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Organo della Società Italiana di Medicina del Lavoro

Work, Environment & Health

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La Medicina del Lavoro

Editorial

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Celebrating the Legacy of a Century of Scientific Research Published by *La Medicina del Lavoro*

The journal's rich legacy, chronicled through its extensive historical series that began with the title *Il Lavoro* in 1901 (Figure 1A), exemplifies the resilience and quality of our research. Since its inception, this journal has consistently adapted to the evolving landscape of Occupational Medicine while remaining at the forefront of scientific advancements. We are proud of this legacy, shaped by many scholars throughout industrial revolutions that have augmented societal wealth and well-being, even as they have sometimes exacerbated worker poverty and health issues. Indeed, the overarching goal of industrial revolutions has always been increasing production at reduced costs, with minimal regard for workers' health. This neglect has underscored how social processes can profoundly affect the health of disadvantaged populations, leading to the emergence of social medicine as a vital field of scientific inquiry.

The editor's pick to celebrate the centennial of our journal's current heading—*La Medicina del Lavoro* (Figure 1B)—falls on the article published in Italian one hundred years ago by Livia Lollini, a remarkable female physician full assistant (assistente effettivo) at the *Clinica del Lavoro* in Milan, to open its first issue in January 1925 (Figure 1C) [1]. This article has been translated into English with the title "The Protection of Women and Children at Work" [2] to offer our readers her views, which are mostly still relevant today. As remarked by Riva and Palladino in their commentary from a historical perspective, such views have paved the way for Occupational Medicine's scientific and social achievements to promote better working conditions and improve workers' health and safety, thereby underscoring the discipline's role in shaping healthcare and advancing medical science in occupational settings [3].

Many things changed over time. For example, female doctors—a tiny minority one century ago—now represent the vast majority, over 70% of medical students. In the early 1920s, the life expectancy in Italy was as low as 35 years, partly because of the terrible toll of young lives associated with WWI from the still low value of 50 years observed a decade earlier, just before the war. After WWII, we enjoyed an unprecedented 75-year peaceful period in Europe, which, combined with social and health achievements, led our life expectancy to 83.1 years (81.9 for males and 85.2 for females). To the extension of life expectancy, a substantial contribution undoubtedly came, at least partly, from the containment or elimination of occupational exposure to harmful agents and improved workers' living conditions.

Lollini's paper was published before the rise of sound cinema when radio was still evolving as a mass communication medium, and the automotive industry was booming, primarily due to Ford's adoption of the assembly line. Nevertheless, her paper transcends temporal and linguistic barriers, providing intellectual and spiritual contributions to our global community audience. It serves as a powerful reminder of occupational physicians' mission today: to advocate for the health and safety of workers and patients and champion workers' rights. Occupational Medicine consultants should again align with the discipline's roots, fostering an additional revolution—Employment 5.0—essentially more than ever. Such a revolution should prioritise unemployment considerations and reimagine the relationship between workers and machines, steering industrial transformation toward a more human-centred future [4].

The ICOH ethical guidelines and current Italian legislation also require them to primarily focus on preventing occupational risks to workers' health. The role of a global business consultant—initially theorized as a technical figure in a typical multidisciplinary process as the implementation of quality systems [5]—is

claimed by occupational physicians today as a professional with instruments (guidelines, protocols, consensus documents, technical assessments provided by scientific societies, and notably by SIML—the Italian Society of Occupational Medicine) for qualifying and updating his/her activities [6]. However, such a role is only meaningful if provided to companies exercising the social responsibility proclaimed by the most enlightened entrepreneurs. Unfortunately, such social responsibility is often ignored by the more widespread, wildly oriented predatory economy dedicated to maximizing financial profit without any respect for the dignity of workers.

Decent work is integral to goal 8 in the Agenda 2030 for Sustainable Development, a global initiative to address our world's challenges today [7-9]. It must provide a just income, workplace stability, and social security for everyone, enhance opportunities for personal growth and societal inclusion, enable individuals to voice their opinions, engage in decision-making processes impacting their lives, and ensure equal opportunities and fair treatment for both women and men.

Implementing automation will highlight the significance of well-being and mental health as fundamental components of a thriving workforce. Creating job opportunities is crucial, as unemployment is associated with various health complications and social unrest. Occupational Medicine calls for proactive strategies designed to mitigate mortality and morbidity risks. Our actions must be grounded in empirical evidence and address hazards impartially, even in the face of potential misjudgements. The collection of compelling evidence for proposed modifications is of utmost importance, as the available data is frequently incomplete and necessitates further investigation into conditions associated with work- and unemployment-related illnesses to promote a healthier future.

The relentless advancement of knowledge demands that we not only critically review scientific findings but also actively seek and incorporate new evidence through our commitment to scientific research. In the field of Occupational Medicine, while only robust research provides a solid foundation for informed action, we must also heed the insights of visionary authors. This dual approach ensures that we acknowledge existing knowledge and act decisively, rather than allowing crucial interventions to be delayed or overlooked. Let us commit to a proactive and inclusive stance in our pursuit of continuous improvement in Occupational Medicine.

Antonio Mutti

References

1. Lollini L. La protezione delle donne e dei fanciulli nel lavoro. Med Lav. 1925;16(1):3-12. Avalable at https://collezioni.unimi.it/dcb/rivlavoro/pdf_ln_new/USMG8_LAVORO_1925/PDF_MULTI//1925_La_Medicina_del_Lavoro_Vol16_ocred.pdf
2. Lollini L. The Protection of Women and Children at Work. *Med Lav*. 2025;116(1):e2025002.
3. Riva MA and Palladino ME. Forward-Thinking: How a Century Ago Protecting Women and Children in the Workplace Laid the Groundwork for Gender Medicine and Decent Work. *Med Lav*. 2025;116(1):e2025003.
4. Kolade O, Owoseni A. Employment 5.0: The work of the future and the future of work. *Technology in Society*. 2022;71:102086. Doi: https://doi.org/10.1016/j.techsoc.2022.102086
5. Apostoli P, Pugliese F. Il medico del lavoro, consulente globale, nell'implementazione dei sistemi di qualità [The occupational physician as global consultant for implementing the quality systems]. *G Ital Med Lav Ergon*. 2010;32(4 Suppl):75-78.
6. Apostoli P. Il Medico competente del Lavoro, consulente globale in azienda [Occupational physician: a global consultant for prevention and health promotion in workplace]. *G Ital Med Lav Ergon*. 2012;34(3 Suppl):458-461.
7. Manandhar M, Hawkes S, Buse K, Nosrati E, Magar V. Gender, health and the 2030 agenda for sustainable development. *Bull World Health Organ*. 2018;96(9):644-653. Doi: 10.2471/BLT.18.211607
8. Sheehan P, Sweeny K, Rasmussen B, et al. Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents. *Lancet*. 2017;390(10104):1792-1806. Doi: 10.1016/S0140-6736(17)30872-3
9. Weir S, Arstein-Kerslake A, Eadie T, McVilly K. Realising economic and social rights for children with communication and swallowing disability: Sustainable Development Goals 1, 8 and 10. *Int J Speech Lang Pathol*. 2023;25(1):37-41. Doi: 10.1080/17549507.2022.2153166.

A

(Conto Corrente colla Posta) Pavia, 1° Dicembre 1901. (Conto corrente colla Posta)

Anno I. **IL LAVORO** Num. 1.

RIVISTA DI FISIOLOGIA, CLINICA, IGIENE ED ASSISTENZA SOCIALE DEL LAVORO

Diretta dal Prof. L. DEVOTO
della Facoltà medica di Pavia.

Redatta dal Dott. C. MORESCHI
Assistente di Patologia medica nella R. Università di Pavia.

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SOMMARIO.

B

Anno XVI - N. 1 Gennaio 1925

LA MEDICINA DEL LAVORO

"Il LAVORO" fondato a Pavia nel 1901

FISIOLOGIA, CLINICA, IGIENE, PREVIDENZA ED ASSISTENZA SOCIALE DEL LAVORO

SOMMARIO: Presentazione (L. Devoto). - La protezione delle donne e dei fanciulli nel lavoro (L. Lollini). - Studio sulla mortalità per cause violente accidentali in rapporto alla professione (G. Gherardi). - *Fisiologia del lavoro:* Effetti di condizioni esterne sul consumo energetico del lavoro. - *Patologia del lavoro* - Avvelenamenti collettivi da gas illuminante negli operai degli stabilimenti di Mosca. - Sulle malattie ed infortunii professionali delle telefoniste. - Rilievi di patologia del lavoro desunti dalle pubblicazioni statistiche delle Casse renane ammalati 1922. - Un caso mortale di intossicazione saturnina. - Le malattie degli zincografi di Napoli. - Le intossicazioni da piombo tetraetile negli chauffeurs e negli addetti ai motori a scoppio. - *Igiene. - Previdenza ed Assistenza sociale. - Infortunistica. - Vita Accademica. - Libri nuovi. - Cronaca della Clinica:* Movimento nell'anno 1924. - Studenti allievi della Clinica del Lavoro

Col 1925 il nostro giornale, senza abbandonare il suo glorioso battesimo nel quale vide la luce a Pavia nel 1901, e di cui riproduciamo in questo numero la sua prima pagina, si chiamerà pubblicamente « La Medicina del Lavoro ». Questa è oggi l'insegna ufficiale di un grandioso contenuto scientifico-politico e sociale che trova in ogni parte del mondo e tra i popoli più giovani, ovunque si trovano spiriti illuminati e sereni, il più compiuto riconoscimento; sotto questa insegna sintetica si tengono in Italia i nostri Congressi, si danno corsi ufficiali, si bandiscono concorsi, si concedono libere docenze. E sotto questa bandiera, che sventolerà, sovratutto coi colori della tradizione italiana, si riuniranno i cultori vecchi e giovani di tutte le branche della medicina, che, puntando verso il più alto grado di benessere fisico e morale di tutti i lavoratori, vogliono rendere tutti gli Italiani uguali davanti alla salute e a tutte le conquiste della scienza della salute. Utopia di ieri, non più di oggi!

Ai vecchi e nuovi amici della Medicina del Lavoro *il nostro caldo augurale saluto.*

L. Devoto.

C

LA MEDICINA DEL LAVORO 3

DOTT. LIVIA LOLLINI

La protezione delle donne e dei fanciulli nel lavoro[1]

Il lavoro delle donne e dei fanciulli non è un fatto recente nella storia; esso è anzi antichissimo: assurse primamente ad importanza economica all'epoca della pastorizia e dell'agricoltura, s'intensificò allorchè gli uomini divennero schiavi, persistè attraverso tutta l'evoluzione umana; delle donne in particolare si può dire che esse, se perdettero col tempo in forza fisica, non furono mai dei parassiti economici. Ma allorchè la macchina a vapore e la macchina a filare rivoluzionarono il mondo, accrescendo la potenza dell'uomo, ma chiedendogli minor dispiego di forza muscolare, le donne e i fanciulli invasero le officine, e il loro lavoro acquistò un valore sociale e economico enorme, convertendosi in un vero sfruttamento delle forze umane minime a favore di una plutocrazia industriale, che vide in esse la possibilità di un eguale produzione con salari minori. Furono così le donne e i fanciulli, gli esseri destinati dalla natura al maggior risparmio delle energie fisiche per la conservazione della specie e per il miglioramento della razza, ridotti a vere bestie da soma, a macchine umane.

Noi non possiamo dare che alcune cifre incomplete e non recenti, riguardanti il numero delle donne e dei fanciulli impiegati nell'industria italiana e straniera.

Troviamo che in Inghilterra il numero delle donne lavoratrici salì dopo lo scoppio della guerra a 1.240.000 costituendo il 38 % di tutti i lavoratori. Alla fine della guerra si contavano 3.000.000 d'operaie.

In alcuni degli Stati Uniti, come nel New England, nel Sud-Atlantico, era impiegata una donna su cinque al di sopra di dieci anni. In 24 Stati erano impiegate dal 10 al 20 %, mentre in due lavoravano la metà delle donne. 1/10 di queste lavoratrici aveva meno di 16 anni. In complesso 8.075.772 donne si guadagnavano negli Stati Uniti nel 1910 il loro pane. Si calcola che questa cifra sia aumentata a più di 11.000.000 durante la guerra.

Nel 1914 una relazione mostrava che su 400 occupazioni ve ne erano sole 29 nelle quali le donne non erano incluse.

In Germania prima della guerra più di 100.000 donne erano occupate nella lavorazione dei metalli, nelle miniere e nelle fonderie. Durante la guerra il loro numero si triplicò.

Per l'Italia ci riferiamo al censimento del 1911, non essendo ancora noti i risultati dell'ultimo del 1921.

In 243.926 imprese industriali censite su 1.220.459 maschi vi erano 593.962 femmine. E complessivamente erano di età inferiore ai quindici anni 228.947 operai.

(1) Relazione letta al II Congresso delle Dottoresse in Medicina. - Milano, ottobre 1924.

Figure 1. Il Lavoro, founded in 1901 (A) became La Medicina del Lavoro in 1925 (B). Celebrating its centennial, we feature an article by Livia Lollini from January 1925 (C).

La Medicina del Lavoro

History

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The Protection of Women and Children at Work[1]

Livia Lollini

Historically, the work of women and children is not a recent phenomenon; it is indeed very ancient. It first gained economic significance during the era of pastoralism and agriculture, intensified when men became enslaved, and persisted throughout human evolution. It can be said that although women may have lost physical strength over time, they were never economic burdens. However, women and children entered the workshops when the steam engine and the spinning machine transformed the world—enhancing male power while requiring less physical strength. Their labour gained tremendous social and economic value, turning into exploitation of minimal human efforts in favour of an industrial plutocracy, which viewed them as a means for equal production with lower costs and wages. Thus, women and children were beings destined by nature to have more significant savings of physical energy for the conservation of the species and the improvement of the race, reduced to veritable beasts of burden to human machines!

We can only give some incomplete and not recent figures regarding the number of women and children employed in Italian and foreign industries.

We find that in England, the number of working women rose after the outbreak of the war to 1,240,000, constituting 38% of all workers. At the end of the war, there were 3,000,000 workers.

In some of the United States, such as New England, one in five women over ten was employed in the South Atlantic. In 24 states, 10 to 20% were employed, while half as many women worked in two; 1/10 of these workers were under 16 years old. Overall, 8,075,772 women earned their living in the United States in 1910. This figure is estimated to have increased to more than 11,000,000 during the war.

In 1914, a report showed that out of 400 occupations, there were only 29 in which women were not included. Before the war, more than 100,000 women were employed in metalworking, mining, and foundries in Germany. During the war, their number tripled. For Italy, we refer to the 1911 census, as the results of the last one in 1921 are unknown. In 243,926 industrial companies surveyed, out of 1,220,459 males, there were 593,962 females. Furthermore, overall, 228,947 workers were under the age of fifteen.

Out of 100 male workers, there were 48.7 females; out of 100 workers of both sexes and all ages, there were 12.6 under the age of fifteen.

In the generic census of the population, which must, however, be considered with great caution among the obliged farmers, we can note 295,355 males and 89,938 females.

From the 1911 census, it is impossible to detect the number of home workers. Still, according to 1901, the total number of people working at home mainly for silk spinning, hand lace making, and articles of straw, wood, and clothing, and the vast majority are women. To have more recent data, we must refer to those reported by factories subject to the law on the work of women and children.

In 1919, 411,969 minor children and women were reported. However, this figure does not correspond to reality because it cannot be presumed that all the factories were reported, especially during the war and in the provinces most directly affected by it.

Returning then only to the work booklets issued to children of both sexes and to minor women, we

[1]This paper is an English version of the manuscript "*La protezione delle donne e dei fanciulli al lavoro*", lecture given at the 2nd Congress of Italian Female Doctors in Medicine and published on the issue No. 1 of *La Medicina del Lavoro* on 1st Jan 1925. [Lollini L. La protezione delle donne e dei fanciulli al lavoro. *Med Lav.* 1925; 16(1): 3-12].

note that in 1921, 109,365 were issued, with a maximum percentage of 79% for northern Italy and a minimum of 10 and 20% for southern and insular Italy, respectively.

These last figures are far from reality, as the distribution of workbooks is not taken care of in many provinces, especially in southern Italy. You will forgive me for all these figures. Still, as Filangeri said, no science deserves more attention than statistics to study social questions, a study full of discouragement and anxiety.

If we then consider how few the categories of workers protected by the current law are, and if we add to the blue-collar workers the many white-collar ones, the phenomenon of female labour and the equally critical issue of child labour emerge in all their significance. This situation justifies the passion they have inspired in individuals from religion, philanthropy, science, and politics throughout history, particularly in recent decades.

The principle of worker protection, which had already come to fruition through the convulsions of 1989, from which human rights and the obligation of social solidarity were to blossom, will triumph in the crusade for the race proclaimed by the coming biological, anthropological, and economic doctrines.

However, Italy has more remote hygienic-social traditions.

The Florentine republic had to dictate the first wise rules; Tommaso Campanella's City of the Sun lighted the way. Bernardino Ramazzini's small but golden treatise *De morbis artificum* laid the first foundations of work pathology and hygiene. Others followed, and even today, there are numerous eminent practitioners of social medicine in our country. Nevertheless, the legislators were late, so our Italy, which transmitted the sacred fire to the world, is not today in the place that its thinkers and scientists predicted.

Acknowledging the human element, particularly the psychosocial and physiological organization of labour, has emerged as a global concern. Protecting life within occupational settings and ensuring that work does not threaten life, as Puccinotti envisioned, has garnered international importance. Governments have affirmed their prerogative to merge individual interests with collective interests and to limit personal freedoms for the overarching benefit of society.

Let us restrict our attention to the vast subject matter currently presented, which we can only address in a synthetic and incomplete manner. Protecting the welfare of children, adolescents, and women constitutes the cornerstone of every ideological and operational initiative that has contributed to establishing the International Labour Organization.

In 1842, England prohibited underground labour for women and limited their employment in the textile industry to a maximum of ten hours. In a parallel development, France enacted an inadequate child labour law during the same period.

On February 11, 1886, Italy established its inaugural legislation concerning child labour, which was amended in 1902 to enhance support for women and revised in 1907, culminating in the enforcement of the current Consolidated Law.

The issue of safeguarding female workers on an international scale was introduced in Berlin in 1890. Initiatives were established to prohibit night work for women during the first four weeks following childbirth in industries deemed hazardous. Nonetheless, these measures were only partially implemented.

Underground work by women was prohibited in several countries, including England, Austria, France, Germany, Italy, Sweden, Norway, and Belgium, as well as Holland and Switzerland, which also banned night shifts.

With respect to occupations deemed excessively arduous, hazardous, or detrimental to health, Italy has enacted a prohibition against such employment for women under the age of 21. This prohibition has been implemented, albeit to varying degrees, in the principal regions, as well as during the subsequent four weeks following childbirth. However, Italy permits certain exceptions to this regulation, allowing for a reduction of the mandated rest period to three weeks upon the submission of a medical certificate.

The Bern Conferences held between 1906 and 1903 established guidelines regarding the duration of nighttime rest and working hours. Following the conclusion of the war, the governments that had pledged substantial promises to workers—who viewed their well-being as a fundamental aspect of

peace—established the International Labor Organization (ILO). This organisation convened its inaugural conference in Washington, thereafter followed by conferences in Genoa and Geneva. Significant advancements were made in the legal protection of women and children during this period.

Four conventions were enacted concerning children, setting the minimum age for admission to work in industries, maritime positions, as stokers, and agriculture at 14 years. One convention prohibits night work before the age of 18 but provides exceptions for specific industries after the age of 16.

This issue demands our full attention as social doctors. Italy has authorised the ratification of these conventions, yet only one, regarding night work, has been implemented. There is little indication that the other conventions will be enforced anytime soon.

The existing legislation prohibits children under the age of twelve from engaging in employment within industrial factories, laboratories, construction sites, non-underground job sites, quarries, and mines. For positions involving underground work, the minimum permissible age is thirteen when mechanical assistance is provided and fourteen in its absence. Individuals below the age of fifteen are prohibited from undertaking hazardous and labour-intensive occupations; however, they are allowed to work in rice fields starting from the age of fourteen.

At fifteen-years old, except for regulated night work by Royal Decree 1923, a child is considered an adult and loses hygienic protection when their development is incomplete and puberty is just beginning.

This law, which remains unenforced in many parts of Italy, contradicts scientific findings.

Extensive studies have highlighted the detrimental effects of early and arduous labour on children's bodies and health. Anthropologists have identified physical differences between children and adolescents from different social classes that reveal a clear disadvantage for those from poorer backgrounds. Pathologists have linked early unhygienic labour to bodily deterioration, skeletal deformities, and chronic illnesses—particularly respiratory issues (such as seen in *carusi* employed in Italian mines). Sociologists view this practice as an impediment to the progress of working-class individuals toward moral and spiritual growth.

The impact of child labour is stark; it removes children from the sunlight and the joys of school and life, leading to physical impoverishment and intellectual dimming.

We must continue to assert that child labour is not only against physiological norms but is also fundamentally immoral.

Therefore, the age at which adolescents can enter the workforce should be raised to a minimum of 15 years for regular occupations. Subsequently, the working hours should gradually increase from 15 to 16 and then from 16 to 18, aligning with completing the crucial phase of physical development. From hazardous underground jobs to strenuous tasks that deplete haemoglobin levels and increase susceptibility to diseases like Koch's bacillus, causing bone deformities and premature distress, every child and adolescent should be shielded until they reach 18-20 years of age.

There are no valid economic arguments against this stance. Citing Simon's astute observation that "The wages earned by children come at the expense of their fathers' earnings without contributing an extra cent to the family's total income", we emphasise that industries relying on exploiting children's health have no moral right to exist. Protection against child labour should not be selective but universal, encompassing all children regardless of their industry or livelihood—be it in agriculture, commercial enterprises, rice fields, or family businesses.

It is worth noting that in nearly all European and American countries (with Switzerland leading the way), the minimum age for entry into the workforce is set at 14 years. For instance, in New York State, children under 16 are limited to working six hours a day for six days a week. Russian legislation mandates a maximum working day of four hours for those aged 14 to 16 and six hours for adolescents aged 16 to 18. Germany has made vocational education mandatory; England has introduced a 'half-time' system enabling simultaneous schooling and employment.

The concern surrounding child labour is intricately associated with the matter of education. Without a greater adherence to compulsory schooling requirements—as evidenced by the statistics from the General Directorate for Elementary Education

of 1923, which indicate that for every 100 individuals obliged, only 50 are registered in Sicily and 41 in Calabria—the issue of illiteracy cannot be adequately resolved. As long as illiteracy rates persist at 70% in Calabria and 11% in Piedmont, a satisfactory resolution to establishing vocational schools, professional training programs, and apprenticeships that cultivate intelligent workers rather than mere labourers remains imperative.

The employment of children transcends mere industrial issues; it constitutes a fundamental aspect of the educational system's problem.

I shall abstain from addressing the exclusively significant aspects of professional orientation and psychotechnics, which underscore the optimal psychological and physical capabilities of employees. Instead, my emphasis will be on medical evaluations.

Existing laws mandate compulsory medical examinations for children up to the age of 15 and for women up to the age of 21. These evaluations also extend to adolescents up to the age of 18, all women, and workers employed in hazardous industries. This principle advocates for inclusive medical assessments across all age groups and job categories, representing a comprehensive approach to ensuring overall well-being.

A regulatory provision stipulates that the Health Officer conducts periodic visits to ascertain whether children and minors' health status permits continued employment without jeopardising their organic development. However, no specific timeline is established for these periodic visits. Labour inspectors are also aware of how the physical data recorded in the booklets are structured: typically following a standardised format, which is often incomplete and occasionally compiled without prior examination; the information is sometimes absent.

Actual individual cards should be developed wherein the somatic characteristics and growth indices are systematically recorded; these cards would also yield invaluable scientific data for investigating occupational diseases.

The medical service must be intensified, and the visits must be at least monthly to check whether the state of health allows children and minors to continue the work they are employed. Such compulsory or periodic visits have the utmost importance since, usually, it is not the first visit that counts but the subsequent ones, the healthy child entering work but ruining himself in it.

I remember that here in Milan, the example of a similar occupational health organisation is splendidly offered by the Labor Clinic, where hundreds of arm and brain workers are periodically visited, advised, and protected annually.

Regarding night work, we observe that what has been achieved represents a step forward, but progress must not be stopped. Too many exceptions have been accepted after the age of 16. Moreover, the night shift is from 8 p.m. to 6 a.m.

We express the view that the abolition of night work, which is contrary to hygiene and morality, should increasingly extend to male workers as well and that exceptions should indeed be exceptions. If women have been brought closer to children under the legal protection of labour, we must not see this as a confirmation of their inferiority compared to men.

Much discussion has been about women's intellectual and physical capabilities and endurance. Some have proclaimed that women should only dedicate themselves to family life and the upbringing and education of children, while others have sought to make them thrive in the struggle for life. These issues are not foreign to us, but we frankly say that we do not understand that part of the feminist movement, although inspired by noble ideas which are solely concerned with the equality of men and women in life's competition, refuses to ensure material advantages in labour organisation for women in order not to undermine this equality and not put women in an economically inferior position.

We begin by highlighting the distinction between work as a collective phenomenon and work as an affirmation of specific individuals' identities.

We consider the problem not only from a social point of view but also from a biological and physiological one. Women are not inferior to men, but different. In her, the generation apparatus, so closely connected to the endocrine glands, has such predominance in the various periods of life, in puberty, in pregnancy, in breastfeeding, in menopause that all her vegetative and psychic functions are influenced by it, and made it extremely unstable.

Dispassionate observers' statistics demonstrate more significant morbidity among female workers than among male workers. In some regions, after the extension of industry, an actual deterioration of the race has been noticed, an impressive loss in beauty and strength.

By protecting women at work and removing them from the fever of physical and mental work, the legislator wanted to protect race because, in every girl and every woman, we must always see the potential of a birth mother. Between motherhood and work, as it is currently organised, the conflict is very bitter. Women are allowed to work, but only in conditions that are not contrary to their physiology, and through it, they will contribute to the well-being of their families and the progress of society.

In the sacred writings of the Talmud, it is recommended that women be exempted from labour in the puerperium as long as they breastfeed the child. In the 13th century, Louis IX in France prescribed an edict that women should be treated with great gentleness and left to rest during pregnancy. Tommaso Campanella also had advice for women recently giving birth that could be dictated today. At the international conference in Berlin in 1890, Simon stated that the protection of new mothers' work is directly related to the regeneration of the race. For such a question, money does not count.

Safeguarding women's well-being in the workplace was a pressing concern at the Washington conference.

