	In person	Provision of a short-handled and a long-handled hoe. Observation and a participatory approach were applied to identify the tools tested.	**Content**: Subjects were randomly assigned to either begin with their traditional land preparation method or with one of the intervention methods (new short- or long-handled hoe), and alternated between the traditional and intervention method in subsequent trials, using both methods two times.	**Heart rate.** The same with the three methods, but worked to a 5% lower maximum heart rate when using the new short hoe. **Physical discomfort**. Compared to the traditional hoe, the new long hoe reduced the likelihood of participants reporting physical discomfort. However, the odds of reporting arm and hand discomfort were greater with the new short hoe. Compared to the use of the new short hoe, the new long hoe reduced the odds of reporting discomfort in all body regions. **Posture:** the new long hoe enabled subjects to work with a more upright posture. **Injuries.** No reported with any hoe in the trials or in the two months after the trials. Subjects reported injury near misses in 40 trials, with the fewest when using the new

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N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
							long hoe. **Maintenance behaviors.** 2 months after the initial trials, 25% of subjects reported that they had not used the new long hoes at all since the initial trials, 20 of 48 subjects reported that they had used the new long hoes 25% of their time, and 11 subjects reported using them 75% of their time in land preparation. In contrast, most (34 of 48) subjects reported using the new short hoes 75% of their time in land preparation, with 9 subjects using the new short hoes 25% of their time in land preparation. Compared to traditional land preparation methods, nearly all subjects indicated that they felt both the new long and new short hoes were **safer, easier, faster, and were preferred**.When comparing the new short to new long-handled hoes, more subjects indicated that they thought that the short-handled hoe was safer, easier, faster, and preferred.
20	Quasi-experimental between-groups design	Present-waiting list	Instructor-led training	In personSpanish scenarios	Training delivered in Spanish.	**Content**: sources of pesticides, pesticide absorption and toxicity, general chemical safety, first aid, and emergency responses. **Length**: a 60 min. pesticide program.	**Pesticide knowledge - knowledge acquisition.** In the post-test, it increased in the experimental group **Safety Risk Perception.** In the post-test, it increased in the experimental group **Health Locus of control.** The training did not affect participants' control on their own health component **Safety behaviors** (e.g., wearing long sleeve shirts, wearing long pants, washing hands). They increased, but now when internal locus of control was low and external locus of control was high. **Readiness to change.** It was significant for farmworkers who were already active in behavior outcomes
21	Quasi-experimental between-groups design	Present-inactive	Instructor-led training	In person Spanish materials	Participatory design of bilingual (Spanish/ English) and culturally appropriate training.	**Content**: hazard recognition, injury prevention, post-injury strategies, workers' rights, and communication skills needed to confidently discuss work-related safety concerns with employers and coworkers. **Length**: The Curriculum has eight lessons (each lasting approximately one hour.	**Knowledge acquisition on safety** and **safety risk perception.** They significantly improved for the intervention group. **Safety transfer - Knowledge transfer.** Six weeks after the post-test, students reported not having talked to their supervisor about any job hazard, their safety, or the safety of a coworker (48%), due to lack of employment or lack of time. Students stated that **they**

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N.	Research design characteristics Research design (intervention type)	Control group	Intervention design characteristics Delivery method	Delivery mode	Tailoring strategy	Content and length	Outcomes
							shared Curriculum information with others, such as encouraging coworkers in the use of proper gloves and shoes.
22	Quasi-experimental between-groups design	Absent	E-learning	In personWritten materials Pictures Audios	Multimedia training that included text, pictures and narrations.	**Content**: Instructional text covering the material required in the OSHA Respiratory Protection Standard (29 CFR 1910.139). **Length**: The 10 animations were short (average 15 seconds) and covered a single topic so as not to overload the learner's working memory.	**Knowledge acquisition**. There was no significant age*treatment interaction; after eliminating the interaction, there was no significant effect of age or treatment on the multiple-choice test scores. **Knowledge transfer test.** There was no significant interaction effect. However, for treatment, TAP was better for younger workers than for older people. For younger workers, TXT, TAP and NAP vary all significantly (NAP with a better score). For older people, only TXT was significantly worse than NAP.
23	Quasi-experimental one-group pre–post design	Absent	Instructor-led training	In personSpanish written materials	Participatory, peer-led training tailored to specific needs of Latino day laborers.	**Content**: the Day Laborers' Health and Safety Workbook, includes 14 activities (modules) covering a range of hazards and topics. Specific curriculum activities include "Job Fear" (Overview of injury and illness data related to immigrant Latino workers in construction), Toxic Myths and MSDSs, OSHA Rights, Confined Spaces, Introduction to Ergonomics, Personal Protective Equipment, Excavations; Electrical Safety; Fall Protection; Scaffolds; Ladders and Stairs; Power Tools; Fire Safety; Concrete and Masonry. **Length**: one day (min.six hour) Spanish language health and safety training class.	**Hazard exposure reduction.** Specific hazardous exposures in the previous three months were similar high rates of exposures to serious hazards. **Knowledge transfer.** The number of workers using PPE was similar pre- and post-training, there was a small but statistically significant increase in use of hard hats, work boots, safety vests, and safety harnesses among the workers responding post-training. **Taking the initiative to deal with problems.** With the exception of "leaving a jobsite," the majority of workers, both pre- and post-survey, took actions that can be viewed as "self-protective" in order to find out about a hazardous situation on their own. **Injuries**: there was a decrease in self-reported injuries. **Knowledge acquisition:** consistent improvement in the key points covered in the class (only post).

