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# Occupational Injuries and Their Determinants Among Healthcare Workers in Western Countries: A Scoping Review

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**Abstract**

**Background:** *Healthcare workers (HCWs) in developed countries can be exposed to a wide range of hazards. The systematic identification of working conditions associated with the risk of occupational injury can significantly reduce this risk.* **Methods:** *From January 2000 to December 2021, a scoping review was performed using PCC (Population, Concept, and Context) criteria and searching major scientific databases. Studies conducted in Western Countries, defined as member countries of the Organisation for Economic Co-operation and Development (OECD), were selected.* **Results:** *We identified 282 studies for the present review. Studies focused more frequently on biological injuries (59%). Musculoskeletal injuries and injuries due to aggression and violence followed, based on the frequency of the investigated topic.* **Conclusions:** *Most studies focused on the risk of bloodborne infections, while a knowledge gap emerged on the epidemiology of accidental exposure to other transmission pathways. Although the proportion of injured workers is not negligible in most studies, the most common determinants and risk factors of injury are entirely preventable.*

## 1. Introduction

Workers across various occupations and sectors face risk factors that can lead to occupational injuries. The International Labour Organization defines these incidents as “any personal injury, disease or death resulting from an occupational accident,” which is described as “an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work, which results in one or more workers incurring a personal injury, disease or death” [1]. In the first joint estimates released by the World Health Organization (WHO) and the International Labour Organization (ILO) concerning the burden of work-related diseases and injuries, it was reported that in 2016, over 350 thousand deaths

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and 26 million DALYs were attributed to occupational injuries [2]. Primary prevention, including occupational health and safety risk assessments, can mitigate the burden of loss of life and health.

The healthcare sector stands as one of the largest and fastest-growing occupational fields globally. The global healthcare workforce is estimated at 65 million [3], expanding to over 200 million when including unpaid personal care workers, private sector providers, cleaners, and caterers who contribute to the health and social sectors worldwide [4]. In 2013, the Organisation for Economic Co-operation and Development (OECD) reported that the healthcare sector represented more than 10% of total employment [5], with similar proportions noted in the US and the European Union (EU), the two largest and most developed economies in the Organisation [6, 7]. Healthcare workers (HCWs) is an umbrella term that includes individuals engaged in the study, promotion, protection, and care of the population. This term encompasses various categories, ranging from medical doctors and nurses to allied health professionals, central supply workers, and technicians [8]. In many Western nations, injury rates are higher among HCWs compared to workers in other fields [9, 10]. Indeed, this diverse group of workers may encounter a wide array of hazards, including biological, ergonomic, physical, and chemical risks, as well as psychosocial hazards such as work-related stress and violence [7].

Biological agents, specifically, have historically received significant attention in risk management and prevention within this occupational group. Recognisable occupational biological hazards, such as hepatitis B virus, hepatitis C virus, human immunodeficiency virus, measles, mumps, rubella, varicella, influenza, and tuberculosis, have been addressed with effective preventive measures, including vaccinations and post-exposure prophylaxis. Occupational exposure and injury incidence can indeed be minimised through suitable preventive actions, such as adhering to standard and additional precautions and implementing specialised training targeted at workers at risk. However, several novel viral pathogens with pandemic potential, particularly from the influenza and coronavirus families, have emerged in recent decades. With the emergence of SARS-CoV-2, the seventh human coronavirus, this potential has been fully realised, and since the onset of the COVID-19 pandemic in March 2020, renewed attention has been directed towards the effective and appropriate control of other infectious biological agents in workplaces [11, 12].

Another significant cause of injury among HCWs is ergonomic risk: musculoskeletal injuries can arise from manual patient handling or load handling as well as overexertion caused by exposure to force, vibration, repetitive movements, and awkward body postures. Many professionals, including those involved in patient care, housekeeping, laundry, food services, and maintenance, are at risk of such injuries. Patient characteristics play a crucial role in risk assessment and must be considered. With an increasingly ageing and overweight population in Western countries, patient handling can lead to a considerable burden of injury [13].

Growing attention has focused on injuries stemming from violence and aggression, which seriously affect HCWs' health, both physically and psychologically, as well as their work capacity. According to WHO estimates, between 8% and 38% of HCWs have experienced physical assault from patients or visitors at least once in their careers [14]. In contrast, estimates indicate that all forms of workplace violence exceed 60% [15].

Less frequently addressed sources of injury among HCWs include exposure to chemicals (e.g., anaesthetics, pharmaceuticals, detergents, or reagents) [16, 17] or physical agents (e.g., ionising and non-ionising radiation) [18, 19]. Although exposure to these hazards can be maintained below harmful levels with proper risk assessment and management, accidental exposure can occur at sufficient concentrations to cause occupational injuries, such as burns and mucous membrane irritation.

Moreover, various individual risk factors among workers may pose potential risks for occupational injuries, including characteristics of the individual HCWs (e.g., age, gender, comorbidities), traits of the patients under their care (e.g., sociodemographic factors, type of illness), and the healthcare setting (e.g., organisation, workload, or shift patterns), as well as specific procedures (e.g., invasive treatment). The simultaneous presence of these hazards in specific workplaces can create complex interactions that may result in accidents, potentially imposing significant clinical, economic, and humanistic burdens [20, 21].

A comprehensive identification of working conditions linked to health risk exposure is vital in preventing injuries and diseases. In this context, and according to the previously published protocol [22], the aims of our study are as follows: (1) to provide a comprehensive overview of all studies concerning injuries among HCWs in highly developed countries; (2) to identify the most common types of injuries among HCWs; (3) to determine which types of HCWs are most susceptible to injuries; (4) to identify which variables impact the occurrence of injuries among HCWs; (5) to quantify the burden of injuries among HCWs in terms of associated disabilities, residual work capacity, absence from work, and direct/indirect costs generated; (6) to identify preventive measures that can effectively reduce the occurrence of injuries among HCWs; and (7) to disseminate review findings in the published literature on injuries amongst HCWs.