Data from various nations highlighted the prevalence of gynaecological ailments, abortions, premature or abnormal births among female workers, and the decline in their reproductive capacity. Renowned figure Pinard, credited with introducing intrauterine childcare, presented compelling statistics illustrating how an infant's birth weight increases directly with the mother's resting period before delivery and is influenced by the nature of her work - more or less strenuous. Instances of stillbirths, morbidity, and mortality among newborns and infants were distressingly high. Congresses worldwide advocated for remedies, and many legislative actions were taken.

In Washington, a consensus was reached to grant six weeks of rest before and after childbirth at the request of the pregnant individual. This provision garnered unanimous support and ratification within Italy. Notwithstanding, this convention has largely remained unimplemented.

The inadequate legislation of 1907 was enacted, alongside the minimal support allocated by the National Maternity Fund, which amounts to only 100 lire. Nonetheless, one must consider the number of working women who remain inadequately protected despite these provisions.

From the report of the Director General of the National Maternity Fund of 1923, it appears that in that year, 663,366 were paid with 10 taxes and 34,991 births and abortions were subsidised. The maximum figure is given by Lombardy, and the minimum by Basilicata: 4! In Southern Italy, there are provinces where no childbirth has been subsidised!

It is painful to note this, but here, too, the fact is repeated, highlighted for children, that the law of work for women and children remains unknown or is violated in many regions of Italy, especially in the South.

It is accurate to state that Italy is home to thriving free maternity health funds, one exemplary case being that of Milan, which complements the subsidy with essential assistance, a crucial component for the success of maternal care. These funds are akin to the French Mutualités maternelles. However, they are all very laudable but isolated efforts.

Italian law must comply with the Washington Convention as soon as possible.

It is established that for pregnant women and women who have recently given birth to obtain rest truly, they must be paid a minimum subsistence allowance or an allowance proportionate to their daily earnings, reaching at least 75% of it, and that, as is the case in France, she is guaranteed the preservation of her job; that also, as England has set an example, a domestic service be organised that relieves her of the fatigue of taking care of the house.

It is imperative that the working mothers who require protection encompass all individuals employed in industry, agriculture, commerce, and domestic settings.

The esteemed legislation enacted in 1919 concerning disability and old age insurance encompasses all classifications of wage earners, thereby

providing protection for 11,000,000 workers. There exists a section within the statute that focuses on the prevention of disability; should the maternity fund not be considered a social security institution intended to benefit all women? The national pension fund itself may be restructured to conform to these new objectives through the introduction of new measures.

It is accurate to state that within the comprehensive bill regarding compulsory health insurance, which aims to address the inadequate foresight demonstrated by our populace, women who have recently given birth are sufficiently protected; however, the bill remains in a state of anticipation for its enactment. We remain hopeful that this will transpire as promptly as possible. In numerous countries, such as Austria, Germany, England, Norway, and Belgium, maternity insurance is already integrated into compulsory health insurance, yielding excellent outcomes.

Conversely, in Italy, the issue of breastfeeding employees remains unresolved. The legally mandated nursing rooms in factories and laboratories with a workforce of 50 or more exist in only a tiny fraction of cases; in 1914, a mere 12% of factories, which are subject to regulations about the employment of women and children, reported compliance, equating to approximately 5 per 1000 women.

The Inspection Service should be further intensified in this regard; the benefits of the law ought to be extended to encompass factories and minor workers. Additionally, establishing crèches and nurseries—of which we have some commendable yet rare examples—would be advantageous; such facilities are, however, quite prevalent in France, having notably decreased the mortality rate of working offspring within a single decade. It would be even more beneficial to alleviate women's occupational responsibilities so they can devote their full attention to the upbringing of their children. This goal can only be realised through breastfeeding premiums or allowances.

It is imperative to recognise that infant mortality, which reached 270,000 in 1916 from approximately 720,000 deaths—accounting for two-fifths—was reduced to 110,000 in the first year of life by 1922. This issue primarily arises from congenital atrophy, immaturity, and enterocolitis.

The first causes refer to tiring and unhealthy pregnancies, and the last to improper infant nutrition.

However, let me make a few considerations before concluding.

There is a job, the working proletarian, the most miserable, the most dangerous, the one in whom every human and hygienic law is trampled upon, who exploits women and children to the highest degree, who gives the highest figures of morbidity, mortality, and anti-morality of the offspring of working mothers, the lowest figures of their fertility, a frightening percentage of tuberculosis (up to 50%): this is the sweating system, paid work at home.

Minister Labriola presented a bill in 1921, which, following in the footsteps marked first by the Australian State of Victoria and New Zealand and then by England, America, France, and Germany, raised our country to a higher level of civilisation. However, this project, too, is buried. In Italy, there is still discussion about the minimum wage, the advertising of tariffs, the abolition of intermediaries, and the regulation of the placement of workers by the State; central laboratories are organised here, and there, votes are made for the extension of home inspections, already applied in Austria and England, and for the progressive re-absorption of homework into workshop work. However, we are still waiting for legislative intervention to protect the health of workers and the public. It appeared sketched out during the war for military supplies, bringing significant benefits, but then the work stopped.

It should not be asserted that we lack patience; if that is the case, it is only in pursuit of what is beneficial. We have implemented the eight-hour workday. We are convinced that eight hours may be excessive for women during the third trimester of pregnancy and throughout the breastfeeding period. Pregnant and nursing women are not afforded the same consideration typically extended by farmers and breeders to their animals. The practice of job rotation could be explored, similar to measures adopted in England.

We would also like **all women**, at least pregnant women and nurses, to be excluded from tiring and unhealthy work. Thus, we await the essential occupational hygiene code regulation in preparation and the reform of the labour medical inspectorate.

Furthermore, for the latter, allow me a vote. Satisfying a desire expressed for some time by various women's associations, the art. 427 of the Treaty of Versailles establishes that inspection services must employ women. "Wherever these were admitted, they brought a practical spirit, a fervour for the apostolate, an industrious feeling of duty, a constant aspiration towards high ideals which made their work singularly beneficial and fruitful", said Minister Di San Giuliano.

Let it be this, too, be a work field open to Italian women.

And let us not delay in creating **factory nurses** on a large scale here too, the indispensable collaborators of the **factory doctor**, who in America and England have proven to constitute the best instrument of propaganda and hygienic-social education, succeeding with their tact, their influence, more than any pamphlet or cinematography or conference, to persuade the workers of the need for their cooperation in the difficult task of enforcing labour laws and have favoured the development of all institutions for the welfare of workers.

Promoting the establishment of maternal and childcare schools is essential, as we have observed rare yet commendable examples in Rome and Milan. These institutions should educate working women on effectively fulfilling their maternal responsibilities.

Moreover, it is crucial for Italian women, irrespective of their professional fields—be they intellectual or manual—to fully understand the significant respect that is due to their roles as mothers. They are encouraged to take proactive measures to protect this essential aspect of their lives while also advocating for legislative support against individuals who mistakenly perceive that the neglect of motherhood benefits their interests.

Modern medicine is progressively adopting a social perspective. The era characterized by individualistic physicians is diminishing; conversely, the recognition that human existence is intricately linked to social structures is becoming increasingly significant. The concept that charity should transform into solidarity, that societal enhancement contributes to human advancement, and that prevention is prioritized over cure is widely acknowledged.

It is not unrealistic to foresee a future in which all medical practitioners will recognize the validity of Virchow's assertion: "Doctors are the natural advocates of the poor," as a straightforward reflection of fundamental intuitive truth.

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Forward-Thinking: How a Century Ago Protecting Women and Children in the Workplace Laid the Groundwork for Gender Medicine and Decent Work

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Keywords: Women's Occupational Health; Livia Lollini; History; Labor Legislation; Gender Medicine; Decent Work

Summary

Dr. Livia Lollini, a physician and an early pioneer in women's occupational health, authored a paper published as the lead article in the inaugural issue of La Medicina del Lavoro, which adopted its current title in 1925. Her work, La protezione della donna e del fanciullo sul lavoro (The Protection of Women and Children at Work), constitutes one of her contributions to labor protections for women and children in early 20th-century Italy. Born into a family distinguished by socialist and feminist ideals, she completed her medical education in 1913. Subsequently, she served as an assistant at the Clinica del Lavoro in Milan, where she addressed various issues related to occupational health. Drawing from international labor laws, Dr. Lollini critiqued the inadequate enforcement of existing legislation in Italy and emphasized the notable disparities in maternity protections. Her analysis highlighted the need to safeguard women's health at the workplace and called for systemic reforms, including implementing regular medical examinations, female labor inspectors, and industrial nursing services. Her work, grounded in gender-sensitive approaches to occupational health, continues to resonate with contemporary principles of gender medicine. Although substantial advancements in labor legislation have been realized, many of the challenges she addressed—such as child labor, maternity rights, and workplace safety—remain central to global discussions surrounding decent work and equitable labor practices.

During the *Secondo Congresso Nazionale delle Dottoresse in Medicina*, held in Milan in October 1924, Livia Lollini presented a paper on the protection of women and children in the workplace together with the pediatrician Virginia Angiola Borrino (1880–1965). This presentation received significant attention in the scientific community and was published as the lead article in the 1925 volume of the journal *La Medicina del Lavoro* [1]. Before analyzing this article, it is important to provide some biographical notes about its author.

Born in Rome on February 27, 1889, Livia Lollini was the third of four sisters, daughters of the socialist politician Vittorio Lollini (1860–1924) and Elisa Agnini (1858–1922), a pioneering Italian feminist and pacifist who co-founded the *Associazione per la Donna* (Women's Association) advocating for women's rights [2-3]. There is limited information about Livia Lollini, but it is known that she graduated in medicine in Rome in 1913 and, during her studies, associated with Tatiana Schucht (1887-1943), the sister-in-law of Antonio Gramsci (1891-1937), and

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the circles of Roman socialism [4]. In the summer of 1915, she enlisted as a medical officer during World War I, along with her younger sister Clelia Lollini (1890-1963) (Figure 1), who was also a physician [5]. After the war, Lollini participated in the *Associazione Italiana Dottoresse in Medicina* (AIDM) activities, founded by her sister Clelia in 1921. In the 1920s, she was appointed as a "full assistant" (*assistente effettivo*) at the *Clinica del Lavoro* in Milan, contributing scientifically to different occupational health issues, not limited to the protection of women in the workplace [6].

In 1922, she published two brief reviews in *Il Lavoro* on paradichlorobenzene poisoning and tobacco-related pneumoconiosis [7-8]. She collaborated closely with Luigi Devoto (1864-1936) and translated from German the lectures on tuberculosis by Rudolf von Jaksch (1855-1947) and Anton Ghon (1866-1936), which were issued by the Italian publisher Vallardi in 1924. [9] Livia had a profound knowledge of German, frequently spoken in her household due to the Austrian heritage of her maternal grandmother, Elisabetta Kostner [3]. In 1928, she married Francesco Signore (1886–1959), a distinguished volcanologist. This union was founded on love, yet it did not result in offspring. Subsequently, she relinquished her medical career to support her husband's research endeavors in Naples [3].

Figure 1. Livia Lollini in 1908, when she was still a medical student Rizzini Family Archive

In 1924, when Livia Lollini delivered her lecture, Italy's labor protection legislation had achieved a degree of alignment with other European nations. Nevertheless, the enforcement and societal implementation of these laws remained insufficient. The first law explicitly addressing child labor was enacted in 1886, following years of debates and unsuccessful proposals. This legislation, however, was limited in its scope, establishing a minimum working age of nine years yet failing to incorporate adequate enforcement mechanisms, sanctions, or inspections [10]. Consequently, the law proved largely ineffective and received widespread criticism. In response to increasing political and social pressures, the Law of June 19, 1902, was introduced to safeguard women and children in the workplace [11]. This legislation stipulated a maximum working day of twelve hours, including a two-hour break, and prohibited night work for all minors. The concept of maternity leave was officially recognized for the first time, allowing for 28 days of unpaid leave following childbirth, although no provision for suspension before childbirth was established. Nonetheless, the protections afforded by this law remained limited, characterized by significant gaps and a lack of substantial enforcement measures. Further advancements were realized with the Law of November 10, 1907, which aligned Italian labor protections with the 1906 International Convention on Night Work (ratified by Italy in 1919) [12]. This legislation prohibited night work for women of all ages and barred underground work in mines and quarries for individuals under 15. Additionally, dangerous and unhealthy occupations were restricted to boys under 15 and women under 21. A Maternity Fund was also instituted in 1910 to provide modest, fixed subsidies for women on

maternity leave; however, this amount was insufficient and unrelated to their actual wages [13].

During World War I, both the war and the economic crisis prompted the significant involvement of women in positions traditionally held by men, as protective labor legislation was temporarily suspended to sustain national production levels. Subsequently, as men returned from military service, women were systematically relieved of their positions to facilitate the reintegration of unemployed veterans. In the challenging post-war years, labor protection laws for women were reinstated; nonetheless, women remained excluded from political voting rights and leadership roles [13].

In the political and legislative context of the period, Livia Lollini's paper begins analyzing data about women's and child labor, both within Italy and internationally [1]. It also provides a comprehensive overview of pertinent legislation in industrialized nations. The necessity of safeguarding children from labor was largely undisputed, emphasizing the importance of prioritizing education. However, discussions regarding workplace protections for women were characterized by fervent debates among feminist circles. The comparison of labor protections for women with those for children raised concerns among certain feminists, who feared it might imply "women's inferiority to men" [1]. Consequently, some prominent figures within the feminist movement opposed calls for enhanced labor protections for women, such as restrictions on night work, to uphold the principle of gender equality in the workplace [12]. In response to this controversy, Lollini presented concepts that align with contemporary principles of gender medicine, asserting that "women are not inferior to men, but rather different" [1].

The analysis of the figures cited by Lollini in support of her arguments is imperative, as they furnish insight into her cultural and scientific background. Notably, she referenced Tommaso Campanella (1568-1639) and Bernardino Ramazzini (1633-1714) as pioneers in social medicine. Additionally, she mentioned Jules Simon (1814-1896), a French politician and philosopher renowned for his advocacy for workers' rights, alongside Adolphe Pinard (1844-1934), a pioneer in prenatal and neonatal care [1]. Furthermore, Lollini acknowledged Giovanni Loriga (1861-1950), who directed Italy's labor medical inspectorate in that period. However, she notably excluded Luigi Carozzi (1880-1963), a socialist physician recognized for his substantial political and scientific contributions to the campaign against child labor and night work for women, which substantially influenced the ratification of the International Labour Organization (ILO) conventions concerning these matters. This exclusion is intriguing, as Carozzi had played a pivotal role in shaping labor protections, mainly through his contributions to the ILO conventions on child labor and night work. It is plausible that his departure from the *Clinica del Lavoro* and relocation to Rome and then to Geneva may have led to his omission from Lollini's references [14].

In her paper, Lollini criticized the legislator's efforts to balance economic productivity with maternity protections as insufficient to ensure adequate working conditions for women. She highlighted the inconsistent application of laws, particularly in southern Italy, as a reflection of the country's cultural and infrastructural disparities. According to Lollini, the lack of adequate protections during the postpartum period was especially concerning, along with the absence of designated spaces for breastfeeding in factories, despite such provisions being required by law. She underscored the inadequacy of the maternity benefits provided by the *Cassa Nazionale Maternità*, which were insufficient for women to take meaningful leave. Echoing her progressive stance, Lollini argued: "We would like all women, at least pregnant and nursing mothers, to be excluded from any strenuous or unhealthy work" [1].

To address these legislative shortcomings, Lollini emphasized the need to intensify workplace medical examinations, referencing the "Milanese model" exemplified by the *Clinica del Lavoro*, which pioneered regular medical visits. She also called for strengthening the medical labor inspectorate by including female inspectors who could better address women's workplace conditions. Furthermore, Lollini advocated adopting the industrial nurse model established in the United Kingdom and the United States to assist occupational physicians. It

is worth noting that the Italian government took initial steps in this direction shortly afterward, establishing schools for *assistente sanitaria* (a role akin to the industrial nurse), authorized by the Law of August 15, 1925, No. 1832. Lollini concluded her article by invoking Rudolf Virchow's (1821-1902) words, who declared that "physicians are the natural advocates of the poor" [1].

Lollini's article distinguishes itself through its critique of labor protections and innovative proposals, many of which foresaw contemporary approaches to occupational health and gender medicine. Her work emphasizes the need for systemic reforms in workplace protection and highlights health and equity within labor practices.

Today, many of the issues raised by Lollini remain relevant, albeit with significant advancements in legislation and international standards. Regarding child labor, the ILO has made substantial strides in addressing the issue through conventions such as the Minimum Age Convention (No. 138, 1973) and the Worst Forms of Child Labour Convention (No. 182, 1999). Convention No. 138 establishes a global minimum working age, generally set at 15 years, though it allows for lower ages (14 or 12) in developing countries under specific conditions. Convention No. 182 focuses on eliminating hazardous forms of child labor, including slavery, trafficking, and work that harms children's health, safety, or morals. As of today, both conventions have achieved near-universal ratification, demonstrating a robust global commitment to eradicating child labor.

Nevertheless, according to recent statistics, approximately 160 million children remain engaged in child labor worldwide, with nearly half involved in hazardous work. Progress has slowed, and challenges persist, particularly in regions affected by economic crises, conflicts, and inadequate enforcement [15-16]. Concerning maternity protection, the ILO's Maternity Protection Convention (No. 183, 2000) represents a milestone in safeguarding the rights of pregnant workers. It extends the minimum period of maternity leave to 14 weeks, mandates cash benefits for women on leave (equivalent to their previous earnings), and prohibits discrimination based on pregnancy. It also protects women from dismissal during pregnancy and ensures the right to workplace accommodations, including breastfeeding breaks. While 41 countries have ratified the convention as of 2024, significant disparities remain in its implementation. Many women are excluded from these protections, particularly in informal or precarious employment. Furthermore, some nations still fail to meet the minimum standards set by the convention, highlighting the ongoing need for advocacy and enforcement [17].

Lollini's efforts stand as a historical example of the intersection between occupational and social medicine. She confronted the challenges related to protecting marginalized groups in the workforce. The issues she addressed—child labor, maternity rights, and workplace safety—remain central to the global agenda for decent work and equitable labor practices [18].

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References

1. Lollini L. The Protection of Women and Children at Work. *Med Lav*. 2025;116(1):e2025002.
2. Mori S. Elisa Agnini Lollini, Finale Emilia (MO) 1858 – Roma 1922. Enciclopedia delle Donne, biografie https://

www.enciclopediadelledonne.it/edd.nsf/biografie/elisa-agnini-lollini (Last Accessed on 30 Dec 2024).
3. Mori S. *La dama dl quinquetto*. Ferrara, Luciana Tufani Editrice, 2012.
4. Schucht T. *Lettere ai familiari*. Roma, Editori riuniti, 1991.
5. Branca E. Clelia e Livia Lollini, due sorelle impegnate. Sanità Grande Guerra. Banca dati dei servizi sanitari italiani nella Prima guerra mondiale https://www.sanitagrandeguerra.it/index.php/archivio/uomini-e-donne-della-sanita/dottoresse-al-fronte/307-clelia-livia-lollini (Last Accessed on 30 Dec 2024).
6. Grieco A (ed). Centenario della Clinica del Lavoro Luigi Devoto. Pavia: PI-ME, 2002.
7. Lollini L. Avvelenamento da paradiclorobenzolo. *Il Lavoro*. 1922;13(3):85-86.
8. Lollini L. Sopra la pneumoconiosi da tabacco. *Il Lavoro*. 1922;13(3):86-88.
9. Mauro G. Lollini L. Tubercolosi: conferenze promosse dalla Società tedesca di previdenza per le malattie polmonari in Boemia, direzione prof. Antonio Ghon e prof. R. Jaksch-Wartenhorst; prefazione del prof. Luigi Devoto. Milano, F. Vallardi, 1924.
10. Passaniti P. Lavoro e cittadinanza femminile: Anna Kuliscioff e la prima legge sul lavoro delle donne. Milano, Franco Angeli, 2016.
11. Persico G, Riva MA. Approach to death in the Obstetric-Gynaecological Institute of Milan at the beginning of the 20th Century: Reflections on the doctor's care in accompanying human dying. *Medicina e Morale*. 2024;73(3):295-310.
12. Riva MA, Scordo F, Turato M, Messina G, Cesana G. The web of Penelope. Regulating women's night work: an unfinished job? *Vesalius*. 2015;21(2):14-22.
13. Ballestrero MV. Dalla tutela alla parità: la legislazione italiana sul lavoro delle donne. Bologna, Il Mulino, 2023.
14. Riva MA, Mazzagatti R. Il lavoro nel sistema globale della salute: il contributo italiano da Carozzi a Parmeggiani. Roma, Carocci Editore, 2024.
15. International Labour Organization (ILO). Child Labour: Global estimates 2020, trends and the road forward. Geneva: ILO, 2020. https://www.ilo.org/publications/major-publications/child-labour-global-estimates-2020-trends-and-road-forward (Last Accessed on 2 Jan 2025).
16. International Labour Organization (ILO). Child Labour Statistics and Research [Internet]. Geneva: ILO https://www.ilo.org/topics/child-labour/child-labour-statistics-and-research (Last Accessed on 2 Jan 2025).
17. International Labour Organization (ILO). Gender Equality and Decent Work: Selected ILO Conventions and Recommendations that promote gender equality as of 2012. Geneva: ILO; 2012. https://www.ilo.org/publications/gender-equality-and-decent-work-selected-ilo-conventions-and (Last Accessed on 2 Jan 2025).
18. International Labour Organization (ILO). The Decent Work Agenda: Employment, Social Protection, Rights at Work, and Social Dialogue. Geneva: ILO, 2008. https://www.ilo.org/global/topics/decent-work-agenda/lang--en/index.htm (Last Accessed on 2 Jan 2025).

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Occupational Diesel Exposure and Brain Tumors: A Systematic Review and Meta-Analysis

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Keywords: Occupation; Diesel; Brain Tumor; Central Nervous System Cancers; Meta-Analysis

Summary

Diesel exhaust (DE) is recognized as a carcinogen for the lungs, although evidence linking it to adult brain tumors is limited. We aimed to systematically review the evidence regarding the association between occupational DE exposure and adult brain and other central nervous system (CNS) tumors. A systematic literature review was conducted to identify cohort studies on occupational DE exposure and the risk of adult cancers other than lung cancer. We meta-analyzed relative risks (RRs) and 95% confidence intervals (CIs) for brain or CNS tumors using the DerSimonian and Laird random-effects model. Fourteen studies were included in the meta-analysis. The results showed no increased risk of brain or CNS tumors among workers exposed to DE (RR: 0.99; 95% CI: 0.91, 1.07). Findings were consistent when analyzing studies based on incidence (RR: 0.96; 95% CI: 0.90, 1.03; six studies) and mortality (RR: 1.09; 95% CI: 0.87, 1.37; nine studies) separately, as well as in subgroup analyses based on sex, publication year, geographic region, and study quality score. No evidence of publication bias was found (p=0.244). The findings of our meta-analysis suggest that occupational DE exposure is not associated with adult brain or CNS tumors. Given the limitations of the included studies, these results should be interpreted with caution.

1. Introduction

Brain and other central nervous system (CNS) tumors in adults currently rank as the nineteenth and twelfth most common types of cancer and causes of cancer death worldwide, respectively. It has been suggested that their impact on the global population, both in terms of incidence and mortality, has been increasing in recent decades and is exceptionally high in high-income countries [2].

Various potentially relevant environmental and occupational risk factors for brain and CNS tumors, including diesel exhaust (DE), have been investigated over time. Indeed, among suspected or confirmed carcinogens that can be found in DE, polycyclic aromatic hydrocarbons, nitroarenes, and 3-nitrobenzathrone are also found [3–5]. DE is also categorized as a Group 1 carcinogen, according to the International Agency for Research on Cancer (IARC), based on sufficient human evidence for lung cancer [5]. Parental occupational DE exposure might increase the risk of childhood brain and other CNS cancers, [6–8] possibly through key pollutants such as polycyclic aromatic hydrocarbons (PAHs) [6, 9]. PAHs, in particular, have also been associated with brain cortical thinning among adults, [10]

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which would suggest that they can cross the blood-brain barrier among adults too. Furthermore, DE exposure has been shown to impair functional brain connectivity in adults acutely, [11] similarly confirming the ability of DE particles and their compounds to reach brain cells through the bloodstream in this population group. Also, DE exposure may be correlated with chronic nervous inflammation and oxidative stress [12, 13]. Hence, if the association between parental occupational DE exposure and childhood brain cancer risk is causal, a similar association could be expected between exposure to DE and brain tumors among adults. However, no previous systematic review evaluated the risk of brain and CNS tumors among adult workers exposed to DE, hence hampering the interpretation of available literature. Thus, we aimed to summarize the evidence from cohort studies on this potential association.

2. Methods

We conducted a systematic review according to Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidelines [14] and reported it in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [15]. The protocol of the review was registered in PROSPERO (CRD42022352729).

We retained cohort and nested case-control studies from last IARC Monograph on DE. [5] Additionally, we searched reference lists of the studies included in IARC Monograph, and conducted a search in Pubmed for studies on the association between occupational DE exposure and cancer, published after IARC Monograph (from 2012 onwards). We developed the search strategy according to the Patients, Exposure, Comparator, Outcomes, Study design (PECOS) framework, [14] as follows:

- Population (P): workers in multiple industrial settings;
- Exposure (E): occupational DE exposure;
- Comparator (C): individuals not exposed or with the lowest exposure level to diesel;
- Outcomes (O): incidence or mortality of cancer types other than lung cancer;
- Study design (S): industry-based cohort and nested case-control analysis.

Hence, we conducted the search using the following string: *(diesel OR miner OR garage OR railway OR ((truck OR bus) AND driver) OR (heavy equipment OR docker)) AND (cancer OR neoplasm)*. The search was first conducted in June 2021 and then updated in November 2024.

Two researchers independently evaluated titles, abstracts, and, subsequently, full texts of identified articles. Reference lists of included articles were also screened to identify additional studies. Disagreements were solved by discussion.

The present systematic review is part of a larger project that includes all cancer types other than lung cancer [16]. Thus, during the phases of the study selection process, inclusion criteria were as follows: (i) peer-reviewed studies evaluating the association between occupational DE exposure and incidence or mortality of any cancer types other than lung, (ii) cohort (including nested case-control) design, (iii) studies reporting relative measures of association, such as relative risk (RR), hazard ratio, standardized mortality ratio, and standardized incidence ratio, or reporting sufficient data for their computation.