The second most frequently used delivery method was e-learning (used in five studies). In these cases, the intervention was developed through new technologies, although with different formats. For instance, the intervention could consist of an online training course delivered through texts or animated videos (Evia, 2011; Rohlman et al., 2021; Wallen and Mulloy, 2006), or a simulation carried out through virtual reality to detect warning lights (Sammarco et al., 2012) or other types of hazards (Namkoong et al., 2023). The duration of these interventions varied significantly, depending on the type of input provided; virtual reality inputs could take between 15 seconds and approximately 3 minutes, while interventions using texts, animations or video tutorials took between 15 seconds and 45 minutes.

Only one intervention was carried out exclusively through self-learning, providing written material, images and T-shirts with safety messages. This intervention lasted one year (Levin et al., 2016).

In one case, the researchers intervened by providing working tools, specifically more ergonomic hand hoes, in order to compare the comfort and safety of these instruments with traditional ones (Vanderwal et al.,

2011).

Finally, four interventions used mixed delivery methods. In three cases, this was determined by the characteristics of the intervention, since it contemplated the presence of active control groups that received alternative inputs. One of the articles, an intervention designed for farm workers over 45 years of age, made use of didactic readers' theater in the experimental groups. Such tool combined the features of both readers' theater and didactic theater and encouraged audience discussion after the performance. The actors were the farmers themselves and their families, allowing the audience to identify with them (McCallum et al., 2022). The intervention lasted for two hours, taking place as a live performance while the audience was having dinner. Conversely, the control group only received written information about health and safety by post (self-learning). A second article (Fernández-Esquer et al., 2022), an intervention addressed to Hispanic laborer workers involved three-arm clusters, each receiving different interventions: a control group received only Spanish written material on safety in the construction sector (self-learning); an experimental group participated in a group intervention (group problem solving), designed to foster learning through critical group discussion on work safety; a second experimental group asked participants to engage individually in a brief motivational interview to reflect on the advantages and disadvantages of undertaking unsafe behaviors at work. The intervention in the two experimental conditions lasted between 30 and 45 minutes. A third article (Hussain et al., 2020) was addressed to immigrant workers in Qatar and included three experimental conditions. The delivery method was the instructor-led training in all the groups; however, the first group only received training through a Power Point presentation in a classroom; in the second group a "contemporary approach" was introduced, which included frequent feedback to trainees; in the last group, both "contemporary approach" as well as other types of interventions (e.g. cross-cultural training) were introduced.

Lastly, the article that did not include a control group developed interventions through several actions, such as the provision of OHS services and the promotion of training programs. The implementation of all these actions started in 2011 and its development and evaluation ended in 2015 (Hussain et al., 2020).