## 2. Methods

The objectives, inclusion criteria and methods for this scoping review were prespecified and published in a protocol in the BMJ Open Journal [22]. We followed the methodological framework for scoping reviews by Arksey and O'Malley, improved by Levac et al. and the Joanna Briggs Institute (JBI) [23-25]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-Scr) checklist was followed to ensure the comprehensiveness of the review [26].

### 2.1. Search Strategy and Selection Criteria

The databases searched were PubMed/MEDLINE (NLM), Scopus, SciVerse ScienceDirect, Web of Science, ProQuest Research Library, via the UNO per TUTTO platform databases. These databases were searched for articles published from January 2000 to December 2019. An updated search was conducted from December 2019 to December 2021. We scrutinised the reference lists of published review articles to locate additional relevant publications not identified during the database searches. Publication format was limited to peer-reviewed journal original articles, and grey literature was omitted. We used variants and combinations of search terms relating to occupational injury or healthcare settings. The Medical Subject Headings terms were obtained and combined using Boolean operators "AND" and "OR". Only studies performed in Western Countries, defined for the study as member countries of the Organisation for Economic Co-operation and Development (OECD), were selected. Further details of the search strategy are reported in the published protocol [22].

### 2.2. Publication Selection

Search results were imported into Mendeley (vers. 1.19.4), and duplicates deleted automatically. Studies were eligible if they met the following PECO criteria: P (population): healthcare workers (including medical, nursing, dental practitioners, trainees/residents, and allied health professionals); E (exposure): any injuries; C (comparator): different kinds of HCWs; O (outcome): prevalence/incidence and determinants of injuries, occupational and economic burden (e.g., direct and indirect costs). Included study designs: original articles and prevalence/incidence studies, published in English or Italian, or non-English publications with English abstracts containing sufficient evidence for extraction. A two-stage screening process was employed: first, independent screening of titles and abstracts by two reviewers (GD and AR); second, full-text review of potentially relevant papers by two additional reviewers (GD, AR, AM, NLB). Manual searches of reference lists were conducted, and any uncertainty about inclusion was resolved through discussion among the four reviewers. A fifth reviewer (PD) was consulted when consensus wasn't reached. When full texts of potentially relevant publications were inaccessible, two attempts were made to contact authors via email for requests.

### 2.3. Data Extraction, Synthesis and Analysis

An *ad hoc* data-extraction table was developed *a priori*, reflecting the research questions and the purposes/objectives of the review. The charting table was used to extract relevant data concerning the key characteristics of the studies. The extraction table was revised iteratively during the screening of the first 100 studies, however without requiring any modifications. More details on the development of the charting table can be found in the published protocol [22]. Three authors independently extracted a third of the data, and verified the other two thirds of the data from (AR, GD and AM). Any discrepancies were resolved by re-review of the study or discussion with the fourth reviewer (NLB). The data collected was stored in a Microsoft Excel electronic database. In addition to a narrative synthesis of the data relating to the review questions, we provided a table showing the main characteristics of the studies included in the scoping review. Furthermore, we calculated the frequency of studies investigating the following items: (1) the type(s) of enrolled HCWs, (2) the types of injuries and (3) the outcomes studied.

### 2.4. Quality Assessment

The scoping review was broad and exploratory, so a detailed methodological quality assessment was not required [27].

### 2.5. Patient and Public Involvement

No specific patient involvement was performed. However, preliminary findings and patient involvement were publicly debated at national and international occupational health scientific conferences and in consultations with Italian occupational health and safety institutions.

## 3. Results

The initial systematic search resulted in a pool of 112.708 potentially relevant records, of which 81.673 remained after duplicates were removed. After applying restrictions on language, study design, and year of publication, 5.135 full-text articles were retrieved and reviewed. Finally, 282 studies satisfied the inclusion criteria and were included in the present review (Figure 1).

### 3.1. Description of Included Studies

The majority of studies were published in three Regions: the USA, with 99 studies (35%), the European Union, with 86 studies (30%) (among which the country with most contributions was Italy, with 32 studies (11%)), and Australia and New Zealand, with 29 studies (10%). Most studies were published in two time-frames, between 2006-2011 with 94 studies (33%) and between 2016-2021 with 110 studies (39%). Concerning study design, the vast majority were observational, in particular cross-sectional (154 studies, 55%). The primary type of injury investigated in the articles were needlestick/sharp injuries and accidental Blood or other bodily fluids (163 studies), followed by musculoskeletal injuries (41 studies) and injuries due to aggression or violence (29 studies). The most common study population was "any type of healthcare worker" (107 studies), followed by healthcare students and nurses, respectively investigated in 46 and 41 studies (Table 1). Thorough details of study characteristics can be found in Supplementary Table 1. Among the studies that included the student and trainee population, the majority concerned medical and nursing students (18 and 16 studies, respectively), closely followed by resident physicians (15 studies). In each of the subsections, findings concerning students have been kept in a separate and following paragraph.

### 3.2. Injuries Due to Biological Risks

As no single preventive definition for injuries due to biological risk has been established, the following section includes all injuries caused by exposure to potentially infectious agents retrieved from the literature, including accidental mucocutaneous and percutaneous exposures to body fluids and accidents involving contaminated needlesticks and sharps.

The majority of injuries among healthcare personnel were caused by exposure to biohazards. One hundred fifteen studies specifically investigated needle-stick and sharp injuries, and 52 investigated events involving Blood and other biological fluids. The different outcomes have been summarized as follows.