Exclusion criteria were: (i) case-control studies not nested within a cohort, (ii) cross-sectional and descriptive studies, (iii) systematic reviews or meta-analyses, (iv) conference abstracts, theses, letters, commentaries, book chapters, (v) studies not focused on occupational exposures, (vi) studies not mentioning DE exposure, (vii) studies not in English. Whenever multiple articles referred to the same study population, we included the most recent update or the one with the highest number of cases in the review. If study populations overlapped by less than 10% across different studies, we considered them independent.

The following information was independently extracted by two researchers from included studies: author details, publication year, country, study period, type of cohort (retrospective, prospective), type of reference (internal, external), type of workers, person-years of observation time, sample size,

participants' sex, outcome (incidence, mortality), type of cancer and International Classification of Diseases (ICD) code, number of cases, and main results, including adjustment factors.

Hence, the present meta-analysis retained studies on adult brain and other CNS tumors, which are the focus of this report. Studies on childhood brain tumors were excluded because of the differences in molecular and clinical characteristics between the two groups of neoplasms.

Two researchers independently evaluated study quality using a modified Critical Appraisal Skills Programme (CASP) checklist for cohort studies [17]. The modified scale includes three sections: 'Are the study's results valid?' (6 items), 'What are the results?' (2 items), and 'Will the results help locally?' (3 items). The scale has 11 items, and the total score ranged between 0 and 14 (Table S1).

We considered all relative measures of association described above as approximations of RRs. Hence, we estimated pooled RRs and 95% Confidence Intervals (CIs) using the DerSimonian-Laird random-effects model [18] and evaluated statistical heterogeneity using the I^2 statistic. [19, 20]. We performed the analysis by combining data on both incidence and mortality (including incidence for studies reporting both outcomes), and then separately for each outcome. Where needed, stratified estimates from a single study were combined using an inverse variance fixed-effects model before being pooled with those from other studies. Whenever possible, we included in the analysis estimates specifically for brain and other CNS tumors only and for nervous system cancers without further specification if the former were not available.

We performed sensitivity analyses by excluding studies that required computation of 95% CIs, omitting one study at a time, and limiting the analysis to studies that used an external reference population. Furthermore, we carried out subgroup analyses according to publication year (< 2000, ≥ 2000), participants' sex (≥ 90% male, ≥ 90% female), study region (North America, Europe), and CASP score (≤ median, > median).

The occurrence of publication bias was assessed by visual inspection of a contour-enhanced funnel plot and through Egger's test [21–23].

Analyses were performed using STATA software version 17.0 (StataCorp LLC, College Station, Texas, USA).

3. Results

The study selection process is reported in Figure 1. We initially identified 19 studies from the IARC Monograph [5]. Furthermore, the search of studies published after 2012 allowed the identification of 2,988 records, 2,902 of which were excluded from the screening phase according to title and abstract. Subsequently, 81 studies were excluded after evaluating their full text for the reasons reported in Figure 1. Hence, we eventually identified 33 studies on DE exposure and cancer types other than lung. Fourteen of them reported estimates on brain and other CNS tumors, which were included in the meta-analysis [24–37].

The main characteristics of the included studies are summarized in Table 1. They were published between 1983 and 2012, with half of them (n=7) conducted in North America [24, 26–28, 31, 36, 37], and the other half (n=7) in Europe [25, 29, 30, 32–35]. Most studies were conducted in retrospective cohorts (n=12, 86%) [24–26, 28–36], and they utilized an external population as a reference (n=12 86%) [24–26, 28–30, 32–37].

The median CASP score of the studies included was 9.63 (interquartile range: 9, 11). Overall, 5 of the studies (36%) reported estimates solely on the incidence of brain and other CNS tumors [31–35], while 8 of them (57%) reported estimates on mortality only [24–28, 30, 36, 37]. One study provided results on both incidence and mortality instead [29].

When analyzing results for combined incidence and mortality, no association was found between occupational DE exposure and brain or other CNS tumors (Figure 2, RR: 0.99; 95% CI: 0.91, 1.07). Estimates remained consistent across subgroups based on participants' sex, study country, and CASP score, as well as when excluding studies that required the computation of the 95% CI or when limiting the analysis to studies that used an external reference population (Table 2 and Figure S1).

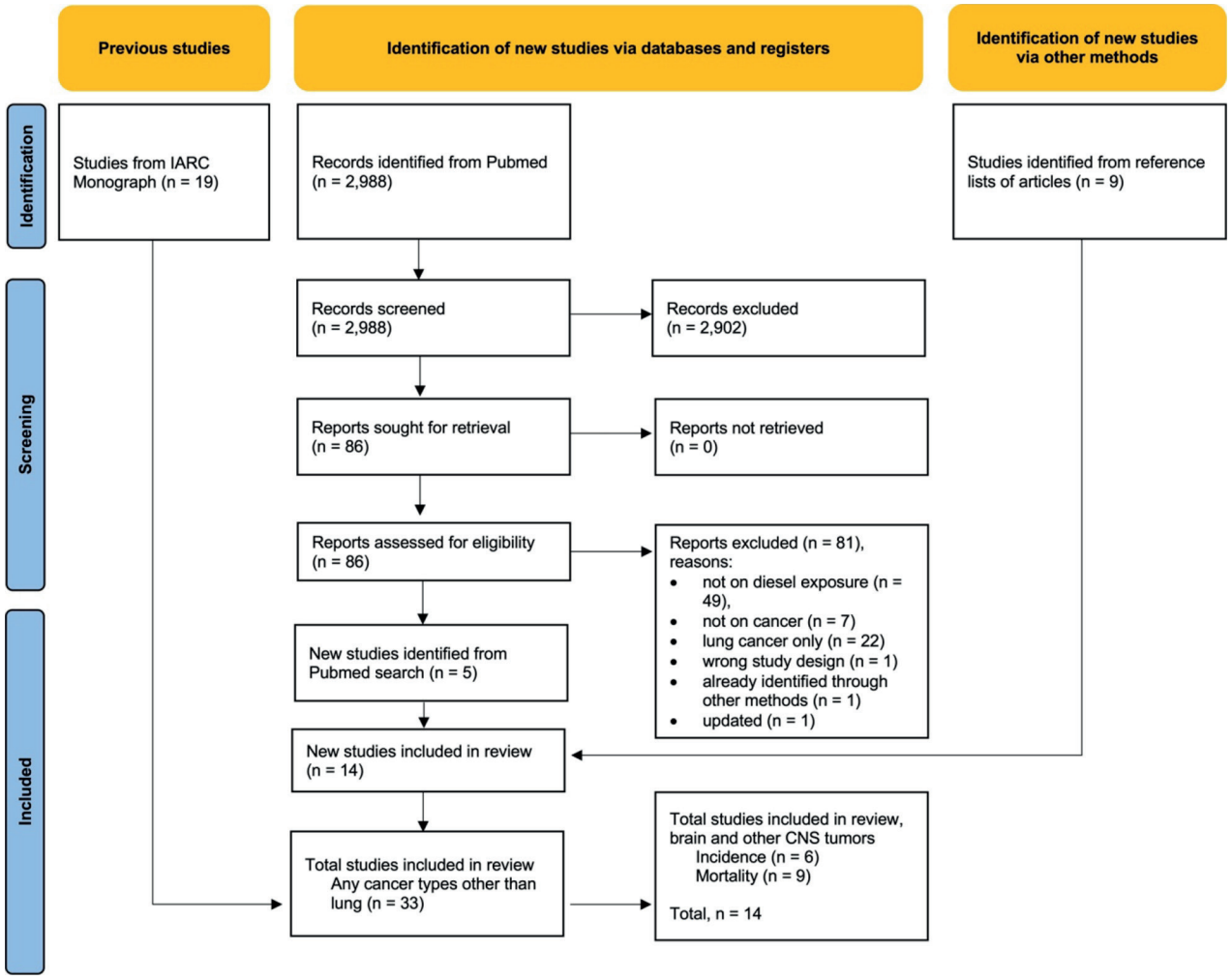

Figure 1. Flow diagram of the study selection process.

The results on incidence were similar (RR: 0.96; 95% CI: 0.90, 1.03). In line with the results on incidence and mortality combined, no substantial variations occurred in subgroup analyses (Table 2).

Similarly, the analysis of mortality revealed no association, both overall (RR: 1.09; 95% CI: 0.87, 1.37) and across the considered subgroups (Table 2). The results generally demonstrated a low degree of heterogeneity (Table 2). Furthermore, the results mostly remained similar when one study was omitted at a time, although estimates occasionally tended to move towards an inverse association (Figure S2).

As for publication bias, no substantial asymmetry in the contour-enhanced funnel plot was evident (Figure 3), and Egger's test result (p=0.244) paralleled this.

4. Discussion

The findings of our study do not support the hypothesis of an association between occupational DE exposure and the incidence or mortality of adult brain or CNS tumors. Inhalation of pollutants from DE could enter the bloodstream, potentially reaching various organs where they might exert carcinogenic effects. Exposure to PAHs, which are also found in DE, has been reported to be associated with neurodegeneration in adults [38], and DE exposure has been shown to impair functional brain connectivity in humans [11], suggesting that these pollutants could cross the blood-brain barrier. In fact, DE exposure may alter the blood-brain barrier itself, making it easier for pollutants to cross pollutants [39].

Table 1. Main characteristics of the studies included in the meta-analysis

First author, year [ref]	Country	Study period	Type of cohort	Reference	Type of workers	Person-years	Sample size	Sex, male (%)	Outcome	ICD code	Number of cases	Results, estimate (95% C.I.)	Variables controlled for	CASP score
Howe GR, 1983 [24]	Canada	1965-1977	Retrospective	External	Railway workers	290,186	43,826	100	M	ICD-7: 193; ICD-8: 191, 192	38	SMR: 1.15	Age (standardization)	9
Rushton L, 1983 [25]	United Kingdom	1968-1975	Retrospective	External	Bus garage workers	50,008		100	M		7	SMR: 1.21	Age (standardization)	7
Schenker MB, 1984 [26]	USA	1967-1979	Retrospective	External	Railway workers	28,400	2,519	100	M	ICD-8: 191, 192	5	SMR: 1.32 (0.43, 3.08)	Age (standardization)	7
Boffetta P, 1988 [27]	USA	1982-1984	Prospective	Internal	Mixed	939,817	476,648	100	M	ICD-9: 191	Exposed: 12	RR: 0.90	Age, smoking, other occupational exposures (standardization)	10
Bender AP, 1989 [28]	USA	1945-1984	Retrospective	External	Highway maintenance workers		4,849	100	M	ICD-9: 191.0-192.9	6	SMR: 0.66 (0.24, 1.44)	(standardization)	10
Gustavsson P, 1990 [29]	Sweden	1952-1986	Retrospective	External	Bus garage workers		695	100	M	ICD-8: 191	4	SMR: 2.20 (0.60, 5.63)	Age, sex (standardization)	10
		1958-1984							I	ICD-7: 193	6	SIR: 1.90 (0.70, 4.15)		
Rafnsson V, 1991 [30]	Iceland	1951-1988	Retrospective	External	Truck drivers	28,788	868	100	M	ICD-7: 193	3	SMR: 1.40 (0.29, 4.10)	Age (standardization)	9
Van Den Eeden SK, 1993 [31]	USA	1964-1988	Retrospective	Internal	Mixed		160,230	46	I		130	HR: 1.38 (0.79, 2.41)	Age, gender, education, race/ethnicity, smoking status, duration, amount	12
Soll-Johanning H, 1998 [32]	Denmark	1943-1992	Retrospective	External	Bus drivers and tramway employees	386,395	18,120	100	I		36	SIR: 0.70 (0.50, 1.00)	Age, sex (standardization)	10
								0			5	SIR: 1.60 (0.50, 3.80)		

Table 1 (*Continued*)

First author, year [ref]	Country	Study period	Type of cohort	Reference	Type of workers	Person-years	Sample size	Sex, male (%)	Outcome	ICD code	Number of cases	Results, estimate (95% C.I.)	Variables controlled for	CASP score
Boffetta P, 2001 [33]	Sweden	1971-1989	Retrospective	External	Mixed	5,305,895		100	I	ICD-7: 193	1318	SIR: 0.94 (0.89, 0.99)	Age (standardization)	11
						240,586		0			40	SIR: 0.90 (0.65, 1.23)		
Järvholm B, 2003 [34]	Sweden	1971-1995	Retrospective	External	Heavy construction equipment operators		14,364	100	I	ICD-7: 193	32	SIR: 0.97	Age (standardization)	11
					Drivers		6,364				16	SIR: 0.92		
Pukkala E, 2009 [35]	Denmark, Finland, Iceland, Norway, Sweden	1960-2005	Retrospective	External	Engine operators		~14.9 million (entire cohort)	100	I		804	SIR: 0.98 (0.91, 1.05)	Age (standardization)	13
								0			44	SIR: 1.19 (0.86, 1.60)		
Birdsey J, 2010 [36]	USA	1989-2004	Retrospective	External	Truck drivers		156,241	94	M		45	SMR: 0.76 (0.56, 1.02)	Age, race/ ethnicity, and sex (standardization)	9
Koutros S, 2023 [37]	USA	1960-2015	Prospective	External	Non-metal miners	422,343	12,315	96	M		45	SMR: 1.41 (1.03, 1.88)	Age, calendar-time, race, and sex (standardization)	10

I: incidence, M: mortality, HR: hazard ratio, SMR: standardized mortality ratio, SIR: standardized incidence ratio, RR: relative risk, ICD: International Classification of Diseases, CASP: Critical Appraisal Skills Programme.

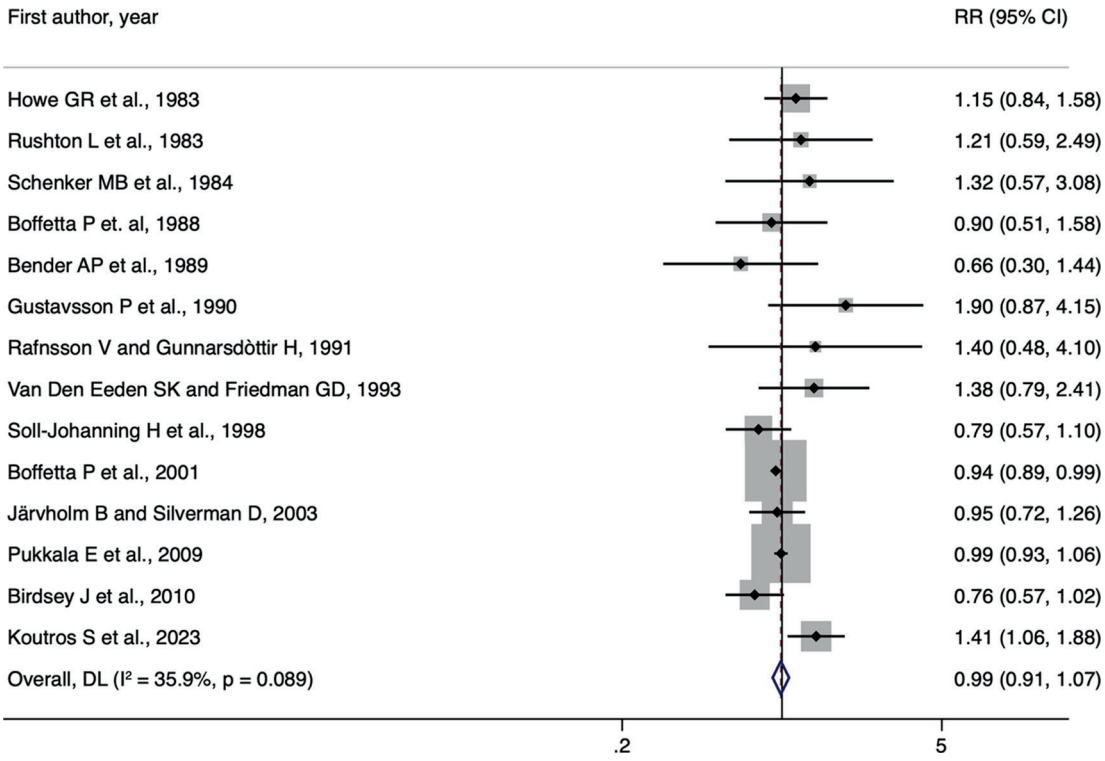

Figure 2. Results of the meta-analysis on the association between occupational exposure to diesel exhausts and brain and CNS tumors incidence and mortality combined.

Previous meta-analyses explored the link between occupational DE exposure and various cancer types, but evidence suggests an increased risk only for lung and bladder cancers [40-42]. While associations have been reported between parental occupational DE and PAH exposures and childhood brain and other CNS cancers [6-9], the estimates from individual studies in adults included in our review consistently indicate a lack of association. The combination of these findings may imply an increased susceptibility during early childhood, potentially due to the incompletely developed blood-brain barrier. Indeed, these earlier studies highlight the adverse effects of exposures occurring before birth [6, 9]. Germline mutations or epigenetic modifications of germ cells have also been proposed as mechanisms of childhood carcinogenesis, particularly for exposures happening before conception and for paternal exposure [9], and these mechanisms would not apply to cancer development in adults.

Among the limitations of our study is the lack of a detailed environmental assessment of exposure in the included studies, which were primarily based on occupations involving DE exposure. While we included only studies on likely exposed cohorts of workers in the meta-analysis, this approach does not account for variations in intensity, frequency, and duration of exposure among study participants, assuming exposure is the same for all individuals within a specific occupation. Additionally, due to insufficient data, we could not evaluate the effects of varying doses and durations of exposure, nor the time since cessation of exposure. In this context, a certain degree of exposure heterogeneity can be anticipated across different cohorts, as individuals in various occupations may experience different levels of exposure, and even among participants within the same cohort due to differing tasks performed.

Overall, a non-differential misclassification of the exposure might be expected, potentially biasing our

Table 2. Meta-analysis on the association between occupational exposure to diesel exhausts and brain and CNS tumors.

Outcome	Stratum	n of studies	RR	95% CI	I^2, p-value
Incidence and mortality	Sex				
	Male	13	0.98	0.90, 1.06	39.4%, 0.071
	Female	3	1.08	0.84, 1.38	20.2%, 0.286
	Publication year				
	Before 2000	9	1.05	0.87, 1.27	7.7%, 0.371
	2000 or later	5	0.98	0.89, 1.07	63.0%, 0.029
	Region				
	North America	7	1.06	0.84, 1.34	49.1%, 0.067
	Europe	7	0.96	0.91, 1.01	10.0%, 0.353
	CASP score				
	≤ median	7	0.91	0.76, 1.10	12.3%, 0.335
	> median	7	1.01	0.92, 1.12	53.3%, 0.045
	Without computed CIs	10	0.99	0.89, 1.09	51.7%, 0.029
Incidence	Overall	6	0.96	0.90, 1.03	32.7%, 0.191
	Sex				
	Male	5	0.95	0.88, 1.03	40.9%, 0.149
	Female	3	1.08	0.84, 1.38	20.2%, 0.286
	Publication year				
	Before 2000	3	1.17	0.69, 1.99	65.8%, 0.054
	2000 or later	3	0.96	0.92, 0.997	0.0%, 0.471
	Region				
	North America	1	1.38	0.79, 2.41	na
	Europe	5	0.96	0.90, 1.02	30.7%, 0.217
	CASP score				
	≤ median	1	0.79	0.57, 1.10	na
	> median	5	0.97	0.91, 1.04	34.3%, 0.193
	Without computed CIs	5	0.97	0.89, 1.05	46.2%, 0.115
Mortality	Overall	9	1.09	0.87, 1.37	41.2%, 0.093
	Sex				
	Male	9	1.09	0.87, 1.37	41.2%, 0.093
	Female	0	nc		
	Publication year				
	Before 2000	7	1.12	0.90, 1.40	0.0%, 0.582
	2000 or later	2	1.04	0.57, 1.90	88.5%, 0.003
	Region				
	North America	6	1.02	0.79, 1.33	54.2%, 0.053
	Europe	3	1.49	0.90, 2.46	0.0%, 0.609

Outcome	Stratum	n of studies	RR	95% CI	I^2, p-value
	CASP score				
	≤ median	6	0.96	0.77, 1.21	15.9%, 0.311
	> median	3	1.31	0.90, 1.91	35.7%, 0.211
	Without computed CIs	6	1.12	0.77, 1.62	61.4%, 0.024

RR: relative risk, CI: confidence interval, nc: not computable, na: not applicable.

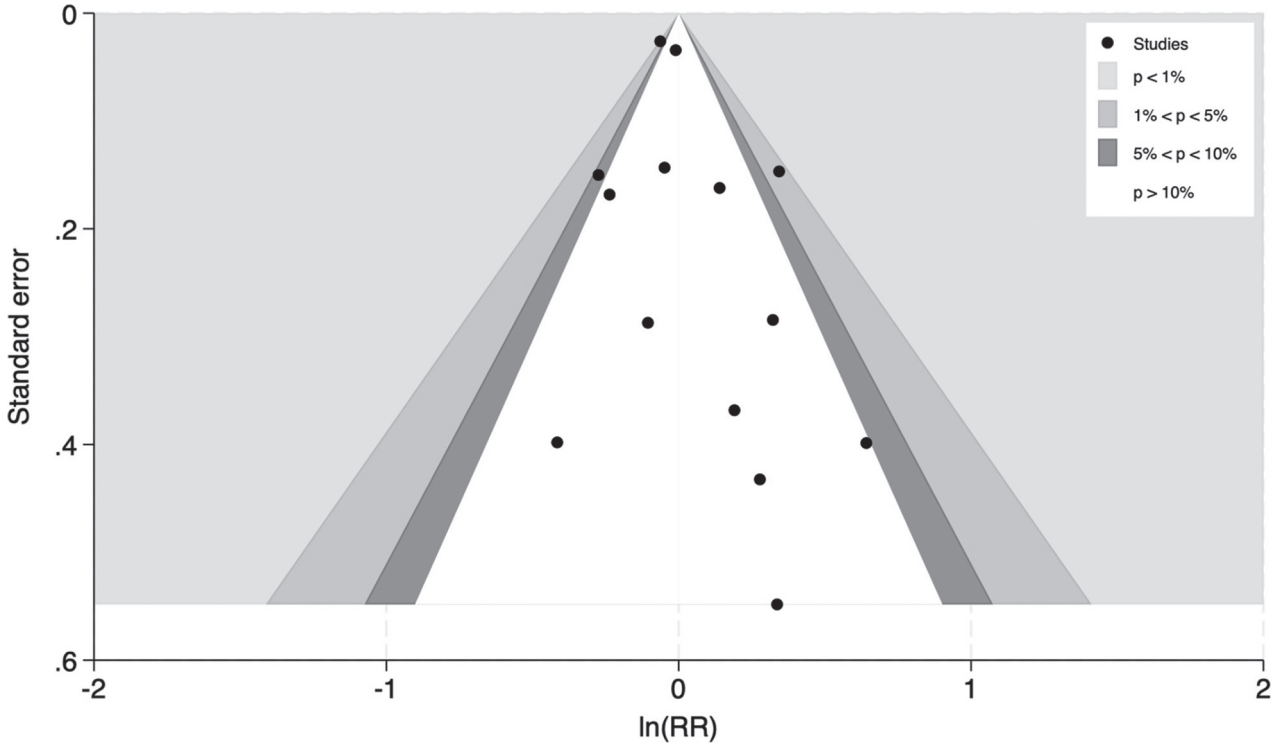

Figure 3. Contour-enhanced funnel plot to explore small-study effect for brain and CNS tumors incidence and mortality combined.

estimates towards the null. Additionally, the included studies did not report whether measures to prevent exposure were implemented in the workplaces. Furthermore, most studies did not consider other occupational exposures occurring concurrently with DE exposure or prior to it, even though these could bias the results towards a positive association. Most studies utilized an external population as a comparator, which might introduce the healthy worker effect and bias the results towards the null [43, 44]. Moreover, we excluded case-control studies not nested within cohorts due to a higher potential for exposure misclassification, particularly if community-based [45]; however, this may have resulted in the exclusion of other potentially relevant studies. Grouping various types of cancers of the nervous system in primary studies might also have caused outcome misclassification, likely in a non-differential manner. Ultimately, relying solely on PubMed as the database for searching scientific papers published after the IARC

Monograph may have limited the comprehensiveness of our search, potentially causing us to miss additional studies on the topic.

5. Conclusion

In summary, our meta-analysis's results indicate that occupational DE exposure does not increase the risk of adult brain or CNS tumors. However, these findings should be interpreted with caution due to limitations in the studies' exposure assessments, including the reliance on an external population as a reference in most cases and the potential oversight of co-exposures. Therefore, further high-quality studies with detailed and quantitative exposure assessments using an internal reference population could help to completely rule out this possible association.

Supplementary Materials: The following are available online: Table S1. A modified version of the Critical Appraisal Skills Programme (CASP) checklist for cohort studies adopted for quality assessment. Figure S1. Results of the meta-analysis on the association between occupational exposure to diesel exhausts and brain and CNS tumors incidence and mortality combined, including only studies that used an external reference population. Figure S2. Leave-one-out meta-analysis for the association between occupational exposure to diesel exhausts and brain and CNS tumors incidence and mortality combined.

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Declaration of Interest: P.B. acted as an expert witness in litigation concerning diesel exhaust exposure and cancer, unrelated to the present work. The other authors reported no conflicts of interest.

Author contribution statement: All authors contributed to the study's conception and design. G.C. and F.T. carried out study selection and quality assessment; M.S. performed the statistical analysis and wrote the first draft of the manuscript; P.B. supervised the study. All authors reviewed the manuscript and read and approved its final version.