3.4. Tailoring strategies applied

The tailoring strategies applied during the interventions varied considerably depending on the diverse group of workers considered. With regard to immigrant and ethnic minority workers, the most frequently used adaptation was the linguistic adjustment of the inputs provided during the intervention, namely a translation of the intervention content into the language spoken by the participants (García-Mainar et al., 2018; Vela-Acosta et al., 2005). A few studies adapted the intervention content to the participants' low literacy levels, for example, avoiding text in video inputs and increasing oral delivery (Evia, 2011; Forst et al., 2013; Juárez-Carrillo et al., 2017; Liebman et al., 2014). Other studies included peer facilitators or community role models, who shared similar values or cultural background, (Fernández-Esquer et al., 2022; Forst et al., 2013; Liebman et al., 2014; Williams et al., 2010) to better reach out to the targeted population. Language adaptation was often used in conjunction with other cultural adaptations (Evia, 2011; Hussain et al., 2020; Juárez-Carrillo et al., 2017; Vela-Acosta et al., 2009), such as adopting specific strategies to acknowledge the participants' cultural background and belief systems. As an example, in Evia's intervention (Evia, 2011), not only the materials were translated into the participants' language, but also cultural differences were incorporated in the resources provided during the training, such as the use of humor and sporadic jokes in Spanish. Some of the interventions that considered the language diversity of the target group also employed specific tools or strategies to achieve the desired goals. For instance, one intervention was computer-based (Evia, 2011), whereas another conveyed the safety information through multiple means (such as written materials, images, signals) (Levin et al., 2016). These strategies were chosen to facilitate the training of low-literacy participants. Several studies adopted a community participatory approach as a tailoring strategy aimed at designing interventions that were culturally relevant to their participants (De Souza et al., 2012; Helitzer et al., 2014). In those cases, the involvement of peer educators or community role models were reported as fundamental to the intervention outcomes.

When young workers were the focus of the intervention, tailoring strategies included different types of simulations, such as physical, narrative and virtual (Kidd et al., 2003; Namkoong et al., 2023), which enhanced the achieved outcomes by providing participants with an immersive and enjoyable experience. One specific study addressing younger workers' safety implemented an intervention directed at their supervisors (Rohlman et al., 2021). In this case, the tailoring strategies pertained the training content, which considered the specific threats younger workers may encounter in the agricultural sector (such as those related to developmental differences and risky behaviors), and the communication skills required to supervisors to successfully engage with those workers.

The only study that targeted older workers in the farming sector (McCallum et al., 2022) involved tailoring strategies based on research showing that older farmers prefer receiving information on safety through personal stories than traditional delivery methods (e.g. written materials). Thus, this intervention aimed at modifying social norms related to health and safety through social interaction, theater, and peer discussion. Interventions focusing on different age groups often combined multiple multimedia inputs (e.g., text, images, and narration) (Wallen and Mulloy, 2006), offering insights into which formats produced the desired outcomes in each age range. Another intervention, developed in the mining sector (Sammarco et al., 2012), combined different types of visual warning stimuli with continuous mining machine movements, and compared workers' ability across age groups to detect such movements.

Only one study addressing gender diversity (Vanderwal et al., 2011) provided information about the tailoring strategies applied. Vanderwal et al.'s study (2011), which included only women farmers, identified the intervention task and adapted the land preparations tools after observing them during land preparation and using a participatory approach that allowed researchers to collect feedback from key informants about such tools .

Overall, the description of the tailoring strategies was often limited and, in some cases, absent. The main reason is probably because the primary goal of the intervention was not to adapt it to a specific diverse group of workers (Brumby et al., 2009; Mehta et al., 2012; Nkomo et al., 2018; Thiede and Thiede, 2015). Nevertheless, these studies were still included in this review because they provided disaggregated data for certain diverse groups (women and/or age) (Brumby et al., 2009; Mehta et al., 2012; Nkomo et al., 2018) or because they were conducted in low-income countries (Thiede and Thiede, 2015).

3.5. Interventions contents

Regarding the content of the interventions included in the study, most of them focused on identifying and preventing occupational accidents, as well as improving competencies related to the use of PPE. The content of the interventions varied depending on the work sector of the study sample. For instance, some interventions addressed the most common risks in the construction sector, such as preventing falls from scaffolding (Evia, 2011; Forst et al., 2013; Williams et al., 2010). Other studies focused on reducing risks in the agricultural sector, including those related to pesticide use (Helitzer et al., 2014; Vela-Acosta et al., 2005) and rollover accidents (Namkoong et al., 2023). Some interventions promoted the appropriate use of agricultural technologies and tools (Mehta et al., 2012; Vanderwal et al., 2011) and, in general, aimed to increase knowledge about occupational safety and encourage safe behaviors (Juárez-Carrillo et al., 2017; Kidd et al., 2003; Rohlman

et al., 2021; Vela-Acosta et al., 2009).