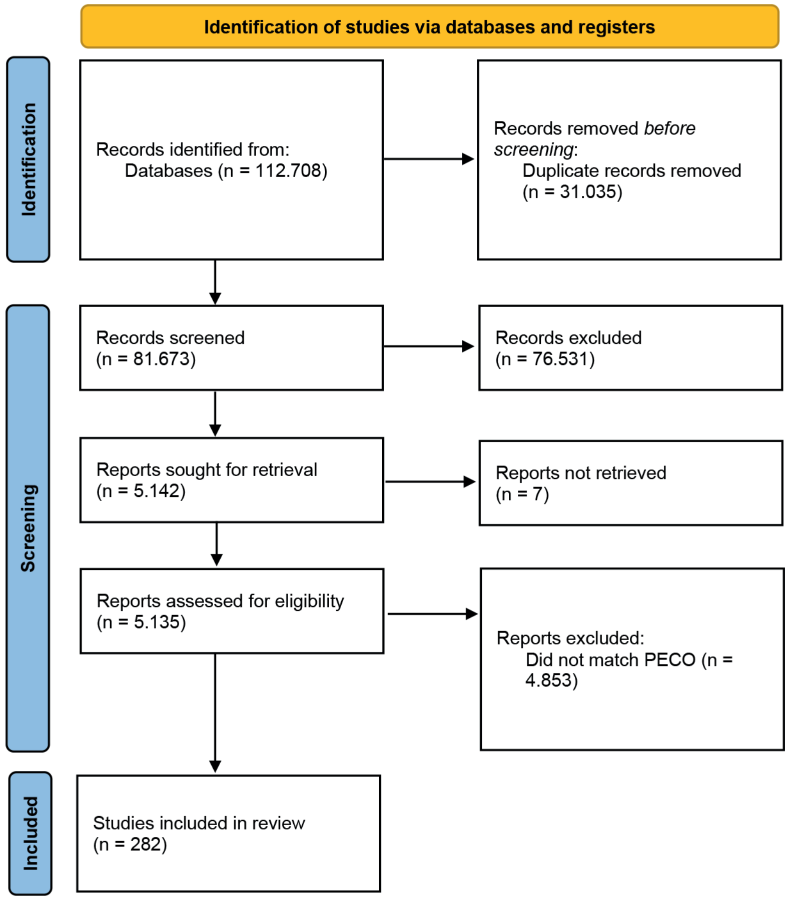


**Figure 1.** Study selection [28].

### *3.2.1. Incidence Rate*

NSI incidence rate of injury was measured with differing indicators and varied widely based on professional role and seniority between studies, ranging, in increasing order of events, from 0.6 per 1,000 procedures among home healthcare workers in the United States and Canada [30], 13 injuries per 100 beds in hospital HCWs in Italy [31], and a similar rate of 11.8 per 100 beds in Spain [32]. In contrast, in South Korea, a rate of 20.3 per 100 bed-years among healthcare personnel working in a teaching hospital was found [33] and 1.0 per 100 FTE in care aides in the US [34]. In a US dental teaching hospital, a rate of injury of 1.97/100 person-years was found for faculty and staff [35], and 2.73 occupational NSIs per 100 clinical general practice staff in the UK [36], 2.2 per 100 FTE physicians in France [37], 30 exposures every 1000 radiographers and 33 among theatre sterile supply staff in Britain [38], 3.66 events per 100 persons-years in HCWs in a teaching hospital in Ireland [39], 4.07/100 person-years for predoctoral dental students in the US [35]. Furthermore, senior house officers in the UK showed an incidence of 45/1000 employees per year [38], 5.1 per 100 FTE among nurses, and 1.0 per 100 FTE among aides in the US [34], while in a teaching hospital in South Korean a rate of 5.6 cases per 100 FTE-years was demonstrated [33]. Among French nurses, a rate of 7.0 per 100 was shown [37], with similar rates of 8.79 NSI per 100 FTE among nurses and 10.27 NSI per 100 FTE among medical staff in Australia [40], and 12.6 per 100 FTE among registered nurses in the US [41]. A study in

**Table 1.** Summary of included studies characteristics.

| Characteristic | Number (%) of Studies |
|---|---|
| **Year of publication** | |
| 2000-2003 | 30 (10.6) |
| 2004-2007 | 54 (19.1) |
| 2008-2011 | 60 (21.3) |
| 2012-2015 | 28 (9.9) |
| 2016-2019 | 79 (28.0) |
| 2020-2021 | 31 (11.0) |
| **Country of origin** | |
| United Stated of America | 99 (34.4) |
| European Union | 86 (29.9) |
| Australia-New Zealand | 29 (10.1) |
| United Kingdom | 22 (7.6) |
| Canada | 18 (6.3) |
| Turkey | 15 (5.2) |
| Japan | 8 (2.8) |
| South Korea | 4 (1.4) |
| Switzerland | 2 (0.7) |
| Israel | 2 (0.7) |
| Chile | 1 (0.3) |
| Mexico | 1 (0.3) |
| Norway | 1 (0.3) |
| **Study design** | |
| Cross-sectional (questionnaire based) | 154 (54.0) |
| Longitudinal (surveillance and database based) | 122 (42.8) |
| Case-control study | 5 (1.8) |
| Interventional study | 4 (1.4) |
| **Type of HCW** | |
| Any type of HCW | 110 (39.0) |
| Nurses and care aides | 53 (18.8) |
| Medical students, interns and residents | 26 (9.2) |
| EMS personnel and paramedics | 23 (8.2) |
| Medical doctors, surgical specialists | 21 (7.4) |
| Nursing students | 16 (5.7) |
| Allied health professionals | 13 (4.6) |
| Medical doctors, medical specialists | 12 (4.3) |
| Other healthcare students | 8 (2.8) |
| **Primary type of injury or accident** | |
| Biological injury | 167 (59.2) |
| Musculoskeletal injury | 42 (14.9) |
| Injury due to violence | 39 (13.8) |
| Any type of injury | 32 (11.3) |
| Chemical injury | 2 (0.7) |
| **Sample size** | |
| Questionnaire based | Range 31 – 34,318 |
| Surveillance and database | Range 126 – 883,500 |

the UK showed higher rates for phlebotomists of 154/1000 employees and pre-registration house officers (164/1000) [38], increasing up to 31.6 NSIs per 100 FTEs among US operating room staff members [42], 42 events per 100 person-years for correctional HCWs with clinical job duties in the US [43], and 62.6 injuries/100 paramedics in Poland [44].