Declaration on the use of AI: None.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J Clin*. 2021;71:209–249.
2. Fan Y, Zhang X, Gao C, et al. Burden and trends of brain and central nervous system cancer from 1990 to 2019 at the global, regional, and country levels. *Archives of Public Health*. 2022;80:1–14.
3. Ris C. U.S. EPA Health Assessment for Diesel Engine Exhaust: A Review. *Inhal Toxicol*. 2008;19: 229–239.
4. International Agency for Research on Cancer (1989) Diesel and Gasoline Engine Exhausts and Some Nitroarenes, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 46. World Health Organization
5. International Agency for Research on Cancer (2013) Diesel and Gasoline Engine Exhausts and Some Nitroarenes, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 105. World Health Organization
6. Peters S, Glass DC, Reid A, et al. Parental occupational exposure to engine exhausts and childhood brain tumors. *Int J Cancer*. 2013;132:2975–2979.
7. Volk J, Heck JE, Schmiegelow K, Hansen J. Parental occupational exposure to diesel engine exhaust in relation to childhood leukaemia and central nervous system cancers: a register-based nested case-control study in Denmark 1968–2016. *Occup Environ Med*. 2019; 76:809–817.
8. Cordier S, Mandereau L, Preston-Martin S, et al. Parental occupations and childhood brain tumors: Results of an international case-control study. *Cancer Causes and Control*. 2001;12:865–874.
9. Cordier S, Monfort C, Filippini G, et al. Parental Exposure to Polycyclic Aromatic Hydrocarbons and the Risk of Childhood Brain TumorsThe SEARCH International Childhood Brain Tumor Study. *Am J Epidemiol*. 2004;159:1109–1116.
10. Cho J, Sohn J, Noh J, et al. Association between exposure to polycyclic aromatic hydrocarbons and brain cortical thinning: The Environmental Pollution-Induced Neurological Effects (EPINEF) study. *Science of The Total Environment*. 2020;737:140097.
11. Gawryluk JR, Polombo DJ, Curran J, Parker A, Carlsten C. Brief diesel exhaust exposure acutely impairs functional brain connectivity in humans: a randomized controlled crossover study. *Environ Health*. 2023:22:1–7.
12. Chen Z, Chen F, Fang Z, et al. Glial activation and inflammation in the NTS in a rat model after exposure to diesel exhaust particles. *Environ Toxicol Pharmacol*. 2021; 83:103584.
13. Pradhan SH, Gibb M, Kramer AT, Sayes CM. Peripheral (lung-to-brain) exposure to diesel particulate matter

induces oxidative stress and increased markers for systemic inflammation. *Environ Res*. 2023;231:116267.
14. Dekkers OM, Vandenbroucke JP, Cevallos M, Renehan AG, Altman DG, Egger M. COSMOS-E: Guidance on conducting systematic reviews and meta-analyses of observational studies of etiology. *PLoS Med*. 2019;16:e1002742.
15. Higgins J, Thomas J, Chandler J, et al. (editors) (2019) Cochrane Handbook for Systematic Reviews of Interventions, 2nd Editio. Chichester (UK): John Wiley & Sons.
16. Sassano M, Collatuzzo G, Teglia F, Boffetta P. Occupational exposure to diesel exhausts and liver and pancreatic cancers: a systematic review and meta-analysis. *Eur J Epidemiol*. 2024;39:241–255.
17. Critical Appraisal Skills Programme (2022) CASP Cohort Study Checklist. https://casp-uk.net/casp-tools-checklists/. Accessed 10 Mar 2023
18. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7:177–188.
19. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21:1539–1558.
20. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003; 327:557–560.
21. Higgins J, Thomas J, Chandler J, et al. (2019) Cochrane Handbook for Systematic Reviews of Interventions. 2nd Edition. Chichester (UK): John Wiley & Sons.
22. Peters JL, Sutton AJ, Jones DR, Abrams KR, Rushton L. Contour-enhanced meta-analysis funnel plots help distinguish publication bias from other causes of asymmetry. *J Clin Epidemiol*. 2008;61:991–996.
23. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple , graphical test measures of funnel plot asymmetry. *Bmj*. 1997;315:629–34.
24. Howe GR, Fraser D, Lindsay J, Presnal B, Yu SZ. Cancer Mortality (1965–77) in Relation to Diesel Fume and Coal Exposure in a Cohort of Retired Railway Workers. *JNCI*. 1983;70:1015–1019.
25. Rushton L, Alderson MR, Nagarajah CR. Epidemiological survey of maintenance workers in London Transport Executive bus garages and Chiswick Works. *Occup Environ Med*. 1983;40:340–345.
26. Schenker MB, Smith T, Munoz A. () Diesel exposure and mortality among railway workers: results of a pilot study. *Occup Environ Med*. 1984;41:320–327.
27. Boffetta P, Stellman SD, Garfinkel L. Diesel exhaust exposure and mortality among males in the American cancer society prospective study. *Am J Ind Med*. 1988;14: 403–415.
28. Bender AP, Parker DL, Johnson RA, et al. Minnesota highway maintenance worker study: Cancer mortality. *Am J Ind Med*. 1989;15:545–556.
29. Gustavsson P, Plato N, Lidstrom EB, Hogstedt C. Lung cancer and exposure to diesel exhaust among bus garage workers. *Scand J Work Environ Health*. 1990;16: 348–354.
30. Rafnsson V, Gunaarsdottir H. Mortality among professional drivers. *Scand J Work Environ Health*. 1991;17: 312–317.
31. Van Den Eeden S, Friedman GD. Exposure to Engine Exhaust and Risk of Subsequent Cancer. *J Occup Med*. 1993;35:307–11.
32. Soll-Johanning H, Bach E, Olsen JH, Tüchsen F. Cancer incidence in urban bus drivers and tramway employees: a retrospective cohort study. *Occup Environ Med*. 1998;55:594–598.
33. Boffetta P, Dosemeci M, Gridley G, Bath H, Moradi T, Silverman D. Occupational exposure to diesel engine emissions and risk of cancer in Swedish men and women. *Cancer Causes and Control*. 2001;12:365–374.
34. Järvholm B, Silverman D. Lung cancer in heavy equipment operators and truck drivers with diesel exhaust exposure in the construction industry. *Occup Environ Med*. 2003;60:516–520.
35. Pukkala E, Martinsen JI, Lynge E, et al. Occupation and cancer – follow-up of 15 million people in five Nordic countries. *Acta Oncol* (*Madr*). 200948:646–790.
36. Birdsey J, Alterman T, Li J, Petersen MR, Sestito J. Mortality among Members of a Truck Driver Trade Association. *AAOHN J*. 2010;58:473–480.
37. Koutros S, Graubard B, Bassig BA, et al. Diesel Exhaust Exposure and Cause-Specific Mortality in the Diesel Exhaust in Miners Study II (DEMS II) Cohort. *Environ Health Perspect*. 2023;131(8):87003.
38. Humphreys J, Valdés Hernández M del C. Impact of polycyclic aromatic hydrocarbon exposure on cognitive function and neurodegeneration in humans: A systematic review and meta-analysis. *Front Neurol*. 2023;13:2890.
39. Nesbit M, Ko CKL, Mamo JCL, et al. Exposure to biodiesel exhaust is less harmful than exposure to mineral diesel exhaust on blood-brain barrier integrity in a murine model. *Front Neurosci*. 2024;18:1440118.
40. Boffetta P, Silverman D. A Meta-Analysis of Bladder Cancer and Diesel Exhaust Exposure. *Epidemiology*. 2001;12:125–130.
41. Lipsett M, Campleman S. Occupational exposure to diesel exhaust and lung cancer: a meta-analysis. *Am J Public Health*. 2011;89:1009–1017.
42. Tsoi CT, Tse LA. Professional drivers and lung cancer: a systematic review and meta-analysis. *Occup Environ Med*. 2012;69:831–836.
43. McMichael AJ. Standardized mortality ratios and the "healthy worker effect": Scratching beneath the surface. *J Occup Med*. 1976;18:165–168.
44. Li CY, Sung FC. A review of the healthy worker effect in occupational epidemiology. *Occup Med* (*Chic Ill*). 1999;49:225–229.
45. McGuire V, Nelson LM, Koepsell TD, Checkoway H, Longstreth WT. Assessment of occupational exposures in community-based case-control studies. *Annu Rev Public Health*. 1998;19:35–53.

Supplementary Material

Table S1. Modified version of the Critical Appraisal Skills Programme (CASP) checklist for cohort studies adopted for quality assessment.

Items	Possible scores
Section A: Are the results of the study valid?	
1. Did the study address a clearly focused issue?	- 1.5 - 1.0 - 0.0
2. Was the cohort recruited in an acceptable way?	- 1.5 - 1.0 - 0.0
3. Was the exposure accurately measured to minimise bias?	- 1.0 - 0.5 - 0.0
4. Was the outcome accurately measured to minimise bias?	- 1.0 - 0.5 - 0.0
5. (a) Have the authors identified all important confounding factors?	- 1.0 - 0.5 - 0.0
5. (b) Have they taken account of the confounding factors in the design and/or analysis?	- 1.0 - 0.5 - 0.0
6. (a) Was the follow up of subjects complete enough?	- 1.0 - 0.5 - 0.0
6. (b) Was the follow up of subjects long enough?	- 1.0 - 0.5 - 0.0
Section B: What are the results?	
7. What are the results of this study?	Excluded
8. How precise are the results?	- 1.0 - 0.5 - 0.0
9. Do you believe the results?	- 1.0 - 0.5 - 0.0
Section C: Will the results help locally?	
10. Can the results be applied to the local population?	- 1.0 - 0.5 - 0.0
11. Do the results of this study fit with other available evidence?	- 1.0 - 0.5 - 0.0
12. What are the implications of this study for practice?	- 1.0 - 0.5 - 0.0

For each item, scores were assigned according to researchers' consideration of the quality of the content (higher score means higher quality).

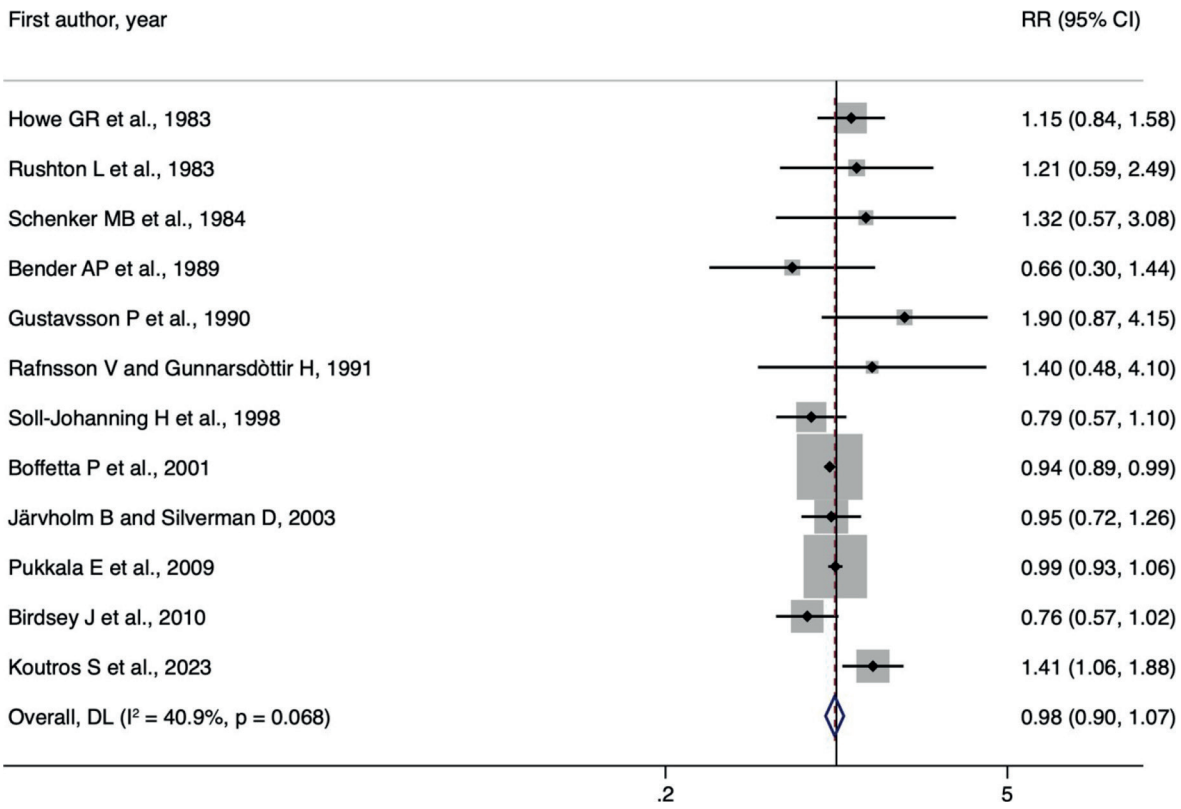

Figure S1. Results of the meta-analysis on the association between occupational exposure to diesel exhausts and brain and CNS tumors incidence and mortality combined, including only studies which used an external reference population.

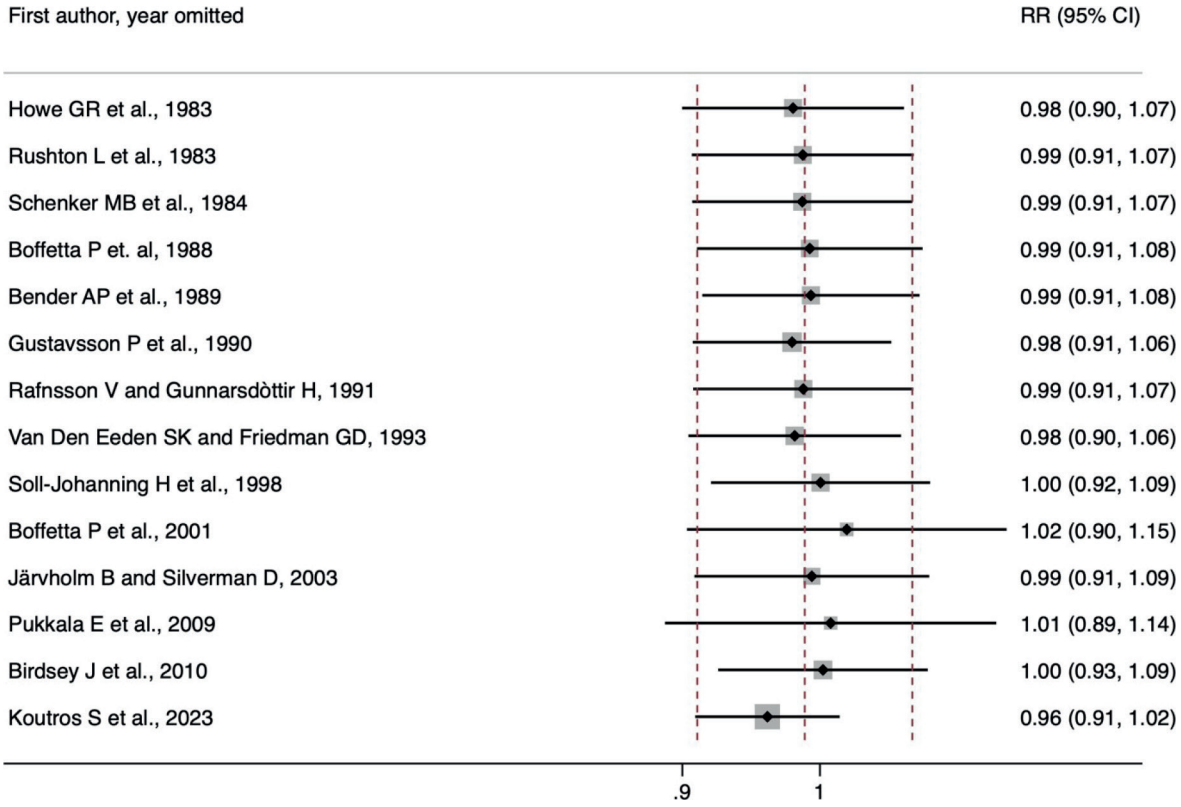

Figure S2. Leave-one-out meta-analysis for the association between occupational exposure to diesel exhausts and brain and CNS tumors incidence and mortality combined.

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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.

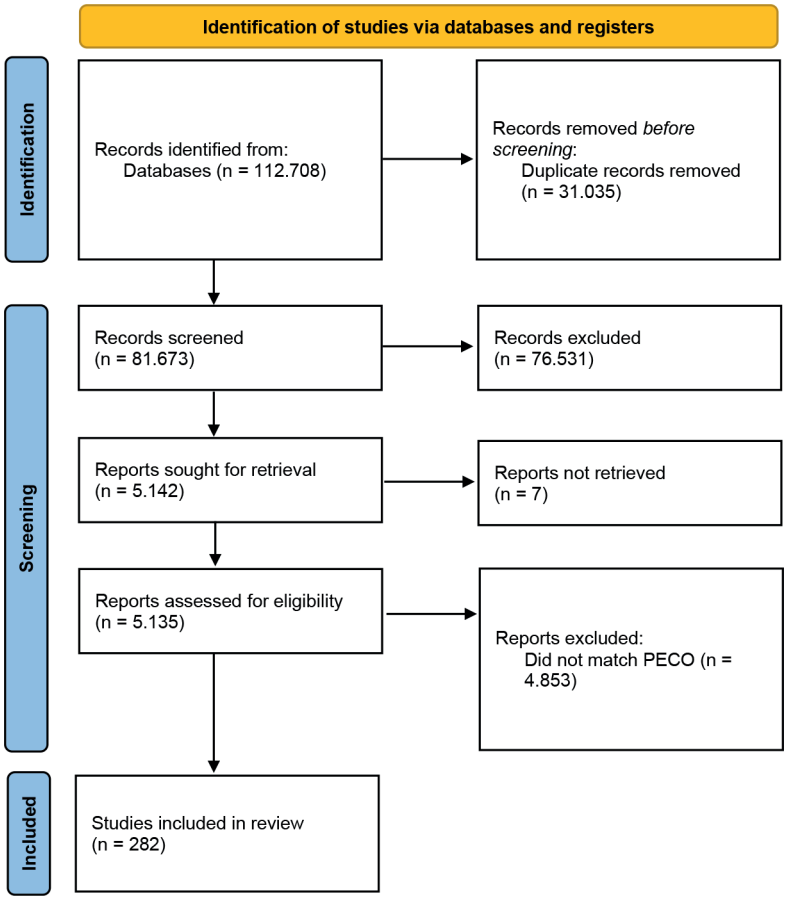

Figure 1. Study selection [28].

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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References

1. International Labour Organization (ILO). Quick guide on sources and uses of statistics on occupational safety and health. 2020. Geneva, Switzerland. Available at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_759401.pdf. Accessed June 25, 2024.
2. WHO/ILO joint estimates of the work-related burden of disease and injury, 2000-2016: global monitoring report: Geneva: World Health Organization and the International Labour Organization, 2021. Available at: https://apps.who.int/iris/rest/bitstreams/1370920/retrieve. Accessed June 25, 2024.
3. World Health Organization (WHO). Global Strategy on Human Resources for Health: Workforce 2030: Reporting at Seventy-fifth World Health Assembly. 2022. Available at: https://www.who.int/news/item/02-06-2022-global-strategy-on-human-resources-for-health--workforce-2030. Accessed June 25, 2024.
4. World Health Organization (WHO). Working for health and growth: investing in the health workforce. Report of the High-Level Commission on Health Employment and Economic Growth. 2016. Available at: https://apps.who.int/iris/bitstream/handle/10665/250047/9789241511308-eng.pdf. Accessed June 25, 2024.
5. OECD (2016), Health Workforce Policies in OECD Countries: Right Jobs, Right Skills, Right Places, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264239517-en.

6. Centers for Disease Control and Prevention (CDC). The National Institute for Occupational Safety and Health (NIOSH). Healthcare Workers. Available at: https://www.cdc.gov/niosh/healthcare/?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/healthcare/default.html. Accessed June 25, 2024.
7. European Commission, Directorate-General for Employment, Social Affairs and Inclusion, Occupational health and safety risks in the healthcare sector, Publications Office, 2014, https://data.europa.eu/doi/10.2767/27263. Accessed June 25, 2024.
8. World Health Organization (WHO). Classifying health workers: mapping occupations to the international standard classification. 2019. Available at: https://cdn.who.int/media/docs/default-source/health-workforce/dek/classifying-health-workers.pdf?sfvrsn=7b7a472d_3&download=true. Accessed June 25, 2024.
9. Dressner MA. Hospital workers: an assessment of occupational injuries and illnesses. Monthly Labor Review, U.S. Bureau of Labor Statistics, 2017. Available at: https://www.bls.gov/opub/mlr/2017/article/hospital-workers-an-assessment-of-occupational-injuries-and-illnesses.htm. Accessed June 25, 2024.
10. Miller K. Risk factors and impacts of occupational injury in healthcareworkers: A critical review. *OA Musculoskeletal Medicine*. 2013;1:4.
11. International Labour Organization (ILO). Biological hazards in the working environment. Geneva, Switzerland. 2022. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_863811.pdf. Accessed June 25, 2024.
12. International Labour Organization (ILO). Technical guidelines on biological hazards in the working environment. 2022. Geneva, Switzerland. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---lab_admin/documents/meetingdocument/wcms_846253.pdf. Accessed June 25, 2024.
13. European Agency for Safety and Health and Work (EU-OSHA). Musculoskeletal disorders in the healthcare sector. Discussion paper, 2020. Available at: https://osha.europa.eu/en/publications/musculoskeletal-disorders-healthcare-sector/view. Accessed June 25, 2024.
14. World Health Organization (WHO). Preventing violence against health workers. Available at: https://www.who.int/activities/preventing-violence-against-health-workers. Accessed June 25, 2024.
15. Liu J, Gan Y, Jiang H, et al. Prevalence of workplace violence against healthcare workers: a systematic review and meta-analysis. *Occup Environ Med*. 2019;76(12):927-937. Doi:10.1136/oemed-2019-105849
16. Charlier B, Coglianese A, De Rosa F, et al. Chemical risk in hospital settings: Overview on monitoring strategies and international regulatory aspects. *J Public Health Res*. 2021;10(1):1993. Published 2021 Mar 24. Doi: 10.4081/jphr.2021.1993
17. Centers for Disease Control and Prevention (CDC). The National Institute for Occupational Safety and Health (NIOSH). Chemical Hazards for Healthcare Workers. Available at: https://www.cdc.gov/niosh/healthcare/risk-factors/chemical-hazards.html?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/healthcare/chemical.html. Accessed June 25, 2024.
18. Smalley PJ. Laser safety: Risks, hazards, and control measures. *Laser Ther*. 2011;20(2):95-106. Doi: 10.5978/islsm.20.95
19. International Atomic Energy Agency (IAEA). Radiation protection and safety in medical uses of ionizing radiation. 2018. Vienna, Austria. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf. Accessed June 25, 2024.
20. Institute of Medicine (US) Committee on Quality of Health Care in America; Kohn LT, Corrigan JM, Donaldson MS, editors. To Err is Human: Building a Safer Health System. Washington (DC): National Academies Press (US); 2000. 8, Creating Safety Systems in Health Care Organizations. Available from: https://www.ncbi.nlm.nih.gov/books/NBK225188/. Accessed June 25, 2024.
21. Schulte PA, Pandalai S, Wulsin V, Chun H. Interaction of occupational and personal risk factors in workforce health and safety. *Am J Public Health*. 2012;102(3):434-448. Doi: 10.2105/AJPH.2011.300249
22. Bragazzi NL, Dini G, Parodi V, et al. Protocol of a scoping review assessing injury rates and their determinants among healthcare workers in western countries. *BMJ Open*. 2019 Jan 30;9(1):e023372. Doi: 10.1136/bmjopen-2018-023372
23. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8:19–32.43.
24. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci*. 2010;5:69.45.
25. Peters MDJ, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil, H. Chapter 11: Scoping Reviews (2020 version). In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis, JBI, 2020. Available from https://synthesismanual.jbi.global. Doi: https://doi.org/10.46658/JBIMES-20-12.
26. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med*. 2018;169(7):467-473. Doi: 10.7326/M18-0850
27. Colquhoun HL, Levac D, O'Brien KK, et al. Scoping reviews: time for clarity in definition, methods, and reporting. *J Clin Epidemiol*. 2014;67:1291–4.46.
28. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:71. Doi: 10.1136/bmj.n71.
29. World Health Organization (WHO). The impact of COVID-19 on health and care workers: a closer look at

deaths. Health Workforce Department – Working Paper 1. 2021. Geneva, Switzerland. Available at: https://apps.who.int/iris/bitstream/handle/10665/345300/WHO-HWF-WorkingPaper-2021.1-eng.pdf?sequence=1&isAllowed=y. Accessed June 25, 2024.
30. Beltrami EM, McArthur MA, McGeer A, et al. The nature and frequency of blood contacts among home healthcare workers. *Infect Control Hosp Epidemiol*. 2000;21(12):765-770. Doi: 10.1086/501730
31. Castella A, Vallino A, Argentero PA, Zotti CM. Preventability of percutaneous injuries in healthcare workers: a year-long survey in Italy. *J Hosp Infect*. 2003;55(4):290-294. Doi:10.1016/j.jhin.2003.08.013
32. Hernández Navarrete MJ, Campins Martí M, Martínez Sánchez EV, et al. Exposición ocupacional a sangre y material biológico en personal sanitario. Proyecto EPINETAC 1996-2000 [Occupational exposures to blood and biological material in healthcare workers. EPINETAC Project 1996-2000]. *Med Clin* (*Barc*). 2004;122(3):81-86. Doi: 10.1157/13056811
33. Lee JH, Cho J, Kim YJ, et al. Occupational blood exposures in health care workers: incidence, characteristics, and transmission of bloodborne pathogens in South Korea. *BMC Public Health*. 2017;17(1):827. Published 2017 Oct 18. Doi:10.1186/s12889-017-4844-0
34. Quinn MM, Markkanen PK, Galligan CJ, et al. Sharps injuries and other blood and body fluid exposures among home health care nurses and aides. *Am J Public Health*. 2009;99 Suppl 3(Suppl 3):S710-S717. Doi: 10.2105/AJPH.2008.150169
35. Younai FS, Murphy DC, Kotelchuck D. Occupational exposures to blood in a dental teaching environment: results of a ten-year surveillance study. *J Dent Educ*. 2001;65(5):436-448.
36. Atenstaedt R, Roberts R, Russell I, Payne S, Parry R, Capewell S. Needle-stick injuries presenting to GP practices across north Wales. *Commun Dis Public Health*. 2004;7(2):151
37. Venier AG, Vincent A, L'heriteau F, et al. Surveillance of occupational blood and body fluid exposures among French healthcare workers in 2004. *Infect Control Hosp Epidemiol*. 2007;28(10):1196-1201. Doi: 10.1086/520742
38. Waclawski ER. Evaluation of potential reduction in blood and body fluid exposures by use of alternative instruments. *Occup Med* (*Lond*). 2004;54(8):567-569. Doi:10.1093/occmed/kqh116
39. O'Connell T, Hayes B. Occupational sharps injuries in a Dublin teaching hospital. Ir Med J. 2003;96(5):143-145
40. Whitby RM, McLaws ML. Hollow-bore needlestick injuries in a tertiary teaching hospital: epidemiology, education and engineering. *Med J Aust*. 2002;177(8):418-422. Doi: 10.5694/j.1326-5377.2002.tb04881.x
41. Lipscomb J, Sokas R, McPhaul K, et al. Occupational blood exposure among unlicensed home care workers and home care registered nurses: are they protected?. *Am J Ind Med*. 2009;52(7):563-570. Doi:10.1002/ajim.20701
42. Nicholas J, Grimmond T, Bradywood A, Church E, Moran J, Ogg M. Addressing Underreporting of Blood and Other Body Fluid Exposures Among Perioperative Personnel. *AORN J*. 2021;114(4):368-375. Doi: 10.1002/aorn.13502
43. Gershon RR, Sherman M, Mitchell C, et al. Prevalence and risk factors for bloodborne exposure and infection in correctional healthcare workers. *Infect Control Hosp Epidemiol*. 2007;28(1):24-30. Doi: 10.1086/510813
44. Ganczak M, Topczewska K, Biesiada D, Korzeń M. Frequency of Occupational Bloodborne Infections and Sharps Injuries among Polish Paramedics from Selected Ambulance Stations. *Int J Environ Res Public Health*. 2020;18(1):60. Published 2020 Dec 23. Doi: 10.3390/ijerph18010060
45. Fullerton M, Gibbons V. Needlestick injuries in a healthcare setting in New Zealand. *N Z Med J*. 2011;124(1335):33-39. Published 2011 May 27.
46. Rybacki M, Piekarska A, Wiszniewska M, Walusiak-Skorupa J. Work safety among Polish health care workers in respect of Bloodborne pathogens. *Med Pr*. 2013;64(1):1-10.
47. Ganczak M, Topczewska K, Budnik-Szymoniuk M, Korzeń M. Seroprevalence of anti-HBc, risk factors of occupationally acquired HBV infection and HBV vaccination among hospital staff in Poland: a multicenter study. *BMC Public Health*. 2019;19(1):298. Published 2019 Mar 12. Doi: 10.1186/s12889-019-6628-1
48. Doebbeling BN, Vaughn TE, McCoy KD, et al. Percutaneous injury, blood exposure, and adherence to standard precautions: are hospital-based health care providers still at risk?. *Clin Infect Dis*. 2003;37(8):1006-1013. Doi: 10.1086/377535
49. Garus-Pakowska A, Górajski M. Behaviors and Attitudes of Polish Health Care Workers with Respect to the Hazards from Blood-Borne Pathogens: A Questionnaire-Based Study. *Int J Environ Res Public Health*. 2019;16(5):891. Published 2019 Mar 12. Doi: 10.3390/ijerph16050891
50. Elmiyeh B, Whitaker IS, James MJ, Chahal CA, Galea A, Alshafi K. Needle-stick injuries in the National Health Service: a culture of silence [published correction appears in *J R Soc Med*. 2004 Sep;97(9):458]. *J R Soc Med*. 2004;97(7):326-327. Doi: 10.1177/014107680409700705
51. Dobie DK, Worthington T, Faroqui M, Elliott TS. Avoiding the point. *Lancet*. 2002;359(9313):1254. Doi: 10.1016/s0140-6736(02)08245-4
52. Amuwo S, Sokas RK, McPhaul K, Lipscomb J. Occupational risk factors for blood and body fluid exposure among home care aides. *Home Health Care Serv Q*. 2011;30(2):96-114. Doi: 10.1080/01621424.2011.569690