Other interventions focused on identifying and managing risks in specific sectors, such as forestry (Nkomo et al., 2018), dairy (Liebman et al., 2014), shipbuilding (Thiede and Thiede, 2015), and electronic manufacturing (Wallen and Mulloy, 2006). Although some of the studies included in the review were not developed for a specific sector (De Souza et al., 2012; Fernández-Esquer et al., 2022), as we mentioned above, they targeted specific groups, such as Hispanic laborers. Additionally, one intervention addressed the physical health of workers in rural areas (Brumby et al., 2009; McCallum et al., 2022), focusing on aspects such as diet, nutrition, and cardiovascular diseases. Lastly, one intervention focused on hearing conservation in the fishing industry (Levin et al., 2016).

3.6. Main outcomes

All the studies included in this scoping review evaluated the outcomes of the interventions implemented (see Table 1 for a summary of the main results). These outcomes were conceptualized and measured in various ways, although one of the most frequently used variables was knowledge acquisition (Brumby et al., 2009; De Souza et al., 2012; Evia, 2011; Forst et al., 2013; Helitzer et al., 2014; Juárez-Carrillo et al., 2017; Liebman et al., 2014; Mehta et al., 2012; Rohlman et al., 2021; Vela-Acosta et al., 2005; Vela-Acosta et al., 2009; Wallen and Mulloy, 2006; Williams et al., 2010). In general, all the included articles reported an increase in knowledge immediately after the intervention as compared to the initial assessment. However, they did not always track the maintenance of these results in the medium and long term, with a few exceptions (Brumby et al., 2009; Helitzer et al., 2014; Rohlman et al., 2021). In only one case (Rohlman et al., 2021) a decrease in knowledge was observed three months after the intervention. In the remaining two cases, an increase in knowledge level was maintained.

Another frequently measured outcome was knowledge transfer (De Souza et al., 2012; Helitzer et al., 2014; Hussain et al., 2020; Juárez-Carrillo et al., 2017; McCallum et al., 2022; Nkomo et al., 2018; Vela-Acosta et al., 2009; Wallen and Mulloy, 2006; Williams et al., 2010). The interventions considered were effective in this regard, but to different extents. For instance, the participants of the intervention described by Vela-Acosta and colleagues (2009) were not able to discuss work-related safety concerns with their employers. Nevertheless, they shared the curriculum information with co-workers, encouraging them to use PPE. As expected, knowledge transfer also varied depending on the participant's experimental condition. For instance, in the study by Hussain and colleagues (2020), groups that received the intervention demonstrated better knowledge transfer as compared to the control group.

In general, participants demonstrated an increased ability to identify or perceive workplace hazards (Forst et al., 2013; Hussain et al., 2020; Namkoong et al., 2023; Vela-Acosta et al., 2005; Vela-Acosta et al., 2009; Williams et al., 2010), reduce their exposure to these hazards (Fernández-Esquer et al., 2022), proactively address them (Fernández-Esquer et al., 2022; Williams et al., 2010), and communicate hazards to supervisors or other relevant actors in the workplace (Forst et al., 2013; Vela-Acosta et al., 2009). In the intervention conducted by Rohlman et al. (2021), which focused on supervisors of young workers in the farm industry, the likelihood of supervisors initiating discussions about safety with their young workers increased. However, considering the outcomes before mentioned, the interventions were not always effective, as shown in Williams and colleagues' study (Williams et al., 2010), where it was not possible to achieve significant reductions in hazard exposure.

Another significant outcome was the increase in safety behaviors and practices following the intervention. In some cases, participants began implementing safer practices, such as proper pesticide storage (Helitzer et al., 2014), using PPE (Helitzer et al., 2014; Vela-Acosta et al., 2005), and generally adhering to safe workplace behaviors, even some time after the intervention (Helitzer et al., 2014; Kidd et al., 2003). In certain studies, intervention outcomes were assessed through safety behavior intentions (Namkoong et al., 2023), which were also positively influenced by the intervention programs.

Attitudes and beliefs regarding workplace safety were another area of focus. After the interventions, participants showed more positive attitudes and beliefs toward safety (Levin et al., 2016) which, in some cases, were sustained over time (Helitzer et al., 2014; Sammarco et al., 2012).

The outcomes of the interventions were also measured in terms of the reduction of injury rates (Nkomo et al., 2018; Thiede and Thiede, 2015; Vanderwal et al., 2011; Williams et al., 2010). However, in one instance, the intervention failed to achieve such a goal when participants had less work experience (Nkomo et al., 2018). The economic benefits of injury reduction were also considered, revealing savings from reduced absenteeism, lower annual labor costs, and decreased injury treatment expenses (Thiede and Thiede, 2015). Another important result related to safety practices, such as the proper use of pesticides, was demonstrated by the economic returns in terms of agricultural yield (Helitzer et al., 2014).