### *3.2.2. Period Prevalence*

Results varied across different healthcare settings regarding the annual prevalence of injured personnel without professional characterisation. The prevalence ranged from 9% among HCWs in New Zealand [45], 21% in various health centres in Poland [46], and 27.8% in another study conducted in the same country [47], to 30% in community hospitals in the USA [48], and 32% in a larger study involving over 250 Polish hospitals [49]. It reached 38% in a district general hospital in the UK [50] and 41.7% in a teaching hospital in the same country [51]

In studies assessing the yearly prevalence among specific professional categories, the prevalence ranged from as low as 3.1% among home care aides in the US [52], 13.8% among medical doctors in

Australia [53], and 14% in dentists working in primary dental care in Scotland [54]. Among this latter category, a study performed in the UK showed a prevalence of injury equal to 20.8% [55], 27.7% in an Australian study [56], and 40% in Italy [57]. Among emergency medical service (EMS) personnel, a prevalence of 18.2% was reported in the US [58]. At the same time, higher values were seen among other surgical specialists and sub-specialists, up to 28% among oral and maxillofacial surgeons in the UK [59], reaching values of 55% among operating room (OR) staff members in a US hospital [42] and 73.2% among surgeons in a UK hospital [60]. Among nurses, ranges varied widely from 42% in Japan [61], and 48.1% in Turkey [62], while 70.4% of registered nurses from 60 hospitals in South Korea reported this type of injury [63].

Similarly, wide variations were seen among healthcare students, with an annual prevalence among nursing students ranging from around 7% in the US [64], 10.5% in Belgium [65], 13.9% in Australia [66], 18% in Italy [67], reaching higher values of 35.5% among nursing and midwifery students in Turkey [68] and 49% among nursing students in a teaching hospital in Turkey [69]. Concerning medical students and residents, the proportion of injured subjects varied from 14.6% among medical students in a UK medical faculty [70], 14.8% in Italy [71], 16.6% in Australia [72], 23% among medical students in Germany, ranging from 12% (first-year students) to 41% (fourth-year students) [73], in a Canadian community teaching hospital, 25% of medical trainees reported an injury [74], with values up to 30% in the US [75] and among medical residents in Japan equal to 34% [76].

#### *3.2.3. Lifetilme Prevalence*

Concerning the prevalence of injury during the whole career, a study performed in the US found among home care nurses and aides a proportion of injury of 35.0% and 6.4%, respectively [34]. In the same country, 38.7% of surgical team HCWs in a teaching hospital reported at least one NSI (100% of fellows, 73.7% of residents, 51.3% of nurses, 21.7% of medical students), of which 11% were high-risk (patient positive for HBV, HCV or HIV) [77], with similar results in another large academic hospital where 56% had been exposed to a sharp injury at some point in their careers (100% faculty members, 83% residents/fellows, 28% of medical students) [78], and a prevalence of 55% in another study (of which 89% of attendings, 72% of residents, 68% of surgical technicians/or nurses and 2% of medical students) [79]. Indeed, 84.6% of orthopedic surgeons at four US institutions reported this type of injury [80], while among acute care nurses in US hospitals, it reached 78.3% [81]. In Germany, dental care workers reported a prevalence of 54.3% [82]. Among healthcare workers in Poland, a lifetime prevalence of 55% among physicians and 81.1% among nurses was reported [83], while in a study performed in Ireland, 58% of doctors reported past NSI [84]. Among hospital workers in Israel, 53% reported at least one NSI in the previous 5 years in one study [85], and in another, a prevalence of 65.9% was reported [86]. Two studies on hospital workers in the UK reported a 53% lifetime prevalence in one [87] and 57% in the other [50].

In studies that focused on healthcare students and trainees, a lifetime prevalence of 22.6% was reported during training activities among healthcare students in the US [88], while 30% of medical students in the same country reported needlestick injuries, most commonly occurring in the operating room [75]. In a study performed among surgical residents at 17 medical centers in the US, 83% reported NSIs during surgical training, while 59% during medical school [89], while among otolaryngology residents it reached 68% [90], and up to 76% among orthopedic residents [91].

#### *3.2.4. Effect of Available Interventions*

Studies have demonstrated significant reductions in incidence rates following the implementation of safety devices, interventions, and policies. For example, a US study showed that targeted interventions decreased injury rates among students from 7.9% (2000-2001) to 2.6% (2001-2002) and among nursing staff from 9.2% (1997-1998) to 2.7% (2001-2002) [92]. Another US study in a tertiary care hospital found that introducing safety-engineered devices reduced percutaneous injury rates from 34.08 to 14.25 per 1,000 FTE post-intervention [93]. In France, a study across over 30 hospitals showed NSI rates of 2.9 per 100,000 SEDs and 11.1 per 100,000 non-SEDs [94]. Contrarily, a UK dental school study revealed that the introduction of safety devices dropped injury rates from 11.8 to 0 per 1,000,000 hours worked, and from 20.5 to 0 per 1,000 employees [95]. Conversely, a Dutch study reported no significant injury rate reduction despite introducing SEDs, changing incidence from 1.9 to 2.2 per 100 HCWs [96]. In an Australian tertiary care hospital, safety education and SED implementation led to a 49% decrease in all hollow-bore NSI events [40]. Legislative efforts like the Needlestick Safety and Prevention Act (NSPA) in the USA reduced injury rates from 4.00 per 100 FTE to 2.48 per 100 FTE [97]. Additionally, a study found declines in non-surgical settings from 24.1 to 16.5 per 100 occupied beds, while surgical settings remained stable [98]. In Italy, a safety-engineered intravenous catheter system reduced injury rates from 24.1 to 0.4 per 100,000 [99]. Lastly, a quasi-experimental trial in Spain showed that introducing SEDs with appropriate training decreased injury rates in hospital wards and emergency departments from 44.0 to 5.2, and from 18.5 to 0.0 per 100,000 patient days, respectively [100].