53. Smith DR, Leggat PA. Needlestick & sharps Injuries among Australian medical students. *J UOEH*. 2005;27(3):237-242. Doi: 10.7888/juoeh.27.237
54. Leavy P, Templeton A, Young L, McDonnell C. Reporting of occupational exposures to blood and body fluids in the primary dental care setting in Scotland: an evaluation of current practice and attitudes. *Br Dent J*. 2014;217(4):E7. Doi: 10.1038/sj.bdj.2014.734
55. Trayner KMA, Hopps L, Nguyen M, Christie M, Bagg J, Roy K. Cross-sectional survey of a sample of UK primary care dental professionals' experiences of sharps injuries and perception of access to occupational health support [published online ahead of print, 2018 Nov 30]. *Br Dent J*. 2018;10.1038/sj.bdj.2018.1031. Doi: 10.1038/sj.bdj.2018.1031
56. Leggat PA, Smith DR. Prevalence of percutaneous exposure incidents amongst dentists in Queensland. *Aust Dent J*. 2006;51(2):158-161. Doi: 10.1111/j.1834-7819.2006.tb00420.x
57. Vitale F, Di Benedetto MA, Casuccio A, et al. Influenza dei percorsi formativi sulle conoscenze di infezioni da HIV, HBV e HCV nella pratica odontoiatrica [The influence of professional degree on the knowledge of HIV, HBV and HCV infections in dentistry practice]. *Ann Ig*. 2005;17(3):185-196.
58. Alhazmi RA, Parker RD, Wen S. Needlestick Injuries Among Emergency Medical Services Providers in Urban and Rural Areas. *J Community Health*. 2018;43(3):518-523. Doi: 10.1007/s10900-017-0446-0
59. Lazenby MG, Anderud J, Whitley SP. Blood-borne viruses: are we taking them seriously? A survey of UK oral and maxillofacial surgeons. *Br J Oral Maxillofac Surg*. 2011;49(5):400-403. Doi: 10.1016/j.bjoms.2010.06.004
60. Kerr HL, Stewart N, Pace A, Elsayed S. Sharps injury reporting amongst surgeons. *Ann R Coll Surg Engl*. 2009;91(5):430-432. Doi: 10.1308/003588409X432194
61. Smith DR, Mihashi M, Adachi Y, et al. Organizational climate and its relationship with Needlestick & sharps injuries among Japanese nurses. *Am J Infect Control*. 2009;37(7):545-550. Doi: 10.1016/j.ajic.2008.11.004
62. Ayranci U, Kosgeroglu N. Needlestick & sharps injuries among nurses in the healthcare sector in a city of western Turkey. J Hosp Infect. 2004;58(3):216-223. Doi:10.1016/j.jhin.2004.06.029
63. Cho E, Lee H, Choi M, Park SH, Yoo IY, Aiken LH. Factors associated with Needlestick & sharp injuries among hospital nurses: a cross-sectional questionnaire survey. *Int J Nurs Stud*. 2013;50(8):1025-1032. Doi: 10.1016/j.ijnurstu.2012.07.009
64. Black Thomas LM. Underreporting of Bloodborne Pathogen Exposures in Nursing Students. *Nurse Educ*. 2020;45(2):78-82. Doi: 10.1097/NNE.0000000000000696
65. Vandijck DM, Labeau SO, De Somere J, Claes B, Blot SI; Executive Board of the Flemish Society of Critical Care Nurses. Undergraduate nursing students' knowledge and perception of infection prevention and control. *J Hosp Infect*. 2008;68(1):92-94. Doi: 10.1016/j.jhin.2007.10.013
66. Smith DR, Leggat PA. Needlestick & sharps injuries among nursing students. *J Adv Nurs*. 2005;51(5):449-455. Doi: 10.1111/j.1365-2648.2005.03526.x
67. Massaro T, Cavone D, Orlando G, Rubino M, Ciciriello M, Musti EM. Infortuni da dispositivi taglienti tra gli studenti di infermieristica: un rischio lavorativo emergente [Needlestick & sharps injuries among nursing students: an emerging occupational risk]. *G Ital Med Lav Ergon*. 2007;29(3 Suppl):631-632.
68. Karadağ M. Occupational Blood and body fluids among a group of Turkish nursing and midwifery students during clinical practise training: frequency of Needlestick & sharps injuries. *Jpn J Nurs Sci*. 2010;7(2):129-135. Doi: 10.1111/j.1742-7924.2010.00148.x
69. Talas MS. Occupational Blood and body fluids among Turkish nursing students during clinical practice training: frequency of needlestick/sharp injuries and hepatitis B immunisation. *J Clin Nurs*. 2009;18(10):1394-1403. Doi: 10.1111/j.1365-2702.2008.02523.x
70. Sullivan M, Masters O, Venkatesan P. Needlestick injuries amongst medical students in Birmingham, UK. *J Hosp Infect.* 2000;44(3):240-241. Doi: 10.1053/jhin.1999.0697
71. Papadopoli R, Bianco A, Pepe D, Pileggi C, Pavia M. Sharps and needle-stick injuries among medical residents and healthcare professional students: pattern and reporting in Italy-a cross-sectional analytical study. *Occup Environ Med*. 2019;76(10):739-745. Doi: 10.1136/oemed-2019-105873
72. Marjadi B, Nguyen JD, Hoppett P, McLaws ML. Needlestick Injury among Medical Students in an Australian University. *J Infect Dis Epidemiol.* 2017, 3:034.
73. Deisenhammer S, Radon K, Nowak D, Reichert J. Needlestick injuries during medical training. *J Hosp Infect*. 2006;63(3):263-267. Doi: 10.1016/j.jhin.2006.01.019
74. Ouyang B, Li LD, Mount J, et al. Incidence and characteristics of needlestick injuries among medical trainees at a community teaching hospital: A cross-sectional study. *J Occup Health*. 2017;59(1):63-73. Doi:10.1539/joh.15-0253-FS
75. Patterson JM, Novak CB, Mackinnon SE, Ellis RA. Needlestick injuries among medical students. *Am J Infect Control*. 2003;31(4):226-230. Doi: 10.1067/mic.2003.44
76. Wada K, Narai R, Sakata Y, et al. Occupational Blood or body fluids as a result of needlestick injuries and other sharp device injuries among medical residents in Japan. *Infect Control Hosp Epidemiol*. 2007;28(4):507-509. Doi: 10.1086/513448
77. Hasak JM, Novak CB, Patterson JMM, Mackinnon SE. Prevalence of Needlestick Injuries, Attitude Changes,

and Prevention Practices Over 12 Years in an Urban Academic Hospital Surgery Department. *Ann Surg*. 2018;267(2):291-296. Doi: 10.1097/SLA.0000000000002178
78. Bernard JA, Dattilo JR, Laporte DM. The incidence and reporting of sharps exposure among medical students, orthopedic residents, and faculty at one institution. *J Surg Educ*. 2013;70(5):660-668. Doi: 10.1016/j.jsurg.2013.04.010
79. Choi LY, Torres R, Syed S, et al. Sharps and Needlestick Injuries Among Medical Students, Surgical Residents, Faculty, and Operating Room Staff at a Single Academic Institution. *J Surg Educ*. 2017;74(1):131-136. Doi: 10.1016/j.jsurg.2016.06.003
80. Maniar HH, Tawari AA, Suk M, Bowen TR, Horwitz DS. Percutaneous and Mucocutaneous Exposure Among Orthopaedic Surgeons: Immediate Management and Compliance With CDC Protocol. *J Orthop Trauma*. 2015;29(10):e391-e394. Doi: 10.1097/BOT.0000000000000360
81. Lee WC, Nicklasson L, Cobden D, Chen E, Conway D, Pashos CL. Short-term economic impact associated with occupational needlestick injuries among acute care nurses. *Curr Med Res Opin*. 2005;21(12):1915-1922. Doi: 10.1185/030079905X65286
82. Wicker S, Rabenau HF. Occupational exposures to bloodborne viruses among German dental professionals and students in a clinical setting. *Int Arch Occup Environ Health*. 2010;83(1):77-83. Doi: 10.1007/s00420-009-0452-3
83. Garus-Pakowska A, Szatko F. Ekspozycje przezskórne personelu medycznego [Percutaneous exposures in medical personnel]. *Med Pr*. 2011;62(5):473-480.
84. O'Connor MB, Hannon MJ, Cagney D, et al. A study of needle stick injuries among non-consultant hospital doctors in Ireland. *Ir J Med Sci*. 2011;180(2):445-449. Doi: 10.1007/s11845-010-0667-z
85. Bahat H, Hasidov-Gafni A, Youngster I, Goldman M, Levtzion-Korach O. The prevalence and underreporting of needlestick injuries among hospital workers: a cross-sectional study. *Int J Qual Health Care*. 2021;33(1):mzab009. Doi: 10.1093/intqhc/mzab009
86. Tabak N, Shiaabana AM, Shasha S. The health beliefs of hospital staff and the reporting of needlestick injury. *J Clin Nurs*. 2006;15(10):1228-1239. Doi: 10.1111/j.1365-2702.2006.01423.x
87. Raghavendran S, Bagry HS, Leith S, Budd JM. Needle stick injuries: a comparison of practice and attitudes in two UK District General Hospitals. *Anaesthesia*. 2006;61(9):867-872. Doi: 10.1111/j.1365-2044.2006.04751.x
88. Kessler CS, McGuinn M, Spec A, Christensen J, Baragi R, Hershow RC. Underreporting of blood and body fluid exposures among health care students and trainees in the acute care setting: a 2007 survey. *Am J Infect Control*. 2011;39(2):129-134. Doi: 10.1016/j.ajic.2010.06.023
89. Sharma GK, Gilson MM, Nathan H, Makary MA. Needlestick injuries among medical students: incidence and implications. *Acad Med*. 2009;84(12):1815-1821. Doi: 10.1097/ACM.0b013e3181bf9e5f
90. Ahadizadeh EN, Quintanilla-Dieck L, Pfeifer H, Wax MK. Needlestick Injury in Otolaryngology-Head and Neck Surgery Resident Programs. *Laryngoscope*. 2021;131(4):E1076-E1080. Doi: 10.1002/lary.29234
91. Manoli A, Hutzler L, Regan D, Strauss EJ, Egol KA. Unreported Sharps Exposures in Orthopedic Surgery Residents A Silent Majority. *Bull Hosp Jt Dis*. (2013). 2018;76(2):133-138.
92. Trapé-Cardoso M, Schenck P. Reducing percutaneous injuries at an academic health center: a 5-year review. *Am J Infect Control*. 2004;32(5):301-305. Doi: 10.1016/j.ajic.2003.12.003
93. Sohn S, Eagan J, Sepkowitz KA, Zuccotti G. Effect of implementing safety-engineered devices on percutaneous injury epidemiology. *Infect Control Hosp Epidemiol*. 2004;25(7):536-542. Doi: 10.1086/502436
94. Lamontagne F, Abiteboul D, Lolom I, et al. Role of safety-engineered devices in preventing needlestick injuries in 32 French hospitals. *Infect Control Hosp Epidemiol*. 2007;28(1):18-23. Doi: 10.1086/510814
95. Zakrzewska JM, Greenwood I, Jackson J. Introducing safety syringes into a UK dental school--a controlled study. *Br Dent J*. 2001;190(2):88-92. Doi: 10.1038/sj.bdj.4800891
96. Schuurmans J, Lutgens SP, Groen L, Schneeberger PM. Do safety engineered devices reduce needlestick injuries?. *J Hosp Infect*. 2018;100(1):99-104. Doi: 10.1016/j.jhin.2018.04.026
97. Phillips EK, Conaway M, Parker G, Perry J, Jagger J. Issues in understanding the impact of the Needlestick Safety and Prevention Act on hospital sharps injuries. *Infect Control Hosp Epidemiol*. 2013;34(9):935-939. Doi: 10.1086/671733
98. Jagger J, Berguer R, Phillips EK, Parker G, Gomaa AE. Increase in sharps injuries in surgical settings versus nonsurgical settings after passage of national needlestick legislation. *J Am Coll Surg*. 2010;210(4):496-502. Doi: 10.1016/j.jamcollsurg.2009.12.018
99. Sossai D, Puro V, Chiappatoli L, et al. Using an intravenous catheter system to prevent needlestick injury. *Nurs Stand*. 2010;24(29):42-46. Doi: 10.7748/ns2010.03.24.29.42.c7628
100. Valls V, Lozano MS, Yánez R, et al. Use of safety devices and the prevention of percutaneous injuries among healthcare workers [published correction appears *in Infect Control Hosp Epidemiol*. 2008 Mar;29(3):288]. Infect Control Hosp Epidemiol. 2007;28(12):1352-1360. Doi: 10.1086/523275
101. O'Malley EM, Scott RD 2nd, Gayle J, et al. Costs of management of occupational exposures to blood and body fluids. *Infect Control Hosp Epidemiol*. 2007;28(7):774-782. Doi: 10.1086/518729

102. d'Ettorre G. Job stress and needlestick injuries: which targets for organizational interventions?. *Occup Med* (Lond). 2016;66(8):678-680. Doi:10.1093/occmed/kqw110
103. Puro V, De Carli G, Petrosillo N, Ippolito G. Risk of Bloodborne infection for Italian healthcare workers, by job category and work area. Studio Italiano Rischio Occupazionale da HIV Group. *Infect Control Hosp Epidemiol*. 2001;22(4):206-210. Doi: 10.1086/501890
104. Smith DR, Leggat PA, Takahashi K. Percutaneous exposure incidents among Australian hospital staff. *Int J Occup Saf Ergon*. 2005;11(3):323-330. Doi: 10.1080/10803548.2005.11076654
105. Sindoni L, Calisto ML, Alfino D, et al. Indagine retrospettiva sul monitoraggio epidemiologico degli infortuni biologici da esposizione professionale nell'A.O.U. "G. Martino" di Messina [Retrospective survey on epidemiologic monitoring of accidents due to professional exposure to biological agents in A.O.U. "G. Martino" of Messina, Italy)] [published correction appears in Ann Ig. 2006 Jan-Feb;18(1):9 p following 96. Squeri, L [corrected to Squeri, R]]. *Ann Ig*. 2005;17(1):67-74
106. Leigh JP, Wiatrowski WJ, Gillen M, Steenland NK. Characteristics of persons and jobs with needlestick injuries in a national data set. *Am J Infect Control*. 2008;36(6):414-420. Doi: 10.1016/j.ajic.2007.07.020
107. Kiss P, De Meester M, Braeckman L. Needlestick injuries in nursing homes: the prominent role of insulin pens. *Infect Control Hosp Epidemiol*. 2008;29(12):1192-1194. Doi: 10.1086/592407
108. Ghauri AJ, Amissah-Arthur KN, Rashid A, Mushtaq B, Nessim M, Elsherbiny S. Sharps injuries in ophthalmic practice. *Eye* (Lond). 2011;25(4):443-448. Doi: 10.1038/eye.2011.13
109. Garus-Pakowska A, Ulrichs M, Gaszyńska E. Circumstances and Structure of Occupational Sharp Injuries among Healthcare Workers of a Selected Hospital in Central Poland. *Int J Environ Res Public Health*. 2018;15(8):1722. Published 2018 Aug 10. Doi: 10.3390/ijerph15081722
110. Erturk Sengel B, Tukenmez Tigen E, Bilgin H, Dogru A, Korten V. Occupation-Related Injuries Among Healthcare Workers: Incidence, Risk Groups, and the Effect of Training. *Cureus*. 2021;13(4):e14318. Published 2021 Apr 6. Doi: 10.7759/cureus.14318
111. Oh HS, Yi SE, Choe KW. Epidemiological characteristics of occupational blood exposures of healthcare workers in a university hospital in South Korea for 10 years. *J Hosp Infect*. 2005;60(3):269-275. Doi: 10.1016/j.jhin.2004.11.026
112. Bi P, Tully PJ, Pearce S, Hiller JE. Occupational blood and body fluid exposure in an Australian teaching hospital. *Epidemiol Infect*. 2006;134(3):465-471. Doi: 10.1017/S0950268805005212
113. Bakaeen F, Awad S, Albo D, et al. Epidemiology of Blood borne pathogens on a surgical service. *Am J Surg*. 2006;192(5):e18-e21. Doi: 10.1016/j.amjsurg.2006.08.013
114. Wada K, Yoshikawa T, Lee JJ, et al. Sharp injuries in Japanese operating theaters of HIV/AIDS referral hospitals 2009-2011. *Ind Health*. 2016;54(3):224-229. Doi: 10.2486/indhealth.2015-0066
115. Davanzo E, Bruno A, Beggio M, et al. Il rischio biologico da incidente nel personale sanitario universitario [Biologic risk due to accident in academic personnel]. *G Ital Med Lav Ergon*. 2007;29(3 Suppl):761-762.
116. Davanzo E, Frasson C, Morandin M, Trevisan A. Occupational blood and body fluid exposure of university health care workers. *Am J Infect Control*. 2008;36(10):753-756. Doi:10.1016/j.ajic.2008.04.254
117. Ertem M, Dalar Y, Cevik U, Sahin H. Injury or body fluid splash incidence rate during three months period in elective surgery procedures, at Dicle University Hospital, Diyarbakir, Turkey. *Ulus Travma Acil Cerrahi Derg*. 2008;14(1):40-45
118. Marnejon T, Gemmel D, Mulhern K. Patterns of Needlestick & sharps Injuries Among Training Residents. *JAMA Intern Med*. 2016;176(2):251-252. Doi:10.1001/jamainternmed.2015.6828
119. Tabachnick DL, Peña JP, Nabeel I, Klingman KJ. Understanding Causes of Needlestick and Other Sharps Injuries Among OR Personnel. *AORN J*. 2021;114(4):361-367. Doi:10.1002/aorn.13499
120. Ugonabo N, Shah P, Adotama P, Zampella JG. Needlestick & sharps Injuries Among Resident Physicians. *JAMA Surg*. 2021;156(1):96-97. Doi: 10.1001/jamasurg.2020.4112
121. Fica C A, Jemenao P MI, Ruiz R G, et al. Accidentes de riesgo biológico entre estudiantes de carreras de la salud: Cinco años de experiencia [Biological risk accidents among undergraduate healthcare students: five years experience] [published correction appears in Rev Chilena Infectol. 2010 Apr;27(2):178]. *Rev Chilena Infectol*. 2010;27(1):34-39
122. Morinaga K, Hagita K, Yakushiji T, Ohata H, Sueishi K, Inoue T. Analysis of Needlestick and Similar Injuries over 10 Years from April 2004 at Tokyo Dental College Chiba Hospital. *Bull Tokyo Dent Coll*. 2016;57(4):299-305. Doi: 10.2209/tdcpublication.2015-0036
123. Nunn A, Prakash P, Inaba K, et al. Occupational exposure during emergency department thoracotomy: A prospective, multi-institution study. *J Trauma Acute Care Surg*. 2018;85(1):78-84. Doi: 10.1097/TA.0000000000001940
124. Foytl J, Chisholm F, Varsou O. Sharps Injuries during Dissection: A Five-Year Retrospective Study in the Context of Safety. *Anat Sci Educ*. 2020;13(2):158-167. Doi: 10.1002/ase.1894
125. Duarte Rico R, Loya Loya M, Helena Sanín L, Reza López S. Accidentes por Objetos Punzocortantes en

Estudiantes de una Escuela de Odontología. Ciencia & Trabajo. 2006;8(21):131-34
126. Cofini V, Capodacqua A, Calisse S, Galassi I, Cipollone L, Necozione S. Trend analysis and factors associated with biological injuries among health care workers in Southern Italy. *Med Lav.* 2018;109(4):308-315. Published 2018 Aug 28. Doi: 10.23749/mdl.v109i4.7245
127. d'Ettorre G. Needlestick & sharp Injuries Among Registered Nurses: A Case-Control Study. *Ann Work Expo Health*. 2017;61(5):596-599. Doi: 10.1093/annweh/wxx027
128. Kotelchuck D, Murphy D, Younai F. Impact of underreporting on the management of occupational bloodborne exposures in a dental teaching environment. *J Dent Educ*. 2004;68(6):614-622
129. Trinkoff AM, Le R, Geiger-Brown J, Lipscomb J. Work schedule, needle use, and needlestick injuries among registered nurses. *Infect Control Hosp Epidemiol*. 2007;28(2):156-164. Doi: 10.1086/510785
130. Lukianskyte R, Gataeva J, Radziunaite L. Needle sticks and sharps injuries experienced by staff nurses and nursing students and their prevention. *Int J Infect Control*. 2011;8(1): 3–9
131. Leiss JK. Work experience, work environment, and blood exposure among home care and hospice nurses. *Ind Health*. 2012;50(6):521-528. Doi: 10.2486/indhealth.ms1313
132. McCarthy GM, Britton JE. A Survey of Final-Year Dental, Medical and Nursing Students: Occupational Injuries and Infection Control. *J Can Dent Assoc*. 2000;66(10):561
133. Schmid K, Schwager C, Drexler H. Needlestick injuries and other occupational exposures to body fluids amongst employees and medical students of a German university: incidence and follow-up. *J Hosp Infect*. 2007;65(2):124-130. Doi: 10.1016/j.jhin.2006.10.002
134. Petrucci C, Alvaro R, Cicolini G, Cerone MP, Lancia L. Percutaneous and mucocutaneous exposures in nursing students: an Italian observational study. *J Nurs Scholarsh*. 2009;41(4):337-343. Doi: 10.1111/j.1547-5069.2009.01301.x
135. Stefanati A, Boschetto P, Previato S, et al. Indagine sugli infortune tra il personale infermieristico e gli studenti del corso di laurea in infermieristica: analisi epidemiologica descrittiva nel period 2002-2012 in un'Azienda Ospedaliero-Universitaria [A survey on injuries among nurses and nursing students: a descriptive epidemiologic analysis between 2002 and 2012 at a University Hospital]. *Med Lav*. 2015;106(3):216-229. Published 2015 May 4
136. Stefanati A, Brosio F, Kuhdari P, et al. Studio di incidenza sugli infortuni biologici nei medici in formazione specialistica dell'Azienda Ospedaliero - Universitaria di Ferrara e stato immunitario nei confronti delle principali infezioni prevenibili [Incidence of biological accidents at work and immune status for vaccine-preventable diseases among resident physicians in specialist training at Ferrara University Hospital]. *Ig Sanita Pubbl*. 2017;73(6):633-648.
137. Dulon M, Lisiak B, Wendeler D, Nienhaus A. Unfallmeldungen zu Nadelstichverletzungen bei Beschäftigten in Krankenhäusern, Arztpraxen und Pflegeeinrichtungen [Workers' Compensation Claims for Needlestick Injuries Among Healthcare Personnel in Hospitals, Doctors' Surgeries and Nursing Institutions]. *Gesundheitswesen*. 2018;80(2):176-182. Doi: 10.1055/s-0043-114003
138. Gillen M, McNary J, Lewis J, et al. Sharps-related injuries in California healthcare facilities: pilot study results from the Sharps Injury Surveillance Registry. *Infect Control Hosp Epidemiol*. 2003;24(2):113-121. Doi: 10.1086/502181
139. Clarke SP, Schubert M, Körner T. Sharp-device injuries to hospital staff nurses in 4 countries. *Infect Control Hosp Epidemiol*. 2007;28(4):473-478. Doi: 10.1086/513445
140. Nagao M, Iinuma Y, Igawa J, et al. Accidental exposures to blood and body fluid in the operation room and the issue of underreporting. *Am J Infect Control*. 2009;37(7):541-544. Doi: 10.1016/j.ajic.2009.01.009
141. Garus-Pakowska A, Górajski M, Gaszyńska E. Occupational Safety and Hygiene of Dentists from Urban and Rural Areas in Terms of Sharp Injuries: Wound Structure, Causes of Injuries and Barriers to Reporting-Cross-Sectional Study, Poland. *Int J Environ Res Public Health*. 2018;15(8):1655. Published 2018 Aug 4. Doi: 10.3390/ijerph15081655
142. Bilski B. Needlestick injuries in nurses--the Poznań study. *Int J Occup Med Environ Health*. 2005;18(3):251-254.
143. Wicker S, Nürnberger F, Schulze JB, Rabenau HF. Needlestick injuries among German medical students: time to take a different approach?. *Med Educ*. 2008;42(7):742-745. Doi:10.1111/j.1365-2923.2008.03119.x
144. Rice BD, Tomkins SE, Ncube FM. Sharp truth: health care workers remain at risk of bloodborne infection. Occup Med (Lond). 2015;65(3):210-214. Doi: 10.1093/occmed/kqu206
145. Kanamori H, Weber DJ, DiBiase LM, et al. Impact of Safety-Engineered Devices on the Incidence of Occupational Blood and Body Fluid Exposures Among Healthcare Personnel in an Academic Facility, 2000-2014. *Infect Control Hosp Epidemiol*. 2016;37(5):497-504. Doi: 10.1017/ice.2016.10
146. Panlilio AL, Orelien JG, Srivastava PU, et al. Estimate of the annual number of percutaneous injuries among hospital-based healthcare workers in the United States, 1997-1998. *Infect Control Hosp Epidemiol*. 2004;25(7):556-562. Doi: 10.1086/502439
147. Yoshikawa T, Wada K, Lee JJ, et al. Incidence rate of Needlestick & sharps injuries in 67 Japanese hospitals: a national surveillance study. *PLoS One*.