The intervention outcomes were also assessed through participants' health-related physical indicators after using tools introduced as part of the program, by measuring variables such as heart rate, physical discomfort, and posture (Vanderwal et al., 2011). In other cases, the extent to which the new tools reduced drudgery (Mehta et al., 2012) or improved reaction times to workplace hazards (Sammarco et al., 2012) were evaluated.

4. Discussion

The goal of this scoping review was to map interventions aimed at promoting workplace safety and reducing occupational injuries among diverse workers, who are defined as people with specific attributes or identities that might make them more vulnerable in a specific context (American Psychological Association, 2023). Additionally, this study sought to identify the outcomes of such interventions. Answering to our first goal, our findings revealed that the number of intervention programs targeting diverse groups is relatively small, and the range of groups they address is limited. The primary focus of the included articles was on immigrants, particularly Hispanic and Latino people residing in the United States, which is also the country where most of the studies included in this scoping review were conducted.

Another individual characteristic considered in the interventions included in our review is age. However, it is notable that only one of the studies focusing on age specifically targeted older workers, whereas the vast majority addressed younger workers or those actors interacting with them (e.g. supervisors). This finding can be interpreted by considering that younger people experience more occupational accidents compared to adult and older workers (Shooshtari et al., 2022), with these accidents often resulting in permanent disabilities (Rohlman et al., 2021). Additionally, in some countries, young people enter the workforce at very early ages, particularly in the agricultural sector and family businesses (Rohlman et al., 2021; Truxillo et al., 2015). Low levels of education combined with limited work experience contribute to the higher incidence of occupational accidents among younger workers (Nkomo et al., 2018), underscoring the need for targeted safety interventions for this group. Although research on safety intervention addressing young workers is relevant, the aging of the workforce is a global trend and might pose new challenges for physical and cognitive demanding work activities (Choi, 2009).

Women represented the other primary group identified in this scoping review. However, it is important to note that studies exclusively targeting women were in the minority. In most cases, the effectiveness of interventions was inferred from comparisons made between men and women. The lack of specific intervention programs tailored to women is concerning, particularly taking into account the studies highlighting the prevalence of occupational accidents involving female workers. These

accidents often result from gender-specific factors that are not adequately addressed when ensuring their workplace safety, such as physical and psychological changes related with menopause and body differences that affect the fit of PPE (EU-OSHA wt al., 2016; International Labour Organization, 2013).

Only one study specifically targeted individuals from low-income countries and with low wages, although it is recognized that workers from these countries are more exposed to occupational risks (Ajith et al., 2021). In such countries, the legislative framework for occupational health and safety might not be in line with the industrial development, making workers even more vulnerable (LaDou et al., 2018).

Additionally, there are other notable gaps in knowledge and focus emerging from our scoping review. For example, an unexpected finding was the complete absence of interventions aimed at people with disabilities, despite previous research indicating that individuals with disabilities are more likely to suffer injuries at work compared to those without disabilities (Price et al., 2012). Organizations should not only implement preventive measures to reduce the risk of acquiring permanent injuries following workplace accidents but also take proactive steps to ensure the safety of individuals entering the labor market with a disability. Workplace adaptations should go beyond basic accommodations, incorporating training, modifications to work procedures, the introduction of assistive technologies, and other measures tailored to the specific and unique needs of these workers (EU-OSHA, 2004).

Future studies should investigate how to tailor specific interventions to people with disabilities to enhance their safety, reduce risks and injuries at work and improve the person-environment fit (Chandola and Rouxel, 2021). This process has to be developed in line with the biopsychosocial model proposed by the World Health Organization (World Health Organization, 2001), which shifted the concept of disability from being solely attributed to an individual's physical limitation to recognizing it as a problem also caused by the lack of appropriate adjustments in the work environment.

LGBTQ workers were also not the focus of any of the studies included in this scoping review. However, researchers showed that LGBTQ individuals are more likely to experience discriminatory or aggressive situations in the workplace (EU-OSHA, 2022; McFadden, 2015) and emphasized the need for targeted safety interventions for these groups. In line with the Minority Stress model (Meyer, 2003), the experience of discrimination can have negative effects on LGBTQ workers' well-being, potentially leading to issues such as sleep problems (Butler et al., 2020). These issues have been previously linked to an increased risk of workplace accidents (Caruso, 2015; Kling et al., 2010). Thus, interventions aimed to reduce the exposure of LGBTQ workers to psychosocial and organizational risks in the workplace should be developed, trying to give them voice by promoting a participative approach (EU-OSHA, 2022).