#### *3.2.5. Attributed Costs*

Direct and indirect costs related to this type of injury in four US healthcare facilities varied by infection status of source patients: HIV-infected patients had the highest mean cost at $2,456, followed by hepatitis C-infected patients at $650, and unknown or negative infection status patients at $376 [101]. Another US study indicated that the introduction of NSPA legislation saved an estimated $69-$415 million annually [97]. An Italian study found cost savings from reduced NSIs at €4,250 per 100 FTE, with the average cost of post-exposure interventions per exposed worker at €850 per injury [102]. In an 800-bed teaching hospital in Australia, implementing SEDs (devices with retractable syringes) is estimated to cost $46,000 annually, amounting to $14.00 per healthcare worker at risk or $2.00 per occupied bed-day per year [40].

#### *3.2.6. Determinants and Risk Factors*

The main determinants of NSI and risk factors were found to be profession (nursing [34, 48, 86, 95, 96, 103-110], physicians [108, 111-114], residents [76, 77, 89, 115-118] and particularly surgical residents [71, 74, 79, 90, 119, 120], but also trainees and students [121-124], especially nursing students [71], critical care paramedics [44, 58]), work factors such as time of day (diurnal [104, 109, 115, 117, 122, 125, 126], but also night shift workers [127]), time constraints and workload [50, 102, 128-131], and most importantly, lack of work experience and inadequate training or information about personal protective equipment use and other preventive and protective measures [30, 35, 40, 50, 63, 67, 69, 106, 110, 114, 124, 131-137], use of needles [51, 104, 109, 116, 138, 139] of solid-bore [78, 89, 98, 117, 135, 140], or hollow-bore type [44, 62, 64, 68, 69, 141], and specific procedures (surgical [74, 75, 82, 89, 98, 103, 104, 113, 115, 117, 118, 126, 132, 142-145], blood withdrawal [143], inserting intravenous (IV) lines [139]). Few studies found an association with age, particularly correctional HCWs older than 45 (with an aOR of 2.41) [43] and emergency medical services personnel over 60 years old [58]. Furthermore, hospital size was also considered a determinant of injury [146-148].

### 3.3. Injuries Due to Musculoskeletal Risk

As no single preventive definition for injuries affecting the musculoskeletal system had been defined, all injuries that resulted in trauma or lesions to this system, including biomechanical overload, prolonged fixed postures and slips, trips or falls, have been included in the following section.

Exposure to musculoskeletal risk caused the second most common type of injury among healthcare personnel. Forty-two studies investigated this kind of injury, of which 33 focused on biomechanical overexertion, and nine studies concerned slips, trips, and fall injuries. The different outcomes have been narratively summarized as follows, starting each paragraph with the findings concerning musculoskeletal injury due to overload, and ending with those concerning slips, trips, and falls.

*3.3.1. Incidence Rate*

The incidence rate of musculoskeletal injury due to overload was measured with differing indicators and varied widely between studies, ranging from 5.3, 5.5, 7.4 per 100 person-years among part-time, casual, and full-time Canadian registered nurses, respectively [149], 8.8/100 full-time hospital workers and 13.5/100 long-term care workers in the same country [150], 16.5 injuries per 100 FTEs among occupational therapists and 16.9 injuries per 100 FTEs among physical therapists in the US [151].

Concerning injuries due to slips, trips, and falls, rates were 0.76-1.66 claims per 100 FTE in US hospitals [152], 1.35/100 worker-years among endoscopy personnel in a US academic hospital [153], with overall 39.1-40.6 events per 10,000 healthcare workers in the same country [154]. Studies in Canada showed similar findings, with 0.5-0.7 falling events per 100,000 productive hours [155], and a fall injury rate of 0.9-1.5 claims per 100 FTEs [156].

*3.3.2. Period and Lifetime Prevalence*

Concerning the prevalence of injured personnel, results varied between different healthcare settings and professions, ranging from 10.2% of healthcare workers in Denmark who reported at least one back injury incurring during patient transfer [157], 20% of US gastrointestinal diseases specialists reported experiencing an injury during the fellowship, mostly involving the hands and fingers [158], 36.2% of nurses and care aides in a US hospital, who reported at least one patient-handling injury in the past 6 months [159], 56% among registered nurses, behavioral health specialists, and patient care assistants in a pediatric hospital in the same country [160], among chiropractors in Canada a prevalence of 59.1%, mainly affecting lower back, wrists/hands and neck [161], while among obstetricians and gynecologists in Australia and New Zealand, 55.5% reported at least one injury, most commonly to the back followed by shoulder [162]. Higher prevalence values were found among US radiation therapists, of which 76% reported a musculoskeletal injury, mainly to the lower back, neck and shoulders [163]. In comparison, prosthetists and orthotics in Australia reported a prevalence of 80%, primarily affecting the neck, back, and shoulder [164]. Among physiotherapists in Poland, a prevalence of 78.1% was reported, particularly with upper limb symptoms affecting the shoulder, neck, and thumbs [165], and similarly, physiotherapists in Greece reported a prevalence of 89% [166].