2013;8(10):e77524. Published 2013 Oct 30. Doi: 10.1371/journal.pone.0077524
148. Różańska A, Szczypta A, Baran M, Synowiec E, Bulanda M, Wałaszek M. Healthcare workers' occupational Bloodborne pathogens: a 5-year observation in selected hospitals of the Małopolska province. *Int J Occup Med Environ Health*. 2014;27(5):747-756. Doi: 10.2478/s13382-014-0307-3
149. Alamgir H, Yu S, Chavoshi N, Ngan K. Occupational injury among full-time, part-time and casual health care workers. *Occup Med* (Lond). 2008;58(5):348-354. Doi: 10.1093/occmed/kqn026
150. Ngan K, Drebit S, Siow S, Yu S, Keen D, Alamgir H. Risks and causes of musculoskeletal injuries among health care workers. *Occup Med* (Lond). 2010;60(5):389-394. Doi: 10.1093/occmed/kqq052
151. Darragh AR, Huddleston W, King P. Work-related musculoskeletal injuries and disorders among occupational and physical therapists. *Am J Occup Ther*. 2009;63(3):351-362. Doi: 10.5014/ajot.63.3.351
152. Bell JL, Collins JW, Wolf L, et al. Evaluation of a comprehensive slip, trip and fall prevention programme for hospital employees. *Ergonomics*. 2008;51(12): 1906-1925. Doi: 10.1080/00140130802248092
153. Cappell MS. Injury to endoscopic personnel from tripping over exposed cords, wires, and tubing in the endoscopy suite: a preventable cause of potentially severe workplace injury. *Dig Dis Sci*. 2010;55(4): 947-951. Doi: 10.1007/s10620-009-0923-0
154. Yeoh HT, Lockhart TE, Wu X. Non-fatal occupational falls on the same level. *Ergonomics*. 2013;56(2):153-165. Doi: 10.1080/00140139.2012.746739
155. Drebit S, Shajari S, Alamgir H, Yu S, Keen D. Occupational and environmental risk factors for falls among workers in the healthcare sector. *Ergonomics*. 2010;53(4):525-536. Doi: 10.1080/00140130903528178
156. Alamgir H, Ngan K, Drebit S, Guiyun Li H, Keen D. Predictors and economic burden of serious workplace falls in health care. *Occup Med* (Lond). 2011;61(4):234-240. Doi: 10.1093/occmed/kqr025
157. Vinstrup J, Villadsen E, Jay K, Jakobsen MD. Physical and Psychosocial Work Environmental Risk Factors for Back Injury among Healthcare Workers: Prospective Cohort Study. *Int J Environ Res Public Health*. 2019;16(22):4528. Published 2019 Nov 15. Doi: 10.3390/ijerph16224528
158. Austin K, Schoenberger H, Sesto M, Gaumnitz E, Teo Broman A, Saha S. Musculoskeletal Injuries Are Commonly Reported Among Gastroenterology Trainees: Results of a National Survey. *Dig Dis Sci*. 2019;64(6):1439-1447. Doi: 10.1007/s10620-019-5463-7
159. Lipscomb HJ. Job characteristics and work organization factors associated with patient-handling injury among nursing personnel. *Work*. 2009;33(1):117-128. Doi: 10.3233/WOR-2009-0847
160. Macaluso F, Macaluso M, Daraiseh NM. The psychosocial work environment, musculoskeletal disorders and their functional consequences among pediatric healthcare providers. *Ann Epidemiol*. 2021;58:76-82. Doi: 10.1016/j.annepidem.2021.02.015
161. Howarth SJ, Abbas A, Hogg-Johnson S, Mior S. Reported 1-year prevalence of occupational musculoskeletal disorders in Ontario chiropractors. *Chiropr Man Therap*. 2020;28(1):55. Published 2020 Oct 23. Doi: 10.1186/s12998-020-00345-2
162. Kapoor S, Mahomed K, Kapoor V. Work-related musculoskeletal injuries among obstetricians and gynaecologists: A cross-sectional survey of Fellows of Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG). *Aust N Z J Obstet Gynaecol*. 2021;61(5):785-792. Doi: 10.1111/ajo.13339
163. Hanania AN, Cook A, Threadgill MP, Conway SH, Ludwig M. Prevalence of Musculoskeletal Work-related Injuries Among Radiation Therapists. *Radiol Technol*. 2020;91(5):414-421
164. Anderson S, Stuckey R, Oakman J. Work-related musculoskeletal injuries in prosthetists and orthotists in Australia. *Int J Occup Saf Ergon*. 2021;27(3): 708-713. Doi: 10.1080/10803548.2018.1485335
165. Greiner BA, Nolan S, Hogan DAM. Work-Related Upper Limb Symptoms in Hand-Intensive Health Care Occupations: A Cross-Sectional Study With a Health and Safety Perspective. *Phys Ther*. 2019;99(1): 62-73. Doi: 10.1093/ptj/pzy124
166. Anyfantis ID, Biska A. Musculoskeletal Disorders Among Greek Physiotherapists: Traditional and Emerging Risk Factors. *Saf Health Work*. 2018;9(3): 314-318. Doi: 10.1016/j.shaw.2017.09.003
167. Pawa S, Banerjee P, Kothari S, et al. Are All Endoscopy-Related Musculoskeletal Injuries Created Equal? Results of a National Gender-Based Survey. Am J Gastroenterol. 2021;116(3):530-538. Doi: 10.14309/ajg.0000000000001136
168. Al-Rifaie A, Gariballa M, Ghodeif A, Hodge S, Thoufeeq M, Donnelly M. Colonoscopy-related injury among colonoscopists: an international survey. Endosc Int Open. 2021;9(1):E102-E109. Doi: 10.1055/a-1311-0561
169. Campbell EV 3rd, Muniraj T, Aslanian HR, Laine L, Jamidar P. Musculoskeletal Pain Symptoms and Injuries Among Endoscopists Who Perform ERCP. Dig Dis Sci. 2021;66(1):56-62. Doi: 10.1007/s10620-020-06163-z
170. Aaron KA, Vaughan J, Gupta R, et al. The risk of ergonomic injury across surgical specialties. PLoS One. 2021;16(2):e0244868. Published 2021 Feb 9. Doi: 10.1371/journal.pone.0244868

171. Khansa I, Khansa L, Westvik TS, Ahmad J, Lista F, Janis JE. Work-Related Musculoskeletal Injuries in Plastic Surgeons in the United States, Canada, and Norway. Plast Reconstr Surg. 2018;141(1):165e-175e. Doi: 10.1097/PRS.0000000000003961
172. Ho TT, Hamill CS, Sykes KJ, Kraft SM. Work-related musculoskeletal symptoms among otolaryngologists by subspecialty: A national survey. Laryngoscope. 2018;128(3):632-640. Doi: 10.1002/lary.26859
173. Gadjradj PS, Ogenio K, Voigt I, Harhangi BS. Ergonomics and Related Physical Symptoms Among Neurosurgeons. World Neurosurg. 2020;134:e432-e441. Doi: 10.1016/j.wneu.2019.10.093
174. Diaconita V, Uhlman K, Mao A, Mather R. Survey of occupational musculoskeletal pain and injury in Canadian ophthalmology. Can J Ophthalmol. 2019;54(3):314-322. Doi: 10.1016/j.jcjo.2018.06.021
175. Wyatt RW, Lin CC, Norheim EP, Przepiorski D, Navarro RA. Occupation-related Cervical Spine Disease in Orthopaedic Surgeons. J Am Acad Orthop Surg. 2020;28(17):730-736. Doi: 10.5435/JAAOS-D-19-00834
176. Adams R, Branthwaite H, Chockalingam N. Prevalence of musculoskeletal injury and pain of UK-based podiatrists and the impact of enforced altered working practices. J Foot Ankle Res. 2021;14(1):53. Published 2021 Sep 1. Doi: 10.1186/s13047-021-00491-7
177. Penkala S, El-Debal H, Coxon K. Work-related musculoskeletal problems related to laboratory training in university medical science students: a cross sectional survey. BMC Public Health. 2018;18(1):1208. Published 2018 Oct 29. Doi: 10.1186/s12889-018-6125-y
178. Merryweather AS, Thiese MS, Kapellusch JM, Garg A, Fix DJ, Hegmann KT. Occupational factors related to slips, trips and falls among home healthcare workers. Safety science. 2018;107:155-160
179. Alamgir H, Yu S, Fast C, Hennessy S, Kidd C, Yassi A. Efficiency of overhead ceiling lifts in reducing musculoskeletal injury among carers working in long-term care institutions. Injury. 2008;39(5):570-577. Doi: 10.1016/j.injury.2007.11.420
180. Howarth AL, Hallbeck S, Mahabir RC, Lemaine V, Evans GRD, Noland SS. Work-Related Musculoskeletal Discomfort and Injury in Microsurgeons. J Reconstr Microsurg. 2019;35(5):322-328. Doi: 10.1055/s-0038-1675177
181. Engkvist IL, Hjelm EW, Hagberg M, Menckel E, Ekenvall L. Risk indicators for reported over-exertion back injuries among female nursing personnel. Epidemiology. 2000;11(5):519-522. Doi: 10.1097/00001648-200009000-00006
182. Amaro J, Magalhães J, Leite M, et al. Musculoskeletal injuries and absenteeism among healthcare professionals-ICD-10 characterization. PLoS One. 2018;13(12):e0207837. Published 2018 Dec 14. Doi: 10.371/journal.pone.0207837
183. Parikh JR, Bender C, Bluth E. Musculoskeletal Injuries Affecting Radiologists According to the 2017 ACR Human Resources Commission Workforce Survey. J Am Coll Radiol. 2018;15(5):803-808. Doi: 10.1016/j.jacr.2018.01.033
184. Gilchrist A, Pokorná A. Prevalence of musculoskeletal low back pain among registered nurses: Results of an online survey. J Clin Nurs. 2021;30(11-12):1675-1683. Doi:10.1111/jocn.15722
185. Reichard AA, Marsh SM, Tonozzi TR, Konda S, Gormley MA. Occupational Injuries and Exposures among Emergency Medical Services Workers. Prehosp Emerg Care. 2017;21(4):420-431. Doi: 10.1080/10903127.2016.1274350
186. Groenewold MR, Sarmiento RFR, Vanoli K, Raudabaugh W, Nowlin S, Gomaa A. Workplace violence injury in 106 US hospitals participating in the Occupational Health Safety Network (OHSN), 2012-2015. Am J Ind Med. 2018;61(2):157-166. Doi: 10.1002/ajim.22798
187. Rodríguez-Acosta RL, Myers DJ, Richardson DB, Lipscomb HJ, Chen JC, Dement JM. Physical assault among nursing staff employed in acute care. Work.2010;35(2):191-200.Doi:10.3233/WOR-2010-0971
188. Maguire BJ, Browne M, O'Neill BJ, Dealy MT, Clare D, O'Meara P. International Survey of Violence Against EMS Personnel: Physical Violence Report. Prehosp Disaster Med. 2018;33(5):526-531. Doi: 10.1017/S1049023X18000870
189. Kaeser D, Guerra R, Keidar O, et al. Verbal and Non-Verbal Aggression in a Swiss University Emergency Room: A Descriptive Study. Int J Environ Res Public Health. 2018;15(7):1423. Published 2018 Jul 6. Doi: 10.3390/ijerph15071423
190. Sossai D, Molina FS, Amore M, et al. Analisi degli episodi di violenza in in grande ospedale italiano [Analysis of incidents of violence in a large Italian hospital]. *Med Lav*. 2017;108(5):6005. Published 2017 Oct 27. Doi: 10.23749/mdl.v108i5.6005
191. Kim KM, Lee SJ. Work-Related Perceptions, Injuries, and Musculoskeletal Symptoms: Comparison Between U.S.-Educated and Foreign-Educated Nurses. *Workplace Health Saf*. 2019;67(7):326-337. Doi: 10.1177/2165079918821699
192. Quinn MM, Markkanen PK, Galligan CJ, et al. Occupational health of home care aides: results of the safe home care survey. *Occup Environ Med*. 2016;73(4):237-245. Doi: 10.1136/oemed-2015-103031
193. Magnavita N, Heponiemi T. Violence towards health care workers in a Public Health Care Facility in Italy: a repeated cross-sectional study. *BMC Health Serv Res*. 2012;12:108.Published2012May2.Doi:10.1186/1472-6963-12-108
194. Rosenthal LJ, Byerly A, Taylor AD, Martinovich Z. Impact and Prevalence of Physical and Verbal Violence

Toward Healthcare Workers. *Psychosomatics*. 2018; 59(6):584-590. Doi: 10.1016/j.psym.2018.04.007
195. Çelikkalp Ü, Dilek F. Factors affecting the occupational accident rates among nurses. Rev Esc Enferm USP. 2019;53:e03524. Published 2019 Dec 2. Doi: 10.1590/S1980-220X2018049703524
196. Gershon RR, Pearson JM, Sherman MF, Samar SM, Canton AN, Stone PW. The prevalence and risk factors for percutaneous injuries in registered nurses in the home health care sector. *Am J Infect Control*. 2009;37(7):525-533. Doi: 10.1016/j.ajic.2008.10.022
197. Schablon A, Wendeler D, Kozak A, Nienhaus A, Steinke S. Prevalence and Consequences of Aggression and Violence towards Nursing and Care Staff in Germany-A Survey. *Int J Environ Res Public Health*. 2018;15(6):1274. Published 2018 Jun 15. Doi: 10.3390/ijerph15061274
198. Unruh L, Asi Y. Determinants of Workplace Injuries and Violence Among Newly Licensed RNs. *Workplace Health Saf*. 2018;66(10):482-492. Doi: 10.1177/2165079918756909
199. Ramacciati N, Gili A, Mezzetti A, Ceccagnoli A, Addey B, Rasero L. Violence towards Emergency Nurses: The 2016 Italian National Survey-A cross-sectional study. *J Nurs Manag*. 2019;27(4):792-805. Doi: 10.1111/jonm.12733
200. El Ghaziri M, Dugan AG, Zhang Y, Gore R, Castro ME. Sex and Gender Role Differences in Occupational Exposures and Work Outcomes Among Registered Nurses in Correctional Settings. *Ann Work Expo Health*. 2019;63(5):568-582. Doi: 10.1093/annweh/wxz018
201. Grange JT, Corbett SW. Violence against emergency medical services personnel. *Prehosp Emerg Care*. 2002;6(2):186-190. Doi: 10.1080/10903120290938526
202. Heick R, Young T, Peek-Asa C. Occupational injuries among emergency medical service providers in the United States. *J Occup Environ Med*. 2009;51(8): 963-968. Doi: 10.1097/JOM.0b013e3181af6b76
203. Duchateau FX, Bajolet-Laplante MF, Chollet C, Ricard-Hibon A, Marty J. Exposition à la violence en Smur [Exposure of French emergency medical personnel to violence]. *Ann Fr Anesth Reanim*. 2002;21(10):775-778. Doi: 10.1016/s0750-7658(02)00796-7
204. Boland LL, Kinzy TG, Myers RN, et al. Burnout and Exposure to Critical Incidents in a Cohort of Emergency Medical Services Workers from Minnesota. *West J Emerg Med*. 2018;19(6):987-995. Doi: 10.5811/westjem.8.39034
205. Gormley MA, Crowe RP, Bentley MA, Levine R. A National Description of Violence toward Emergency Medical Services Personnel. *Prehosp Emerg Care*.2016;20(4):439-447.Doi:10.3109/10903127.2015.1128029
206. Boyle M, Koritsas S, Coles J, Stanley J. A pilot study of workplace violence towards paramedics. *Emerg Med J*. 2007;24(11):760-763. Doi: 10.1136/emj.2007.046789
207. Gülen B, Serinken M, Hatipoğlu C, et al. Work-related injuries sustained by emergency medical technicians and paramedics in Turkey. *Ulus Travma Acil Cerrahi Derg*. 2016;22(2):145-149. Doi: 10.5505/tjtes.2015.94224
208. Ness GJ, House A, Ness AR. Aggression and violent behaviour in general practice: population based survey in the north of England. BMJ. 2000;320(7247): 1447-1448. Doi: 10.1136/bmj.320.7247.1447
209. Koritsas S, Coles J, Boyle M, Stanley J. Prevalence and predictors of occupational violence and aggression towards GPs: a cross-sectional study. *Br J Gen Pra*ct. 2007;57(545):967-970.Doi:10.3399/096016407782604848
210. Magin PJ, May J, McElduff P, Goode SM, Adams J, Cotter GL. Occupational violence in general practice: a whole-of-practice problem. Results of a cross-sectional study. *Aust Health Rev*. 2011;35(1):75-80. Doi: 10.1071/AH10874
211. Tolhurst H, Baker L, Murray G, Bell P, Sutton A, Dean S. Rural general practitioner experience of work-related violence in australia. *Aust J Rural Health*. 2003;11(5):231-236
212. Marte M, Cappellano E, Sestili C, Mannocci A, La Torre G. Workplace violence towards healthcare workers: an observational study in the College of Physicians and Surgeons of Rome. *Med Lav*. 2019;110(2):130-141. Published 2019 Apr 19. Doi: 10.23749/mdl.v110i2.7807
213. Çevik M, Gümüştakim RŞ, Bilgili P, Ayhan Başer D, Doğaner A, Saper SHK. Violence in healthcare at a glance: The example of the Turkish physician. *Int J Health Plann Manage*. 2020;35(6):1559-1570. Doi: 10.1002/hpm.3056
214. Udoji MA, Ifeanyi-Pillette IC, Miller TR, Lin DM. Workplace Violence Against Anesthesiologists: We are not Immune to this Patient Safety Threat. *Int Anesthesiol Clin*. 2019;57(3):123-137. Doi: 10.1097/AIA.0000000000000237
215. Boucaut R, Knobben L. Occupational health and safety incidents at a university school of nursing: A retrospective, descriptive appraisal. *Nurse Educ Pract*. 2020;44:102776. Doi:10.1016/j.nepr.2020.102776
216. García-Gámez M, Morales-Asencio JM, García-Mayor S, et al. Adverse events encountered during clinical placements by undergraduate nursing students in Spain [published online ahead of print, 2020 May 22]. Nurse Educ Today. 2020;91:104480. Doi: 10.1016/j.nedt.2020.104480
217. Boyle M, McKenna L. Paramedic and midwifery student exposure to workplace violence during clinical placements in Australia - A pilot study. *Int J*

Med Educ. 2016;7:393-399. Published 2016 Dec 11. Doi: 10.5116/ijme.582e.ac04
218. Boyle M, McKenna L. Paramedic student exposure to workplace violence during clinical placements - A cross-sectional study. *Nurse Educ Pract*. 2017;22:93-97. Doi: 10.1016/j.nepr.2017.01.001
219. Papalia F, Magnavita N. Un rischio professionale misconosciuto: la violenza fisica sul luogo di lavoro [Unknown occupational risk: physical violence at the workplace]. *G Ital Med Lav Ergon*. 2003;25 Suppl(3):176-177
220. Thomsen TW, Sayah AJ, Eckstein M, Hutson HR. Emergency medical services providers and weapons in the prehospital setting. *Prehosp Emerg Care*. 2000;4(3): 209-216. Doi: 10.1080/10903120090941218
221. Koritsas S, Boyle M, Coles J. Factors associated with workplace violence in paramedics. *Prehosp Disaster Med*. 2009;24(5):417-421. Doi: 10.1017/s1049023 x0000724x
222. Maguire BJ, O'Neill BJ. Emergency Medical Service Personnel's Risk From Violence While Serving the Community. *Am J Public Health*. 2017;107(11): 1770-1775. Doi:10.2105/AJPH.2017.303989
223. Alamgir H, Yu S. Epidemiology of occupational injury among cleaners in the healthcare sector. *Occup Med* (Lond). 2008;58(6):393-399. Doi: 10.1093/occmed /kqn028
224. Horton DK, Berkowitz Z, Kaye WE. Secondary contamination of ED personnel from hazardous materials events, 1995-2001. *Am J Emerg Med*. 2003;21(3): 199-204. Doi: 10.1016/s0735-6757(02) 42245-0
225. European Centre for Disease Prevention and Control, WHO Regional Office for Europe. Tuberculosis surveillance and monitoring in Europe 2023 – 2021 data. 2023. Stockholm, Sweden and Copenhagen, Denmark. Available at: https://www.ecdc.europa.eu/sites/default /files/documents/tuberculosis-surveillance-monitoring -2023.pdf. Accessed June 25, 2024.
226. European Centre for Disease Prevention and Control. Hepatitis B. In: ECDC. Annual epidemiological report for 2021. 2022. Stockholm, Sweden. Available at: https://www.ecdc.europa.eu/sites/default/files /documents/hepatitis-b-annual-epidemiological -report-2021.pdf. Accessed June 25, 2024.
227. Gohil SK, Okubo S, Klish S, Dickey L, Huang SS, Zahn M. Healthcare Workers and Post-Elimination Era Measles: Lessons on Acquisition and Exposure Prevention. *Clin Infect Dis*. 2016;62(2):166-172. Doi: 10.1093/cid/civ802
228. Prüss-Ustün A, Rapiti E, Hutin Y. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. *Am J Ind Med*. 2005;48(6):482-490. Doi: 10.1002 /ajim.20230
229. Centers for Disease Control and Prevention (CDC). The National Institute for Occupational Safety and Health (NIOSH). Bloodborne Infectious Diseases: HIV/AIDS, Hepatitis B, Hepatitis C. Available at: https://www.cdc.gov/niosh/healthcare/risk-factors /bloodborne-infectious-diseases.html?CDC_AAref _Val=https://www.cdc.gov/niosh/topics/bbp/default .html. Accessed June 25, 2024.
230. Schillie S, Vellozzi C, Reingold A, et al. Prevention of Hepatitis B Virus Infection in the United States: Recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep* 2018; 67(No. RR-1):1–31. Doi: http://dx.doi.org/10.15585 /mmwr.rr6701a1
231. Moorman AC, de Perio MA, Goldschmidt R, et al. Testing and Clinical Management of Health Care Personnel Potentially Exposed to Hepatitis C Virus — CDC Guidance, United States, 2020. MMWR Recomm Rep 2020;69(No. RR-6):1–8. Doi: http:// dx.doi.org/10.15585/mmwr.rr6906a1
232. Kuhar, David T. et al. Updated U.S. Public Health Service guidelines for the management of occupational exposures to HIV and recommendations for postexposure prophylaxis. 2013. Available at: https://stacks .cdc.gov/view/cdc/20711. Accessed June 25, 2024.
233. van den Heuvel S. OSHwiki. Psychosocial risk factors for musculoskeletal disorders (MSDs). 2012. Available at: https://oshwiki.osha.europa.eu/en/themes/psychosocial-risk-factors-musculoskeletal-disorders-msds. Accessed June 25, 2024.
234. Boini S, Colin R, Grzebyk M. Effect of occupational safety and health education received during schooling on the incidence of workplace injuries in the first 2 years of occupational life: a prospective study. *BMJ Open*. 2017;7(7):e015100. Published 2017 Jul 18. Doi:10.1136/bmjopen-2016-015100
235. International Labour Organization (ILO). State practice to address COVID-19 infection as a work-related injury. 2021. Geneva, Switzerland. Available at: https:// www.ilo.org/wcmsp5/groups/public/---ed_emp/--- emp_ent/documents/publication/wcms_741360.pdf. Accessed June 25, 2024.
236. International Labour Organization (ILO). International Journal of Labour Research. Work-related injuries, diseases and Covid-19. 2021. Geneva, Switzerland. Available at: https://www.ilo.org/wcmsp5/groups /public/---ed_dialogue/---actrav/documents/publication /wcms_810045.pdf. Accessed June 25, 2024.
237. Thornton J. Violence against health workers rises during COVID-19. *Lancet*. 2022;400(10349):348. Doi: 10.1016/S0140-6736(22)01420-9

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COVID-19 Pandemic Impact on Sickness Absences Among Healthcare Workers: A Cohort Study in a Spanish Hospital (2018-2023)

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Abstract

Background: *Like other European systems, the Spanish national health system (NHS) is reaching a critical point. This article analyses sickness absence (SA) trends, as a direct indicator of this crisis, among healthcare workers (HCWs) in Spain, comparing the pre-pandemic, pandemic, and post-pandemic periods.* **Methods:** *This study was based on a retrospective cohort of HCWs (n=7.918) hired at Hospital del Mar in Barcelona for at least three months during 2018-2023. The primary outcome was incident SA episodes. Incidence rates (IR) per 1,000 persons-day and 95% confidence intervals (95% CI) were calculated by sex, period, and occupational variables. Longitudinal entropy regression models were estimated to identify the factors influencing the frequency of transitions between the different HCWs' employment states (active or on SA).* **Results:** *Increasing trends in IR (95%CI) were observed, rising from 1.77 (1.71; 1.83) episodes of SA per 1,000 workers-day during the pre-pandemic period to 5.04 (4.93; 5.15) during the post-pandemic among women, and from 1.23 (1.14; 1.31) to 3.79 (3.64; 3.95), respectively, among men. Nurses, nurse aides, orderlies/technicians, workers under 30, and those in intensive care units and emergency rooms showed the highest IR during and after the pandemic, with longitudinal entropy analysis revealing increased state changes, primarily affecting these groups.* **Conclusions:** *This study demonstrates a significant rise in SA incidence among HCWs during and after the pandemic and identifies vulnerable groups with higher incidence. Several hypotheses, such as poor working conditions, burnout, and patient complexity, have been suggested to explain these results. Urgent interventions are needed to safeguard HCWs' health, thus maintaining the sustainability and safety of the NHS.*

1. Introduction

The Spanish health system, similar to those in other European countries, is reaching a critical juncture. The ongoing aging of the general population, coupled with the rising prevalence and complexity of various diseases, alongside the austerity measures stemming from the Great Recession of 2008 and, more recently, the COVID-19 pandemic, are posing an unprecedented challenge to the Spanish National

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Health System (NHS). It has been noted that the system has long experienced diminished service quality, resource shortages, and understaffing, which have led to degrading working conditions, increased exposure to occupational hazards, and an overall decline in the health of healthcare workers (HCWs) [1–3]. The pandemic worsened this situation.