Beyond the specific groups targeted by the interventions, it is important to recognize that addressing the needs of diverse groups requires a more complex approach. This should consider the heterogeneity within each group and the intersection of their multiple identities, which are sometimes stigmatized (Butler et al., 2020). While most of the interventions included in this study made the effort to adapt to the specific characteristics of the target population, future research should also incorporate an intersectional perspective (Lau et al., 2024).

This scoping review also sought to shed light on the approaches and strategies applied to deliver and tailor interventions to the needs of the diverse groups considered. We showed that language and cultural adaptations were the most commonly implemented strategies. This is mainly due to the high prevalence of interventions addressed to immigrant workers. Many studies developed the content of the interventions taking into account the audience's literacy level, and the involvement of peer trainers or community role models was useful to achieve the desired outcomes. However, future studies should provide more detailed descriptions of the strategies used to tailor those interventions. Although all the interventions need to be adapted to specific groups of diverse workers and contexts, previous experiences may guide researchers in the development of future safety and injury prevention interventions.

Finally, it is important to emphasize that interventions should target not only the individual, by enhancing their competencies to prevent and manage risks, but also the organizational context (Lau et al., 2024). This includes creating appropriate levels of psychological safety, enabling workers to identify potential risks (Kang, 2024). Organizational culture and norms related to masculinities are also critical factors, as they may influence expectations around sick leave duration and return-to-work informal norms following workplace injuries, particularly in masculinized sectors (Stergiou-Kita et al., 2016).

The second goal of this scoping review was to identify the outcomes of the safety and injury prevention interventions addressed to diverse workers. As noted in the results, the interventions outcomes were conceptualized and measured in different way, although one of the most used indicators of the interventions impact was the knowledge acquisition. While some research also evaluated knowledge transfer, many others did not. Future research should focus on identifying the factors most critical in applying acquired knowledge in the workplace and maintaining safety behaviors over time.

Furthermore, although some of the studies in this scoping review tried to carry out a medium- and long-term follow-up of the results of the interventions implemented, it is important to extend this practice to better understand how well these results are sustained over time. In particular, interventions that utilize training programs should consider research examining the extent to which such programs lead to long-term changes at the affective, cognitive, and behavioral levels (Kalinoski et al., 2013).

As shown in Table 1, most of the interventions were developed in the farm industry. While this aligns with studies that identify farm workers as being particularly vulnerable to occupational injuries (Pintado Nunes et al., 2023), future research should also investigate the occupational safety of diverse groups in other sectors, especially in those industries with high prevalence and severity of occupational injuries.

Finally, it is worth highlighting that 20 out of 23 articles included in this scoping review received funding for the development of the interventions. The scarcity of studies found may be due to the difficulty of carrying out these types of interventions without financial support. This aspect should prompt governments to invest and take actions to promote public policies and providing financial resources for research focused on enhancing the safety of workers belonging to diverse groups.

The present study may have some limitations related to the selection of the articles included. Although a rigorous process was followed in searching the databases, it is possible that some articles focusing on safety interventions for diverse groups but not including key terms in their abstract and/or title, were overlooked. We attempted to mitigate this limitation through peer review and by searching the reference lists of the selected articles.

This scoping review has both theoretical and practical implications. At a theoretical level, it offers a systematization of safety interventions aimed at diverse workers, highlighting their outcomes and the factors that lead to them. It also provides an overview of areas that still need further development. At a practical level, this study offers insights for organizations to adopt effective practices that enhance safety and prevent occupational hazards for the diverse groups analyzed.

5. Conclusions

The results of this scoping review demonstrate that safety interventions targeting diverse workers can yield positive outcomes and underscore the importance of tailoring such interventions to the specific and unique characteristics of these groups. While it remains crucial to continue exploring ways to enhance workplace safety and reduce risks for diverse groups, the interventions included in this study can serve as a starting point for future design and development of safety intervention programs.

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CRediT authorship contribution statement

Donatella Di Marco: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sara Corlett:** Conceptualization, Formal analysis, Investigation, Writing – review & editing, Visualization, Methodology. **Sílvia da Silva:** Writing – review & editing, Investigation, Formal analysis, Conceptualization, Visualization, Methodology. **Anna Paolillo:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2026.107266.

Data availability

Data will be made available on request.

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