Concerning specific tasks and activities, healthcare professionals performing endoscopies reported high prevalence of musculoskeletal injuries: 75% of gastroenterologists performing endoscopies in the US [167], 79.6% of GI specialists in the EU and UK performing colonoscopies reported injuries, mainly to lower back, neck and left thumb [168], while among those performing endoscopic retrograde cholangiopancreatography (ERCP) in the US a prevalence of 48% was reported, with the most prevalent injuries being De Quervain's tenosynovitis and cervical radiculopathy [169]. Moreover, surgical specialists showed a high proportion of injured workers: 69.4% of surgical specialists in the US reported significant discomfort while operating, with the most common affected area in both the lumbar and cervical regions [170], 78.3% among plastic surgeons in US, Canada and Norway [171], 63.9% among otolaryngologists in the US, particularly affecting neck and shoulders [172], while 73.6% among neurosurgeons in the Netherlands, particularly affecting neck, back and shoulder areas [173]. Moreover, among Canadian ophthalmologists, 54.6% experienced musculoskeletal pain [174], and among US orthopedic surgeons, 59.3% reported neck pain, with 22.8% showing signs of cervical radiculopathy [175]. In a study performed among UK-based podiatrists during the COVID-19 pandemic, 66% reported musculoskeletal pain, mainly affecting shoulders and neck, with increased frequency and intensity due to changes in work practices enforced during the pandemic [176].

Regarding the annual reporting of musculoskeletal problems in the student population, one study was included, showing a prevalence of 34.5% among medical students in laboratory settings, mostly referring to the lower back, neck, and upper back [177].

Finally, regarding slips, trips, and falls, only one study in the US showed a prevalence of 18% among home healthcare workers [178].

*3.3.3. Effect of Available Interventions*

Only one study assessed the impact of interventions and policies in the reduction of MSI incidence rates: in a study performed in three long-term care facilities in Vancouver, Canada, the implementation of overhead ceiling lifts contributed to reducing musculoskeletal injury by 56% (RR=0.44; preintervention 0.16 MSI/bed; postintervention 0.09 MSI/bed) [179].

*3.3.4. Determinants and Risk Factors*

The main determinants of MSI and risk factors were found to be the professional role (nurses, nursing aides, surgeons, endoscopists [150, 159, 168, 171], specific task or procedure (endoscopy [158], laparoscopic surgery [162], microsurgery [171], loupe magnification surgery [180], microdiscectomy and laminectomy [173], slit lamp examinations [174], arthroscopic surgery [175]), type of ward (orthopedic ward), working full-time, type of HCW (assistant nurse), transferring/moving patients [157, 179, 181], age (being younger than 40 years old [181, 182], being older [173, 175]), gender (female [158, 163, 164, 168, 182], male [175, 183]), and importantly protracted fixed body posture [150, 161, 170, 171, 172, 174, 177]. Several other work factors were found to be determinants of injury, such as job dissatisfaction [159], time constraints and workload [162-164, 171, 184], and lack of adequate training [184].

Regarding injuries due to slips, trips, and falls, the occupational categories most affected were food services, transport/emergency medical service, housekeeping staff [152], and nurses and aides during home care activities [155, 156, 178]. Predictors were females and older people [154-156].

### 3.4. Injuries Due to Violence and Aggression

Aggression and violent acts resulted as the third most common form of injury studied among healthcare personnel, assessed in 39 studies. The different outcomes have been narratively summarized as follows.

*3.4.1. Incidence Rate*

Violent injuries were measured with differing indicators and varied widely between studies. In a study performed in the US, EMS workers reported incidence rates of 0.6 per 100 FTE [185]. In a nationwide survey in the same country on violent injuries from 2012 to 2015, an overall incidence rate of 6.38 events per 1000 FTE was recorded, with the highest incidence found amongst nursing assistants at 14.89 and nurses at 8.05 per 1000 FTE, while the lowest being pharmacists at 0.17 and physicians at 0.48 per 1000 FTE [186]. In a study on nursing staff in acute care in the US, an overall assault rate of 1.65 per 100 FTEs was recorded [187]. In an international survey of EMS workers, a rate of violent incidents of 229.3 per 100 FTE workers per year was found [188]. In the emergency department of a university hospital in Switzerland, a total of 84 cases of workplace violence were reported from January 2013 to December 2016, with varying rates from 2013 equal to 4.5 cases per 10,000 patients, 2014 equal to 6.3 cases, in 2015 equal to 4.9 cases, and in 2016 equal to 4.3 cases per 10,000 patients. In this study, most acts of violence were verbal (92.8%), while 56.6% were physical, and over half (51.8%) occurred during night shifts. The aggressors were most frequently intoxicated with alcohol or suffered from mental disorders [189]. In an Italian hospital, from 2012 to 2015, 36 injuries on 539 acts of aggression were recorded (proportion=7.2%), with a rate of 18.6/10.000 workers. In 300 events, the violent act was verbal, while it was physical in 142 events [190].

*3.4.2. Period and Lifetime Prevalence*

Regarding findings on prevalence, values ranged from 3.6% reporting physical violence among US nurses over the past year [191]. Home care aides in the US reported 6.6% for physical violence and 18.8% for verbal violence [192]. In Italy, a study showed 9.2% of healthcare workers reported physical aggression, while 19.6% reported verbal aggression [193]. In a US university hospital, 34.4% of healthcare workers faced any incident of abuse, including 13.5% physical violence [194].

Higher prevalence values were observed among nurses: 32.1% among Turkish nurses over their careers [195], 59% reported exposure to verbal abuse in US home health care, and 3.3% experienced physical assault [196]. A German study noted that 79.5% of nurses and aides reported violence in the previous year, with 94.1% being verbal abuse and 69.8% physical violence [197]. Incidents were more frequent in general wards than in psychiatric wards, linked to the lack of de-escalation training among general ward staff. The highest incidence of sexual harassment was found in senior care at 18.1% [197]. Newly licensed US nurses reported verbal violence (70%); physical violence was noted by 25% in their early licensure years [198]. In Italy, 76.0% of emergency nurses faced verbal violence, and 15.5% experienced both types of violence [199]. A study among correctional nurses found 96.5% experienced at least one episode of violence, often from problematic inmates [200].