In healthcare, hospitals are complex workplaces regarding working conditions, exposing staff to various occupational risks, including ergonomic, safety, hygienic, and psychosocial factors. Employment conditions also play a role, linked to long working hours, variable shifts, workloads, understaffing, and an excessive ratio of patients to professionals [4]. As highlighted, the health sector ranks among the most stressful occupations [5]. Poor working conditions increase HCWs' health problems, such as the high prevalence of mental health disorders [6, 7] and musculoskeletal disorders. [8]

Studies about the effect of the pandemic on working conditions show that not all occupational categories are equally affected. Within HCW, there are several job roles, each with distinct tasks, forming a hierarchical work environment that increases health inequalities. For example, nurses have historically been disadvantaged through more precarious employment conditions [2]. Furthermore, gender imbalance is prevalent, with women occupying 90% of aides' positions but only 25% of high-level positions despite accounting for 70% of the workforce [9]. Female HCWs experience poorer working conditions and health outcomes, underscoring the importance of gender perspective when assessing work conditions [10].

Sickness absence (SA) is considered a global measure of health status and functioning in the working population [11], where poor working conditions are associated with SA [12]. SA is a complex phenomenon that affects quality of life and economics at different structural levels, having a significant impact on both social and economic expenditures. In Spain, the expenditure on SA has shown a growing trend in recent years, accounting for more than €11 billion in 2023 [13]. However, SA research is still modest and there is a need for evidence-based knowledge regarding the causes and consequences of SA [14].

HCWs have been identified as a group with a high incidence of SA, particularly among females, older employees, and those experiencing low control and non-supportive management styles [15]. However, there is a lack of studies examining the impact of this issue during and beyond the pandemic, particularly in comparing the years before and after 2020-2021 based on socio-demographic and employment conditions. The main objective of this article is to describe the trend in the incidence of SA episodes among HCWs from 2018 to 2023 by comparing the pre-pandemic (2018 and 2019), the pandemic (2020 and 2021), and the post-pandemic (2022-2023) periods.

2. Methods

2.1. Study Design and Population

This study is a retrospective cohort conducted from January 1, 2018, to June 30, 2023, at Barcelona Hospital del Mar (HMar), a healthcare institution in Barcelona, Spain. This facility has 1,902 beds, 33,000 annual discharges, and eight acute and long-term care health centers. Information on (HCW) was obtained from the Human Resources Department databases. For each HCW, we collected sociodemographic and occupational variables, along with all information on sick leave episodes. A participant identification number was created to link all the data and ensure confidentiality. Privacy and data safety were guaranteed, and the study received approval from the HMar Ethical Committee (2020/9379/I).

2.2. Inclusion and Exclusion Criteria

The inclusion criteria were being a HCW engaged either in direct patient care or not, aged 18–70 years, and having been employed for at least 3 months during the whole study period. We included a 3-month employment criterion in the cohort because many have successive employment. Workers must have been affiliated with Social Security for at least 6 months in the past 5 years to qualify for sickness absence benefits. The exclusion criteria were staff working in the hospital through an employment contract with an external company (mainly kitchen, security, maintenance, and cleaning staff).

2.3. Variables Definitions

The main outcome was episodes of SA due to any health problem, excluding work-related injuries or accidents, which represent a minimally significant percentage of the total [13] and are covered under a different social security scheme. Employment status was categorized as either actively working or on sickness absence. Time was organized into months and years, then classified into a new variable called "period," which has three categories: "pre-COVID-19" (2018-2019), "COVID-19" (2020-2021), and "post-COVID-19". (2022-2023).

For each worker, the following information was available: type of contract (permanent, temporary/replacement); occupational category (physicians, nurses, nurse aides, medical and other trainees, lab technicians, and administration and management staff); work unit (inpatient care, intensive care, emergencies, surgery, outpatient care, central services, administration/support); health center or facility (Hospital del Mar and Hospital de l'Esperança (acute care), Centre Fòrum (long-term care and psychiatry), and CAEMIL Center (psychiatry)); work shift (day, night, other); age (18–29, 30–49, and 50–70 years) and sex.

2.4. Statistical Analysis

The study variables for each period were described as sample counts and percentages stratified by sex and period. Incidence rates (IR) per 1,000 worker-days and their 95% Confidence Intervals (95% CI) were calculated for every year, and period, also stratified by sex and based on occupational variables. Subsequently, we conducted a regression analysis specifically focused on the entropy associated with employment status (whether active or on sick leave). This analysis aimed to identify factors influencing the frequency of transitions between these two states [16]. Entropy values represent the frequency of state changes within a group, with higher values indicating more frequent changes between active and sickness absence states. For example, if Group A has an entropy of 0.05 and Group B has an entropy of 0.20, workers in Group B experience state changes more frequently than those in Group A. Two approaches adjusted for age were used: one fitted crude models for each occupational variable (Model 1) and the other fitted a single model including all occupational variables (Model 2). All analyses were conducted with RStudio (2024.04.2+764).

3. Results

During the observation period, a total of 7,918 (HCWs) were employed by HMAR, with 72.7% being female. In both genders, approximately 40% were younger than 30 years old, 80% worked during the day shift, more than half had permanent contracts, around 40% were in inpatient care, and about two-thirds were employed at Hospital del Mar, the primary facility. Among women, roughly 32% were nurses and 27% were nurse aides, while among men, about 22% were physicians and 20% were administrative staff. No significant differences or clear trends were observed by period concerning age or any occupational variables (Table 1).

The IR per 1,000 workers-day and 95%CI of SA showed clear, statistically significant increasing trends across the periods both in women and men, from 1.77 (1.71; 1.83) episodes of SA per 1,000 workers-day in 2018-2019, 3.28 (3.20; 3.35) in 2020-2021, to 5.04 (4.93; 5.15) in 2022-2023 among women; and 1.23 (1.14; 1.31), 2.40 (2.29; 2.50) in 2020-2021, to 3.79 (3.64; 3.95), respectively, among men. When stratifying by age and occupational variables, similar increasing trends were observed for most categories, especially in younger ages under 30 years, nurses and nurse aides, intensive care, emergencies and inpatient care, psychiatric and long-term care facilities (Centre Fòrum and CAEMIL), and the night shift. For female nurses, IR increased from 1.63 (1.54; 1.73) in 2018-2019 to 5.14 (4.95; 5.32) in 2022-2023, and for men from 1.51 (1.28; 1.74) to 5.33 (4.88; 5.79). Nurse aides showed similar increases to nurses, but had overall higher IR, with IR for women rising from 2.63 (2.49; 2.77) to 7.75 (7.48; 8.02) and men from 1.80 (1.53; 2.08) to 6.47 (5.95; 7.00). In contrast, physicians had the lowest increases, with female physicians showing an increase from 1.05 (0.93; 1.17) to 2.50 (2.29; 2.71) and men from 0.56 (0.46; 0.65) to 1.52 (1.33; 1.70).

Table 1. Sociodemographic and occupational characteristics by sex and period of healthcare workers at Hospital del Mar (2018-2023).

		Women				Men			
		2018-19 n (%)	2020-21 n (%)	2022-23 n (%)	Total n (%)	2018-19 n (%)	2020-22 n (%)	2022-23 n (%)	Total n (%)
Age	18-29	1,134 (29.4)	1,546 (34.1)	1,358 (32.2)	2,381 (41.4)	421 (30.9)	634 (37.9)	545 (34.8)	950 (43.9)
	30-49	1,709 (44.2)	1,942 (42.8)	1,844 (43.7)	2,276 (39.6)	615 (45.1)	695 (41.5)	672 (43.0)	850 (39.3)
	50-70	1,020 (26.4)	1,051 (23.2)	1,016 (24.1)	1,097 (19.1)	328 (24.0)	346 (20.7)	347 (22.2)	362 (16.7)
Occupational Category	Physician	504 (13.0)	546 (12.0)	536 (12.7)	666 (11.6)	378 (27.7)	418 (25.0)	389 (24.9)	490 (22.7)
	Nurse	1,344 (34.8)	1,512 (33.3)	1,421 (33.7)	1,863 (32.4)	209 (15.3)	253 (15.1)	258 (16.5)	343 (15.9)
	Nurse aide	1,004 (26.0)	1,172 (25.8)	1,154 (27.3)	1,531 (26.6)	191 (14.0)	225 (13.4)	238 (15.2)	320 (14.8)
	Medical & other trainees	236 (6.1)	345 (7.6)	236 (5.6)	493 (8.6)	128 (9.4)	146 (8.7)	110 (7.0)	219 (10.1)
	Orderly/technician	277 (7.2)	317 (7.0)	284 (6.7)	411 (7.1)	230 (16.9)	282 (16.8)	263 (16.8)	355 (16.4)
	Administration	498 (12.9)	648 (14.3)	589 (14.0)	792 (13.8)	228 (16.7)	351 (21.0)	306 (19.6)	435 (20.1)
Work unit	Inpatient care	1,699 (44.1)	2,070 (45.7)	1,846 (43.8)	2,711 (47.1)	499 (36.7)	697 (41.7)	562 (35.9)	924 (42.8)
	Critical Care	142 (3.7)	170 (3.8)	153 (3.6)	199 (3.5)	40 (2.9)	47 (2.8)	47 (3.0)	59 (2.7)
	Emergencies	343 (8.9)	387 (8.6)	376 (8.9)	491 (8.5)	158 (11.6)	175 (10.5)	196 (12.5)	241 (11.2)
	Surgery	507 (13.2)	566 (12.5)	573 (13.6)	715 (12.4)	206 (15.1)	232 (13.9)	227 (14.5)	277 (12.8)
	Outpatient care	607 (15.8)	687 (15.2)	639 (15.1)	856 (14.9)	183 (13.4)	211 (12.6)	206 (13.2)	264 (12.2)
	Central services	219 (5.7)	269 (5.9)	263 (6.2)	318 (5.5)	96 (7.1)	104 (6.2)	110 (7.0)	144 (6.7)
	Administration/support	334 (8.7)	376 (8.3)	369 (8.7)	461 (8.0)	179 (13.2)	206 (12.3)	216 (13.8)	252 (11.7)
Health centre	Hospital del Mar	2,468 (64.0)	3,032 (66.8)	2,745 (65.1)	3,778 (65.7)	958 (70.3)	1,216 (72.6)	1,077 (69.0)	1,545 (71.5)
	Hospital de l'Esperança	389 (10.1)	425 (9.4)	469 (11.1)	589 (10.2)	110 (8.1)	128 (7.6)	147 (9.4)	179 (8.3)
	Centre Fòrum	325 (8.4)	346 (7.6)	340 (8.1)	448 (7.8)	75 (5.5)	76 (4.5)	73 (4.7)	96 (4.4)
	CAEMIL	443 (11.5)	450 (9.9)	416 (9.9)	587 (10.2)	149 (10.9)	162 (9.7)	163 (10.4)	222 (10.3)
	Other	233 (6.0)	283 (6.2)	244 (5.8)	345 (6.0)	71 (5.2)	92 (5.5)	102 (6.5)	118 (5.5)
Shift	Day	3,141 (81.3)	3,663 (80.7)	3,424 (81.1)	4,628 (80.4)	1,110 (81.4)	1,367 (81.6)	1,290 (82.5)	1,727 (79.9)
	Night	586 (15.2)	769 (16.9)	713 (16.9)	938 (16.3)	173 (12.7)	242 (14.4)	227 (14.5)	313 (14.5)
	Other	136 (3.5)	108 (2.4)	83 (2.0)	190 (3.3)	81 (5.9)	66 (3.9)	47 (3.0)	122 (5.6)
Contract type	Permanent	2,680 (69.4)	2,878 (63.4)	3,208 (76.0)	3,122 (54.3)	946 (69.4)	1,005 (60)	1,123 (71.9)	1,134 (52.5)
	Temporary	476 (12.3)	825 (18.2)	223 (5.3)	1,160 (20,2)	194 (14.2)	416 (24.8)	152 (9.7)	554 (25.6)
	Replacement	706 (18.3)	836 (18.4)	788 (18.7)	1,472 (25.6)	224 (16.4)	254 (15.2)	287 (18.4)	472 (21.9)
Total		3,863	4,540	4,220	5,756	1,364	1,675	1,564	2,162

Across all occupational variables, women generally had higher IRs than men (Table 2).

Longitudinal entropy analysis shows that, in the fully adjusted model, both women and men experienced an increase in state changes (active or SA) during and after the pandemic, particularly among nurses, aides, and orderlies/technicians compared to physicians. Female nurses exhibited entropy values rising from 0.07 (in the pre-COVID-19 period) to 0.14 (in the post-COVID-19 period), while nurse aides also surged from 0.11 to 0.25. Male orderlies/technicians, along with male nurse aides, represented the occupational groups with the highest entropy values in the post-COVID-19 period (0.27) (Tables 3 and 4).

Workers with temporary and replacement contracts experienced fewer changes in state compared to those with permanent contracts. While this trend already existed in the pre-COVID-19 period, these differences expanded after the pandemic (e.g., female temporary healthcare workers went from -0.09 state changes to -0.28). In both men and women, workers in inpatient care, intensive care units, and emergency services saw significant increases in state changes compared to administration and support workers. During the pandemic, those in emergency and intensive care roles exhibited significantly higher entropy values (0.24 and 0.21, respectively, among women, and 0.15 and 0.18 among men), with female healthcare workers continuing this trend in the post-COVID-19 period. Health centers and shifts had almost no explanatory power in the adjusted models.

4. Discussion

Our analysis of SA in healthcare workers in a complex healthcare institution shows a significant increasing trend in SA incidence, with post-pandemic rates doubling and even tripling those before the pandemic. An increase in state changes from active to SA can also be observed, primarily affecting nurses, aides, orderlies/technicians, and those working in intensive care units and emergency rooms. Furthermore, SA IRs are always higher among women and, during the post-pandemic period, among workers younger than 30 years old.

While previous studies focused on the SA evolution before and/or during the pandemic [17,18], this study is the first to analyse HCWs' SA trends over a long period comprising before, during, and after the pandemic, shedding light on the HCWs' post-pandemic situation in Spain, and probably in other similar settings. Before the pandemic, SA had been identified as a significant problem among HCWs [19]. Their higher levels of SA have been related to the high exposure to occupational risks and poor employment conditions (such as long working hours, workload and understaffing), the high prevalence of burnout [8, 20] and musculoskeletal disorders which characterize the health sector [4, 5].

It has been shown that, at least during the first months of the pandemic, there has been a substantial increase in sickness absence among HCWs all over Europe [18, 21, 22]. Our findings are coherent with these results, and broadens them, showing how this increase is maintained after the pandemic, even after the decline in COVID infection rates from 2022 onwards in Europe due to vaccination programmes. So, the results obtained show that the COVID-19 pandemic exacerbated an already strained sector [5], that has not returned to normal. In this regard, a significant decline in Spanish HCWs' working conditions was found [3] and several systematic reviews showed that the pandemic caused generalized anxiety and major depression disorders, insomnia, and burnout [6,20], as well as an increasing turnover intention, especially among medical and nursing staff [23]. Also, the increase in SA incidence since the pandemic period could be partly explained by a governmental decision to cover up to 100% of the salary of NHS HCWs during all SA episodes from July 2021 onwards. This could be interpreted as a protective mechanism to support a highly strained health system due to the pandemic. This deserves a specific analysis comparing SA IR before and after July 2021, combined with a qualitative approach to understand the impact of this measure on the incidence of SA since then.

We found that the SA incidence rate was significantly higher among women throughout the entire observation period. This finding aligns with research on SA in Europe [24–26], which indicates that women experience more SA than men [27].

Table 2. Incidence rate (IR) of sickness absence/1,000 worker-day and 95% C.I., by sex and period, according to age and occupational variables. Hospital del Mar, 2018-2023.

		Women			Men		
		2018-19 IR (95% CI)	2020-2021 IR (95% CI)	2022-2023 IR (95% CI)	2018-19 IR (95% CI)	2020-2021 IR (95% CI)	2022-2023 IR (95% CI)
Age	18-29	1.43 (1.31; 1.54)	4.07 (3.90; 4.25)	5.81 (5.59; 6.04)	1.15 (0.99; 1.32)	3.65 (3.39; 3.91)	5.05 (4.72; 5.38)
	30-49	1.80 (1.71; 1.89)	3.17 (3.06; 3.28)	4.99 (4.83; 5.15)	1.38 (1.25; 1.50)	2.18 (2.03; 2.34)	3.76 (3.53; 3.99)
	50-70	1.95 (1.84; 2.06)	2.76 (2.63; 2.89)	4.35 (4.16; 4.54)	1.04 (0.90; 1.17)	1.56 (1.40; 1.73)	2.46 (2.22; 2.70)
Occupational Category	Physician	1.05 (0.93; 1.17)	1.52 (1.37; 1.66)	2.50 (2.29; 2.71)	0.56 (0.46; 0.65)	0.98 (0.85; 1.11)	1.52 (1.33; 1.70)
	Nurse	1.63 (1.54; 1.73)	3.48 (3.34; 3.61)	5.14 (4.95; 5.32)	1.51 (1.28; 1.74)	3.65 (3.30; 4.00)	5.33 (4.88; 5.79)
	Nurse aide	2.63 (2.49; 2.77)	4.96 (4.77; 5.15)	7.75 (7.48; 8.02)	1.80 (1.53; 2.08)	4.11 (3.71; 4.5)	6.47 (5.95; 7.00)
	Medical & other trainees	0.75 (0.59; 0.91)	2.39 (2.13; 2.66)	2.47 (2.17; 2.77)	0.71 (0.51; 0.92)	1.90 (1.57; 2.24)	2.12 (1.71; 2.54)
	Orderly/technician	2.08 (1.84; 2.33)	2.98 (2.69; 3.26)	5.55 (5.10; 6.00)	1.95 (1.70; 2.21)	3.36 (3.04; 3.67)	5.67 (5.21; 6.13)
	Administration	1.58 (1.43; 1.72)	2.03 (1.88; 2.19)	3.45 (3.21; 3.68)	1.31 (1.10; 1.52)	1.75 (1.54; 1.97)	2.66 (2.37; 2.96)
Work unit	Inpatient care	1.95 (1.86; 2.05)	3.98 (3.85; 4.12)	5.89 (5.71; 6.08)	1.30 (1.15; 1.45)	3.17 (2.95; 3.39)	4.72 (4.43; 5.02)
	Critical care	1.83 (1.53; 2.14)	4.38 (3.92; 4.83)	6.08 (5.46; 6.70)	1.27 (0.76; 1.78)	3.57 (2.81; 4.33)	5.95 (4.86; 7.04)
	Emergencies	2.05 (1.83; 2.26)	4.35 (4.05; 4.66)	6.83 (6.39; 7.27)	1.70 (1.40; 2.00)	3.19 (2.80; 3.58)	5.51 (4.93; 6.08)
	Surgery	1.40 (1.26; 1.54)	2.71 (2.52; 2.89)	4.43 (4.17; 4.70)	0.88 (0.72; 1.05)	1.60 (1.39; 1.82)	2.98 (2.65; 3.31)
	Outpatient care	1.75 (1.61; 1.89)	2.79 (2.62; 2.96)	4.37 (4.12; 4.62)	1.46 (1.23; 1.69)	2.38 (2.09; 2.66)	3.42 (3.02; 3.81)
	Central services	1.87 (1.63; 2.11)	2.02 (1.78; 2.26)	3.87 (3.50; 4.25)	0.78 (0.53; 1.03)	1.46 (1.14; 1.78)	2.27 (1.83; 2.71)
	Administration/ Support	1.30 (1.14; 1.46)	1.57 (1.40; 1.74)	2.39 (2.15; 2.63)	1.07 (0.87; 1.27)	1.23 (1.02; 1.43)	2.06 (1.77; 2.35)
Health centre	Hospital del Mar	1.65 (1.58; 1.72)	3.18 (3.08; 3.27)	4.89 (4.76; 5.02)	1.09 (1.00; 1.18)	2.24 (2.11; 2.36)	3.68 (3.50; 3.86)
	Hospital Esperança	1.48 (1.31; 1.66)	3.61 (3.35; 3.87)	5.28 (4.94; 5.61)	0.99 (0.74; 1.25)	3.15 (2.70; 3.61)	3.87 (3.36; 4.37)
	Centre Fòrum	2.17 (1.94; 2.39)	4.05 (3.74; 4.35)	5.61 (5.19; 6.02)	2.30 (1.82; 2.78)	3.28 (2.67; 3.89)	4.51 (3.67; 5.35)
	CAEMIL	2.65 (2.42; 2.87)	3.93 (3.66; 4.20)	6.13 (5.74; 6.52)	1.73 (1.42; 2.03)	2.99 (2.61; 3.37)	5.29 (4.72; 5.86)
	Other	1.47 (1.27; 1.68)	1.93 (1.69; 2.16)	3.79 (3.41; 4.17)	1.35 (0.99; 1.72)	1.73 (1.35; 2.10)	2.26 (1.82; 2.71)
Shift	Day	1.64 (1.58; 1.71)	2.98 (2.90; 3.06)	4.63 (4.52; 4.74)	1.18 (1.10; 1.27)	2.18 (2.06; 2.29)	3.41 (3.25; 3.57)
	Night	2.49 (2.31; 2.66)	4.97 (4.74; 5.21)	7.47 (7.13; 7.80)	1.52 (1.27; 1.78)	3.93 (3.54; 4.32)	6.16 (5.64; 6.68)
	Other	1.42 (1.00; 1.84)	2.44 (2.10; 2.77)	2.87 (2.29; 3.46)	1.19 (0.66; 1.73)	2.00 (1.42; 2.58)	3.37 (2.20; 4.54)
Contract type	Permanent	1.78 (1.72; 1.85)	2.95 (2.87; 3.04)	4.76 (4.64; 4.88)	1.18 (1.09; 1.27)	2.00 (1.89; 2.12)	3.50 (3.34; 3.67)
	Temporary	1.81 (1.44; 2.18)	4.07 (3.76; 4.39)	4.69 (4.04; 5.34)	1.16 (0.70; 1.63)	2.93 (2.51; 3.35)	4.60 (3.76; 5.43)
	Replacement	1.70 (1.56; 1.84)	4.39 (4.17; 4.61)	6.51 (6.20; 6.82)	1.49 (1.26; 1.72)	4.00 (3.65; 4.35)	4.85 (4.45; 5.25)
Total		1.77 (1.71; 1.83)	3.28 (3.20; 3.35)	5.04 (4.93; 5.15)	1.23 (1.14; 1.31)	2.40 (2.29; 2.50)	3.79 (3.64; 3.95)

Table 3. Longitudinal entropy analysis. Relationship of employment state transitions (from active to sickness absence), and age and occupational variables among women, by period. Hospital del Mar 2018-2023.

		Model 1			Model 2		
		2018-19	**2020-21**	**2022-23**	**2018-19**	**2020-21**	**2022-23**
Occupational Category	Physician (ref)	0	0	0	0	0	0
	Nurse	0.07 ***	0.19***	0.17***	0.07***	0.16***	0.14***
	Nurse aide	0.10***	0.25***	0.26***	0.11***	0.26***	0.25***
	Medical & other trainees	0.06***	0.09***	0.03	0	0.01	-0.07**
	Orderly/technician	0.06***	0.08***	0.15***	0.07***	0.11***	0.17***
	Administration	0.02	0.05**	0.07***	0.06***	0.12***	0.17***
Work unit	Administration/ Support (ref)	0	0	0	0	0	0
	Inpatient Care	0.07***	0.17***	0.17***	0.05***	0.17***	0.17***
	Critical Care	0.08***	0.20***	0.20***	0.06***	0.21***	0.21***
	Emergencies	0.05***	0.17***	0.17***	0.06***	0.24***	0.24***
	Surgery	0.05***	0.13***	0.13***	0.05***	0.15***	0.15***
	Outpatient Care	0.05***	0.10***	0.10***	0.06**	0.13***	0.13***
	Central Services	0.06***	0.09***	0.09***	0.06***	0.10**	0.10***
Health center	Hospital del Mar (ref)	0	0	0	0	0	0
	Hospital Esperança	0	0	0	0	-0.01	-0
	Centre Fòrum	0.04***	0.04*	0.04*	0	0.01	0
	CAEMIL	0.05***	0	0.06***	0.04***	-0.03	0.01
	Other	-0.04***	-0.12***	-0.08***	-0.02	-0.05*	-0.02
Shift	Day (ref)	0	0	0	0	0	0
	Night	0.03***	0.10***	0.05***	0.02**	0.03**	0
	Other	-0.06***	-0.28***	-0.33***	0.01	-0.21***	-0.18***
Type of contract	Permanent (ref)	0	0	0	0	0	0
	Temporary	-0.10***	-0.13***	-0.28***	-0.09***	-0.09***	-0.28***
	Replacement	-0.08***	-0.10***	-0.10***	-0.12***	-0.20***	-0.20***

*Model 1: age adjusted; Model 2: fully adjusted; *p<0.1, **p<0.05, ***p<0.01.*

This pattern has been linked to the gendered division of paid labor and family responsibilities, and the related women's double presence [24]. Additionally, it relates to their higher exposure to precarious employment and adverse working conditions in the segmented European labor markets [28, 29].