In EMS studies, 4.5% reported violent acts during US pre-hospital care in one month, with 20.7% being verbal and 48.8% physical [201]. Another US study noted 7.0%, with over half involving physical violence [185]. In another analysis, 22.6% reported physical assaults in the past year, affecting 12.9% of incidents [202]. A French study found a lifetime prevalence of 23% for workplace violence among workers [203]. An international survey revealed 65% of EMS workers experienced physical attacks, with 36.5% injured last year [188]. A US survey found 68% of EMS personnel were assaulted by a patient at least once [204]. Moreover, 69.0% reported at least one form of violence, primarily verbal (67.0%), while 43.6% faced physical violence [205]. In Australia, 87.5% of paramedics experienced workplace violence, with verbal abuse at 82%, physical abuse at 38%, and sexual harassment at 17%, notably among females [206]. A Turkish study noted 94.9% of EMTs and paramedics reported verbal abuse, while 39.8% experienced physical violence in two years, with female workers facing more verbal and male workers facing more physical violence [207]. Among medical categories, violence on general practitioners (GP) was assessed by several studies, with proportions of verbal violence in the UK of 54%, more frequently acted towards women. In comparison, 6% reported physical violence, which is more prevalent among men [208]. In a study on Australian GPs, mainly concentrated in metropolitan areas, an annual prevalence of 57% of at least one form of violence and aggression was reported, with the majority being verbal abuse (44%). In comparison, sexual harassment was experienced by 8%, and physical abuse by 3%. Only sexual abuse showed an association with female gender [209]. Another Australian survey performed on workers in general practice showed that 59.3% of GPs and 74.6% of non-GPs experienced violent episodes during the previous 12 months [210]. Among rural general practitioners in Australia, 73% reported having been abused in some way during their careers, a 12-month prevalence of 45.5% for verbal violence and 3.2% for physical violence. Sexual harassment during the career was three times more common among female rural GPs (45.1%) compared to male colleagues (14.6%) [211]. Among physicians in an Italian study, 66.5% reported at least one episode of aggression during their career, of which 74.2% of verbal aggression and 16.5% of physical violence [212]. In comparison, a career prevalence of 83.3% in a Turkish sample was recorded (34.7% in the previous 12 months), 77.2% verbal and 11.7% physical [213]. Furthermore, one study on US anaesthesiologists showed that 20.1% of workers reported physical violence, with 69.0% reporting nonphysical abuse during their careers [214].

Studies show a significant occurrence of violence against healthcare students. In a study of Australian nursing students, violence-related injuries ranked fourth among reported injuries, making up 9.2%, mostly during placements by patients or relatives [215]. In Spain, 16.1% of nursing students reported similar incidents [216]. An assessment of paramedic and midwifery students in Australia revealed that 32% experienced some form of violence, predominantly verbal abuse (17.6%), with midwifery students facing more violent acts than paramedic students. Only one instance of physical violence was noted among paramedic students [217]. Another study found that 32.6% of paramedic students had been exposed to violence during ambulance placements, with 21.2% experiencing verbal abuse and one case each of sexual harassment (0.08%) and physical abuse (0.08%) [218].

### *3.4.3. Determinants and Risk Factors*

Key risk factors for violent injuries include professional role (nurses [78, 193, 212, 219], paramedics [205], midwifery students [217]), care setting (psychiatric, emergency, geriatric, rural [187, 190, 193, 194, 197, 210]), patient type (psychiatric, intoxicated [193, 201, 208, 211, 219, 220]), gender (males linked to physical abuse, females to verbal or sexual abuse) [187, 188, 190, 194, 197, 206, 208, 212, 217, 221, 222], young age [187, 199, 209], social deprivation (e.g., police presence, poverty) [201, 208, 220], direct patient contact hours [209, 212, 221], time of day [188], insufficient training and inexperience [194, 199, 209], and organizational factors (e.g., long waiting times, overcrowding, lack of care).

### 3.5. Injuries Due to Chemical Risk

Accidental exposure to chemical risk was assessed in two studies, one performed among cleaners in the healthcare setting in British Columbia, Canada [223], and the other among emergency medical services workers in the US [224]. In the first study, among an overall annual incidence of 145 reported injuries identified among cleaners, 10% caused allergies or irritations, of which 43% were caused by exposure to chemicals. The accidental exposure was caused during garbage handling or inhaling chemicals and bleach during cleaning. The most common cleaning solutions mentioned in injury incidents contained chlorine, hydrogen peroxide, n-alkyl dimethyl benzyl ammonium chloride, and didecyl dimethyl ammonium chloride.

The second study, which evaluated injuries among EMS personnel, found that from 1995 to 2001, six events involved injuries to this working category. Exposures ranged from the nonlife-threatening tearing agent o-chlorobenzylidene malononitrile (pepper spray) to extremely lethal substances, such as hydrofluoric acid and chlorine gas. Overall, 15 injured ED personnel sustained 29 injuries; the most commonly reported were respiratory irritation and eye irritation. None of the 15 wounded ED personnel was wearing any form of personal protective equipment (PPE) at the time of injury.

## 4. Discussion

This article is the first to systematically collect and synthesize current evidence on injuries among healthcare workers in Western countries, where occupational hazards are evolving. Research on this topic has significantly increased since 2010, mainly addressing injuries from accidental exposure to biological agents, partly due to emerging microorganisms, as seen during the COVID-19 pandemic. Long-existing pathogens like m. tuberculosis and hepatitis B still cause recurrent epidemics, as rapid global movement allows pathogens to spread quickly [225-227]. Moreover, these agents can evolve, necessitating constant monitoring of occupationally acquired infections and improved infection control measures.

Our review revealed that most studies focus on needle sticks and sharp injuries, largely concerning bloodborne pathogens. Although these injuries persist worldwide—with estimated occupational attributable fractions for HCV, HBV, and HIV infections among healthcare workers at 39%, 37%, and 4.4% [228], respectively—many effective prevention measures, such as antivirals, vaccinations, and safety-engineered instruments, have reduced these injuries [229-232]. However, there remains a knowledge gap regarding the epidemiology of accidental exposure to other pathways, especially airborne pathogens.

The incidence of percutaneous injuries varies by job category, with nurses exhibiting higher rates than physicians, mainly from hollow-bore needles. Most incidents involve surgical staff, linked to solid-bore needles and scalpels. Studies show a lifetime prevalence of needlestick injuries (NSIs) ranging from 10% to over 80%, generally lower for healthcare students and nurses than for surgical personnel and OR specialists. Most studies report a lifetime prevalence of 20-60%, indicating significant risks remain. Key risk factors include professional role, training status, use of needlestick and sharp instruments, procedure type (like IV insertion and surgery), as well as work conditions such as shifts, time constraints, excessive workloads, lack of experience, and training inadequacies. HCWs frequently injure themselves recapping needles or during scalpel handling. These practices are known risks but are preventable with proper training. The high incidence of these injuries in developed nations underscores the need for occupational health services to implement targeted training to reduce such injuries. Preventing occupational exposure to blood is crucial for minimising costs.

Regarding musculoskeletal injuries (MSIs), endoscopists and surgeons are among the most affected due to manual instruments and poor body positioning. At the same time, nurses and physiotherapists are impacted by patient handling, particularly in the back, neck, and shoulder areas. Most studies indicate over 50% of workers have experienced work-related musculoskeletal injuries. Key risk factors include professional roles, specific procedures (like laparoscopic and arthroscopic surgery), and excessive workloads coupled with inadequate training, which can lead to improper lifting techniques and muscle strain. Occupational health professionals should monitor workers' techniques to mitigate risks associated with patient handling. Additionally, job dissatisfaction is linked to MSIs, supporting the correlation between psychosocial factors and musculoskeletal disorders [233].

Variability among studies was notable for injuries caused by work-related violence, the third most common injury type, with prevalence ranging from less than 5% to over 95%. Different ranges were found for physical and verbal violence. This type of injury primarily depends on organisational factors and specific patient populations, with the highest prevalence reported among correctional healthcare workers (HCWs), emergency medical service (EMS) personnel, paramedics, and HCWs in emergency departments, psychiatric wards, and geriatric wards. Assisting patients with mental health issues or substance intoxication increased the risk of violent behaviour, as did prolonged direct patient contact, working in socially deprived areas, and lack of training. Workers trained in de-escalation techniques had a reduced risk of violence. Organisational factors such as long waiting times and department overcrowding also increased this risk.

Few studies assessed accidental exposure to chemicals, showing potential injury risks for healthcare workers using cleaning agents and sterilisers and exposures in emergency medical response teams. While some exposures could be prevented with proper risk assessment, others are unpredictable, often occurring when responders lack sufficient training. Occupational health professionals can help train responders in hazard recognition and rapid assessment at contamination scenes. However, the limited studies indicate a need for further research on chemical or physical exposure injuries.

Throughout this review, we noted a high underreporting rate of various injuries. Few injuries were reported according to recommended procedures due to a workplace culture that diminishes risk perception. Senior staff often view such events as routine, underestimating health risks and only reporting severe cases, while junior staff may fear repercussions. Specific categories, like home care workers, may also underreport injuries due to less controlled occupational settings.

Injuries affect healthcare workers and students differently, with students being less studied. When considered together, professionals showed a higher injury prevalence due to their more demanding roles. Enhancing training and risk awareness for students could help reduce occupational injuries [234]. Active surveillance and periodic intervention reviews are crucial, especially in high-turnover settings like university hospitals. Lastly, violence and aggression increased the likelihood of other injuries, such as needlestick injuries (NSIs), indicating a complex interaction between these risks that must be considered in risk assessments.

A rigorous methodological approach in the literature search and review bolsters the present study's results. However, it faced limitations, notably a lack of a unified international definition of injury. This heterogeneity is particularly evident with injuries from biological agents, such as SARS-CoV-2, among healthcare workers. Despite extensive literature, few countries, including China and Italy, classify this as an accident or injury, while most designate it as an occupational disease. For instance, Italian legislation includes infectious diseases as work-related injuries due to the virulent cause being equated with violent causes, which defines work-related injuries [235-236]. Consequently, studies that did not encompass this specific concept could not be retrieved, limiting discussions on biological hazards to needlestick injuries (NSIs).

Additionally, musculoskeletal injuries were defined variably, with some studies referring to symptoms like pain and discomfort, while others addressed accidents or injuries, often using terms interchangeably with musculoskeletal diseases. Despite a substantial number of studies, results predominantly stem from a few developed countries, with limited focus on specific topics (e.g., NSIs, MSI) and quality of evidence (mostly observational based on reporting databases and questionnaires). Among 38 OECD countries, only a few, notably the USA, Australia, and Italy, produced over half of all published research, indicating limited knowledge in other regions.

Another limitation was the time filter applied, which included studies up to December 2021, potentially omitting newer evidence, particularly on occupational infections and injuries due to aggression against healthcare workers, which may have risen during pandemic waves [237].

In conclusion, the scoping review illustrates that while numerous studies have investigated injury epidemiology in healthcare settings, many injuries remain preventable through effective safety measures. Employers are responsible for ensuring a safe workplace, but occupational health professionals must also engage in risk assessment and management, providing training and information to workers. Informed workers can actively participate in fostering a safer work environment, creating a positive cycle. This study aims to equip safety and health professionals with current evidence to enhance existing protocols. Lastly, there is a need for high-quality studies in under-researched areas to analyse this evolving issue thoroughly and to advance risk management towards injury-free workplaces.

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