In terms of age, since the pandemic, there has been an unexpected shift in the age distribution of SA IR, with individuals under 30 now showing the highest incidence. This change may be attributed to their limited experience (many are residents) and the increased risk of poor working conditions faced by younger workers after the pandemic began [30]. These conditions may expose younger workers to heightened physical and psychological stress. Beyond occupational factors, rates of depression and anxiety among young adults in Catalonia rose by 144% and 133% from 2008 to 2022 [31]. Paradoxically, older adults reported less psychological distress despite being at a higher risk for COVID-19, likely due to better emotional regulation with age [32].

Table 4. Longitudinal entropy analysis. Relationship of employment state transitions (from active to sickness absence), and age and occupational variables among men, by period. Hospital del Mar, 2018-2023.

		Model 1			Model 2		
		2018-19	**2020-21**	**2022-23**	**2018-19**	**2020-21**	**2022-23**
Occupational Category	Physician (ref)	0	0	0	0	0	0
	Nurse	0.07***	0.18***	0.22***	0.08***	0.15***	0.20***
	Nurse aide	0.07***	0.22***	0.26***	0.08***	0.24***	0.27***
	Medical & other trainees	0.06***	0.10***	0.07*	0.03	0.02	-0.01
	Orderly/technician	0.11***	0.21***	0.26***	0.13***	0.22***	0.27***
	Administration	0.04***	0.08***	0.08***	0.08***	0.13***	0.14***
Work unit	Administration/ Support (ref)	0	0	0	0	0	0
	Inpatient Care	0.03*	0.08***	0.10***	0.04*	0.08**	0.10**
	Critical Care	0	0.17***	0.06	0.02	0.18***	0.07
	Emergencies	0.03*	0.11***	0.07*	0.05**	0.15***	0.11**
	Surgery	0.02	0.04	0.07*	0.06**	0.07*	0.11**
	Outpatient Care	0.04**	0.08**	0.06*	0.05**	0.09**	0.08*
	Central Services	0.02	-0.03	-0.01	0.02	-0.03	-0.02
Health center	Hospital del Mar (ref)	0	0	0	0	0	0
	Hospital Esperança	0	0.02	0.01	-0.02	0	-0.05
	Centre Fòrum	0.01	0.06	0.04	0.01	0.02	-0.03
	CAEMIL	0.05***	0.04	0.07**	0.04*	-0.02	-0.01
	Other	-0.01	-0.05	-0.03	-0.01	-0.02	0
Shift	Day (ref)	0	0	0	0	0	0
	Night	0.02*	0.08***	0.07***	0.01	0.02	0
	Other	-0.04*	-0.18***	-0.26***	0.03	-0.07	-0.09*
Contract type	Permanent (ref)	0	0	0	0	0	0
	Temporary	-0.06***	-0.15***	-0.20***	-0.07***	-0.16***	-0.19***
	Replacement	-0.04***	-0.07***	-0.03	-0.07***	-0.17***	-0.13***

*Model 1: age adjusted; Model 2: fully adjusted; *p<0.1, **p<0.05, ***p<0.01.*

Moreover, this finding could signify a paradigm shift in the relationship between younger workers and employment, indicating a need for further research to fully understand this phenomenon.

Furthermore, our investigation revealed significant differences among occupational categories, with nurses, aides, and orderlies/technicians exhibiting the highest SA incidence, alongside increasing trends over the study periods and transitions from active employment to SA across all three phases. These results appear to confirm that, beyond underlying health issues, SA can be influenced by poor working conditions. Nurses and nurse aides inherently face a higher risk of occupational health problems due to the nature of their work, which is why our study, as well as previous research [33], indicated that they already had the highest levels of SA IR even before the pandemic. Recent scientific literature has further corroborated that nurses experience the most significant negative impacts

from poor working conditions stemming from the pandemic [2, 34], potentially explaining the substantial increases in SA observed during the entire period. Additionally, nurses and nurse aides were at the frontline of COVID-19 patient care and dealt with the suffering of their patients throughout their shifts, which may have contributed to mental health challenges due to traumatic work-related experiences. The longitudinal entropy analysis indicated that these occupational categories exhibited more transitions from active employment to SA, suggesting these transitions were associated with short and frequent SA spells rather than long-term episodes. There is an urgent need for further research regarding the duration of SA spells.

A key finding of this study is that certain work units have experienced disproportionately greater increases, thereby exacerbating workplace health inequalities. Several reports indicate that following the COVID-19 pandemic, healthcare workers in critical care or emergency settings are among the most at-risk populations for developing mental health problems or burnout [35, 36]. In fact, the incidence rates and the increases in incidence, as well as the transitions from active employment to SA among workers in these two medical departments, and those in inpatient care, were the highest during and after the pandemic, with post-pandemic rates nearly tripling those prior to the pandemic. This aligns with the hypothesis that burnout and mental health issues are driving this sudden increase [37]. Despite these differences, it is important to note that all work units have experienced significant increases that require attention. Factors such as higher patient intake, increased workload, and a chronic lack of resources within healthcare systems may have placed additional burdens not only on direct patient-care workers but also created ripple effects throughout all occupational categories. Administrative and central services workers, while not directly involved in patient care, have likely faced heightened stress associated with coordinating resources, adapting to rapidly changing protocols, and managing logistical and operational challenges. The pressure to swiftly adapt to evolving protocols while providing administrative and logistical support during the pandemic likely contributed to psychological stress and burnout.

Finally, workers in long-term care and psychiatry (CAEMIL and Centre Fòrum) experienced the highest SA IR throughout the period. While no scientific publications have investigated explicitly whether workers in long-term and psychiatric care are more vulnerable to SA, the results are not surprising given that mental health workers report alarmingly high levels of burnout prevalence [38] and have been recognized as a risk group for workplace violence [39].

4.1. Limitations and Strengths

The primary limitation of this study is the lack of information regarding the underlying health issues related to SA spells, due to data protection regulations. Additionally, by classifying state transitions in the regression model as a dichotomous variable, the model may oversimplify SA dynamics and potentially obscure complex patterns. Nevertheless, SA remains a well-validated and comprehensive indicator for monitoring the health of working individuals. We also lack additional data on potential confounders, such as pre-existing medical conditions or domestic workloads. Finally, the study relies on retrospective data from a single institution, which may limit the external validity of the findings to other settings or regions with different healthcare systems and employment conditions. A significant strength of the study is the use of a large sample followed over almost six years, allowing us to analyze the evolution of the SA trend before and after the pandemic. The data sources were reliable administrative and health records, previously collected, to provide relevant information on the health of HCWs. Furthermore, the data is not self-reported, as all sickness absence spells are validated by physicians. To our knowledge, this is the first study that compares the incidence of SA among HCWs before, during, and after the pandemic, considering occupational characteristics as well as contextual factors.

5. Conclusion

Sickness absence is a complex social measure of health status and functioning in the working population [11, 14], with significant consequences

for individuals, workplaces, and society. The observed upward trend in sickness absences among (HCWs) is influenced by the occupational context, job characteristics, and poor working conditions, along with the pandemic's impact on an already strained healthcare system. Furthermore, individual health and the social determinants of health are key elements [11], highlighting the necessity of a comprehensive approach that considers the interplay of these factors to develop effective interventions aimed at alleviating the inequity in health outcomes faced by specific vulnerable groups such as nurses, aides, orderlies/technicians, and those working in intensive care units and emergency rooms.

It is essential to support healthcare workers by ensuring their safety, providing optimal working and employment conditions, and promoting their mental and physical health. Recommendations to address these challenges include ensuring adequate staffing, guaranteeing professional development opportunities, and enhancing autonomy and participation in the workplace, among other organizational aspects [41, 42]. The findings of this study indicate the need to account for the vulnerability of certain occupational groups in any proposed interventions. Rather than viewing this issue solely as a human resources challenge, these urgent measures must be implemented to maintain the sustainability of the NHS safety.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the HMar Ethical Committee (2020/9379/I).

Informed Consent Statement: Patient consent was waived because there is no recruitment: information on HCWs was available from the Human Resources Department databases. A participant identification number for the study was created to link all the information and ensure confidentiality and anonimity. The analysed databases were fully anonymized and aggregated, so that no one can be identified individually.

Declaration of Interest: None.

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References

1. Alonso J, Vilagut G, Mortier P, et al. Mental health impact of the first wave of COVID-19 pandemic on Spanish healthcare workers: A large cross-sectional survey. *Rev Psiquiatr Salud Ment.* 2021;14(2):90.
2. Llop-Gironés A, Vračar A, Llop-Gironés G, et al. Employment and working conditions of nurses: where and how health inequalities have increased during the COVID-19 pandemic? *Hum Resour Health.* 2021;19(1):1–11.
3. Moreno Martínez M, Feijoo-Cid M, Fernández-Cano MI, Llorens-Serrano C, Navarro-Giné A. Psychosocial risk in healthcare workers after one year of COVID-19. *Occup Med (Chic Ill).* 2022;1–8.
4. Occupational health and safety risks in the healthcare sector – Guide to prevention and good practice | Safety and health at work EU-OSHA. Available from: https://osha.europa.eu/en/legislation/guidelines/occupational-health-and-safety-risks-healthcare-sector-guide-prevention-and-good-practice (accessed on 23 Dec 2024)
5. Tamminga SJ, Emal LM, Boschman JS, et al. Individual-level interventions for reducing occupational stress in healthcare workers. *Cochrane Database Syst Rev.* 2023; 5(5): CD002892. Doi: 10.1002/14651858.CD002892.pub6
6. Pappa S, Ntella V, Giannakas T, Giannakoulis VG, Papoutsi E, Katsaounou P. Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain Behav Immun.* 2020;88:901–7.
7. Schneider A, Weigl M. Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review. *PLoS One*. 2018;13(6):e0197375. Doi: 10.1371/journal.pone.0197375
8. Jacquier-Bret J, Gorce P. Prevalence of Body Area Work-Related Musculoskeletal Disorders among Healthcare Professionals: A Systematic Review. *Int J Environ Res Public Health*. 2023;20(1):841. Doi: 10.3390/ijerph20010841
9. Su Z, Cheshmehzangi A, McDonnell D, Šegalo S, Ahmad J, Bennett B. Gender inequality and health disparity amid COVID-19. *Nurs Outlook*. 2022;70(1): 89-95. Doi:10.1016/j.outlook.2021.08.004
10. López-Atanes M, Pijoán-Zubizarreta JI, González-Briceño JP, et al. Gender-Based Analysis of the Psychological Impact of the COVID-19 Pandemic on

Healthcare Workers in Spain. *Front Psychiatry*. 2021; 12:692215 Doi: 10.3389/fpsyt.2021.692215
11. Marmot M, Feeney A, Shipley M, North F, Syme SL. Sickness absence as a measure of health status and functioning: from the UK Whitehall II study. *J Epidemiol Community Health*. 1995;49(2):124-130. Doi: 10.1136/jech.49.2.124
12. Benavides FG, Benach J, Moncada S, Vahtera J, Kivimäki M. Working conditions and sickness absence: a complex relation. *J Epidemiol Community Health* (1978). 2001;55(5):368–368.
13. Ministerio de Trabajo MYSS. Seguridad Social: Información Presupuestaria y Financiera. 2023. Available from: https://internationalbudget.org/sites/default/files/2024-05/spain-202405131333.pdf
14. Alexanderson K, Hensing G. More and better research needed on sickness absence. *Scand J Public Health*. 2004;32(5):321–3.
15. Gorman E, Yu S, Alamgir H. When healthcare workers get sick: exploring sickness absenteeism in British Columbia, Canada. *Work*. 2010;35(2):117–23.
16. Gabadinho A, Ritschard G, Müller NS, Studer M. Analyzing and Visualizing State Sequences in R with TraMineR. *J Stat Softw.* 2011;40(4):1–37.
17. Leineweber C, Marklund S, Gustafsson K, Helgesson M. Work environment risk factors for the duration of all cause and diagnose-specific sickness absence among healthcare workers in Sweden: a prospective study. *Occup Environ Med*. 2020;77(11):782–9.
18. Reme BA, Grøsland M, Gjefsen H, Magnusson K. Impact of the COVID-19 pandemic on sick leave among healthcare workers: a register-based observational study. *Occup Environ Med*. 2023;80(6):319–25.
19. Marklund S, Gustafsson K, Aronsson G, Leineweber C, Helgesson M. Working conditions and compensated sickness absence among nurses and care assistants in Sweden during two decades: a cross-sectional biennial survey study. *BMJ Open*. 2019;9(11):30096.
20. Papazian L, Hraiech S, Loundou A, Herridge MS, Boyer L. High-level burnout in physicians and nurses working in adult ICUs: a systematic review and meta-analysis. *Intensive Care Med.* 2023;49(4):387–400.
21. Calvo-Bonacho E, Catalina-Romero C, Fernández-Labandera C, et al. COVID-19 and Sick Leave: An Analysis of the Ibermutua Cohort of Over 1,651,305 Spanish Workers in the First Trimester of 2020. *Front Public Health.* 2020;8:580546.
22. Van Der Plaat DA, Edge R, Coggon D, et al. Impact of COVID-19 pandemic on sickness absence for mental ill health in National Health Service staff. *BMJ Open.* 2021;11(11):e054533.
23. de Vries N, Boone A, Godderis L, et al. The Race to Retain Healthcare Workers: A Systematic Review on Factors that Impact Retention of Nurses and Physicians in Hospitals. *Inquiry*. 2023;60.
24. Arcas MM, Delclos GL, Torá-Rocamora I, Martínez JM, Benavides FG. Gender differences in the duration of non-work-related sickness absence episodes due to musculoskeletal disorders. *J Epidemiol Community Health* (1978). 2016;70(11):1065–73.
25. Casini A, Godin I, Clays E, Kittel F. Gender difference in sickness absence from work: a multiple mediation analysis of psychosocial factors. *Eur J Public Health.* 2013;23(4):635–42.
26. Timp S, van Foreest N, Roelen C. Gender differences in long term sickness absence. *BMC Public Health*. 2024; 24(1):1–9.
27. Magnusson C, Shahbazian R, Kjellsson S. Does higher education make women sicker? A study of the gender gap in sickness absence within educational groups. *PLoS One.* 2024;19(6):e0303852.
28. Matilla-Santander N, González-Marrón A, Martín-Sánchez JC, Lidón-Moyano C, Cartanyà-Hueso À, Martínez-Sánchez JM. Precarious employment and health-related outcomes in the European Union: a cross-sectional study. *Crit Public Health.* 2020;30(4):429–40.
29. Oke A, Braithwaite P, Antai D. Sickness Absence and Precarious Employment: A Comparative Cross-National Study of Denmark, Finland, Sweden, and Norway. *Int J Occup Environ Med.* 2016;7(3):125–47.
30. Salas-Nicás S, Moncada S, Llorens C, Navarro A. (2021). Working conditions and health in Spain during the COVID-19 pandemic: Minding the gap. *Safety Science*.134, 105064. Doi: https://doi.org/10.1016/j.ssci.2020.105064
31. Lozano-Sánchez A, Aragonès E, López-Jiménez T, et al. Temporal trends and social inequities in adolescent and young adult mental health disorders in Catalonia, Spain: a 2008-2022 primary care cohort study. *Child Adolesc Psychiatry Ment Health*. 2024;18(1):159. Published 2024 Dec 18. doi:10.1186/s13034-024-00849-2
32. Zamorano S, Sáez-Alonso M, González-Sanguino C, Muñoz M. Social Stigma Towards Mental Problems in Spain: A Systematic Review. https://journals.copmadrid.org/clysa [Internet]. *Clinica y Salud* 2023; 34(1):23–34.
33. Gohar B, Larivière M, Lightfoot N, Wenghofer E, Larivière C, Nowrouzi-Kia B. Meta-analysis of nursing-related organizational and psychosocial predictors of sickness absence. *Occup Med (Chic Ill).* 2020;70(8):593–601.
34. Li TM, Pien LC, Kao CC, Kubo T, Cheng WJ. Effects of work conditions and organisational strategies on nurses' mental health during the COVID-19 pandemic. *J Nurs Manag*. 2022;30(1):71–8.
35. Lai J, Ma S, Wang Y, et al. Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. *JAMA Netw Open*. 2020;3(3):e203976–e203976.
36. Lasalvia A, Amaddeo F, Porru S, et al. Levels of burnout among healthcare workers during the COVID-19 pandemic and their associated factors: a cross-sectional

study in a tertiary hospital of a highly burdened area of north-east Italy. *BMJ Open*. 2021;11(1).
37. Benavides FG, Utzet M, Serra C, et al. Salud y bienestar del personal sanitario: condiciones de empleo y de trabajo más allá de la pandemia. Informe SESPAS 2024. *Gac Sanit*. 2024;38.
38. Pujol-de Castro A, Valerio-Rao G, Vaquero-Cepeda P, Catalá-López F. Prevalencia del síndrome de burnout en médicos que trabajan en España: revisión sistemática y metaanálisis. *Gac Sanit.* 2024.
39. Paris M, Hoge MA. Burnout in the mental health workforce: A review. *Journal of Behavioral Health Services and Research.* 2010;37(4):519–28.
40. Liu J, Gan Y, Jiang H, et al. Prevalence of workplace violence against healthcare workers: a systematic review and meta-analysis. *Occup Environ Med.* 2019;76(12):927–37.
41. Razai MS, Kooner P, Majeed A. Strategies and Interventions to Improve Healthcare Professionals' Well-Being and Reduce Burnout. *J Prim Care Community Health*. 2023;14.
42. Valiee S, Zarei Jelyani Z, Kia M, et al. Strategies for maintaining and strengthening the health care workers during epidemics: a scoping review. *Hum Resour Health*. 2023;21(1):1–12.

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Diagnosing and Reporting Occupational Diseases: An Assessment Study of Reports from an Italian Workplace Safety Prevention Program Service

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Keywords: Occupational Disease; Compensation; Diagnostic Criteria

ABSTRACT

Background: *The criteria for diagnosing and compensating for occupational diseases vary significantly between countries. The lists of occupational diseases often include diagnostic and attribution criteria that are usually not very specific. As a result, the quality of occupational disease reports is frequently subpar. The aims of this study were to assess the quality of diagnosis and reporting, as well as to evaluate the causal link between reported occupational diseases and occupational risk factors.* **Methods:** *Four occupational physicians assessed the quality of diagnosis by blindly applying Spreeuwers' performance indicators for diagnosis and reporting. Following Violante's criteria, the four evaluators also tested the levels of evidence to evaluate the quality (and associated likelihood) of the diagnosis and the quality of exposure to occupational risk factors in a sample of 104 occupational disease reports, grouped by diagnosis and examined by the local Workplace Safety Prevention Service. Separate scores for each performance indicator and the Total Quality Score (TQS, ranging from 0 to 10), along with the progressive levels of evidence, were then assigned for each occupational disease report.* **Results:** *The mean TQS was below the threshold of sufficiency (<6) for 28% of the diagnoses, while an almost sufficient score (>6) emerged for 72% of the diagnoses, primarily including musculoskeletal disorders, pulmonary silicosis, and noise-induced occupational hearing loss. When applying Violante's criteria for the level of evidence of the diagnosis, it was insufficient for 13.5% of the reported cases, while the level of evidence for exposure to occupational risk factors was deemed insufficient for 19% of the cases, and no cases demonstrated a level of evidence that was highly probable or nearly certain.* **Conclusions:** *Despite the overall quality of the reported cases of occupational diseases being reasonably good, improvements in the quality of diagnosis and reporting could be achieved through strict adherence to standardized diagnostic criteria and by training health personnel to collect data regarding occupational and non-occupational risk factors properly.*

1. Introduction

In Italy, as in many European countries, the registration and reporting of occupational diseases serve as a vital source of information for both epidemiological and preventive purposes. Most national registration systems in various countries are based on compensation schemes for occupational diseases,

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while a few countries also implement voluntary registration schemes alongside their national registries. The primary goal of most registries is to provide information on the incidence and distribution of occupational diseases, which is crucial for developing preventive policies. A limited number of registries are mainly established to gather information focused on preventive policy; examples include SENSOR in the United States, THOR in the United Kingdom, RNV3P in France, SUVA in Switzerland, MALPROF in Italy, and SIGNAAL in Belgium and the Netherlands. A key factor affecting the quality of occupational disease registration is the availability of diagnostic criteria or case definitions. Most compensation systems follow strict criteria for recognizing occupational diseases, while alternative reporting schemes tend to apply these criteria less rigorously, allowing for the reporting of suspected cases. Although recognizing an occupational origin for a disease should meet the general criteria of evidence—specifically, evidence of exposure and evidence of a causal relationship—there are no universally valid algorithms available for assessing the evidence of causality. Utilizing criteria from diverse sources, such as the Bradford-Hill criteria, methodologies from the International Agency for Research on Cancer (IARC), and techniques used by epidemiologists, may produce similar results, potentially rendering the causality between work-related exposure and a specific disease either more or less clear plausible.

Despite the establishment of a European list of occupational diseases intended for harmonization, its effectiveness is notably limited. Significant discrepancies in diagnostic guidelines, criteria for notification, and broader cultural, legislative, and social security regulations may explain the restricted efficacy of this list. A critical factor is the considerable variation in the degree of underreporting of occupational diseases. The reliability of most national incidence figures for occupational diseases is generally considered poor due to this underreporting, which arises from various factors such as limited awareness of occupational diseases among the working population, employees' fears about reporting illnesses to supervisors or physicians, restricted access to medical care, insufficient recognition by physicians, and limited notification channels. Given that registries are an important informational resource for policymakers, enhancing their completeness and quality can significantly improve informed decision-making in preventive policies in Italy and across Europe. The underreporting of occupational diseases poses a significant challenge on a global scale. Conversely, certain factors may lead to the opposite phenomenon, resulting in the overreporting of occupational diseases. Elements like the compensation system, precautionary reporting in anticipation of future complications, and numerous institutional norms may encourage claims of an occupational origin for specific diseases, which can commonly be seen in an aging workforce, such as musculoskeletal issues disorders.

1.1. Italian Reporting System

In Italy, occupational diseases are managed through the Social Security and Public Health Care Systems. The National Institute for Insurance against Accidents at Work (INAIL) oversees these conditions, primarily those caused by work-related risk factors. Risk factors must gradually act on the body and can primarily or exclusively result in disease. While non-work-related causes are allowed, they should not disrupt the causal connection. Employer contributions support INAIL, which serves employees, students, domestic workers, professional athletes, and specific self-employed individuals.

The reporting system involves three key information flows: the diagnosing physician sends a medical certificate to INAIL; if the disease is listed under Italian law (art. 139 DPR 1124/65), a report is submitted to the local health authority, where experts compile data in the MALPROF database for epidemiological and preventive purposes. Consequently, INAIL and MALPROF datasets partially overlap, each having distinct criteria for evaluating the causal link in occupational diseases. INAIL focuses on compensation claims, while MALPROF assesses the occupational connection more broadly, categorizing the connection as highly probable, probable, unlikely, or highly unlikely.

Victims must report the disease to their employer within fifteen days, including the occupational

disease certificate and ongoing treatment details. Employers must notify INAIL within five days, and INAIL's medical doctor verifies the diagnosis and the disease's occupational origin. INAIL standardizes the reporting form, which details the physician's identification, the worker's personal information, job details, the disease and its causal agent, the diagnosis date, risk factors, and the physician's signature.

Diagnosis and compensation criteria vary globally. Many nations maintain lists of occupational diseases that may lack specific diagnostic criteria. In Italy, INAIL provides these lists, yet claims can also be made for non-listed conditions. This mixed system complicates reporting and compensating for occupational diseases, sometimes compromising report quality and causal link attribution.

1.2. Objectives

The main objective of this study is to assess the quality of occupational disease diagnosis and reporting and evaluate the causal link between reported occupational diseases and occupational risk factors, not available in the MALPROF dataset but derivable from the INAIL first certificate, in a sample of Italian suspected occupational disease reports notified to the local Workplace Safety Prevention Service of the public local health authority.

2. Methods

2.1. Population

A sample of 104 reports of suspected occupational diseases notified to the Workplace Safety Prevention Service within the local public health authority, included in the MALPROF database by an occupational physician from said service, were randomly selected from the database of 843 reports, covering the period from December 16, 2020, to December 15, 2021.

Each report must have the corresponding INAIL first certificate for the inclusion criteria, adhering to the double-flow information described separately. The random selection comprised 96 reports of occupational musculoskeletal diseases (92%), 7 reports of noise-induced occupational hearing loss (6%), 1 report of pulmonary silicosis, and 1 record of angioneurosis (1.0%). All reported diseases were categorized according to ICD-10 classification system.

2.2. Procedures

2.2.1. Assessment of the Quality of Diagnosing and Reporting: Spreeuwers Criteria

We assessed the quality of diagnosis following Spreeuwers method [22]. Spreeuwers developed performance indicators specifically for diagnosing and reporting noise-induced hearing loss and occupational adjustment disorder. For each performance indicator, we calculated the percentage of cases in which the criteria were met for each disease. As proposed by Spreeuwers, a score of 60% for a performance indicator indicated a need for quality improvement. Next, we determined a score per case by summing all the performance indicators that were met for the disease. In this calculation, all performance indicators carried the same weight, scoring 1 if the criteria were satisfied and 0 if they were not satisfied. Then, we calculated the total quality score (TQS, range 0–10) as the mean score for all cases of a specific disease. The mean score is obtained by dividing the row score by the number of performance indicators and multiplying it by 10. Adapting Spreeuwers' criteria, we applied his performance indicators to assess the quality of all types of occupational disease reports, including musculoskeletal disorders, using the same method. Four occupational physicians with similar experience calculated scores for each of the 104 reported occupational diseases without knowledge of each other's scores. As suggested by the author, we adopted this criterion to evaluate the quality of each performance indicator, categorizing reports with a mean TQS ≥6 as sufficient and those with a mean TQS <6 as insufficient.

2.2.2. Diagnosing and Exposure Assessment: Violante's Levels of Evidence

For each case of occupational disease, the same four occupational physicians evaluated the levels of evidence defined by Violante on the criteria for the quality (and the associated likelihood) of diagnosing musculoskeletal diseases, as well as the requirements

for the quality (and associated likelihood) of exposure to occupational biomechanical risk factors. We applied Violante's criteria for all types of occupational disease, considering the specificity and sensitivity of each clinical finding and the presence of a reference test assumed to be the "gold standard" for a particular disease. In cases where no reference test was available, all relevant evidence, including therapeutic interventions, was considered.

Criteria for diagnosis were assigned a probability of disease presence based on progressive levels of evidence (e.g., insufficient, possible, probable, very probable, near certain) that reflect a literature review guided by evidence-based approaches for evaluating literature, such as the GRADE system. Violante's criteria for the quality of diagnosing musculoskeletal disease encompass pertinent symptoms, clinical examination findings, and other tests, including imaging and instrumental examinations, while adhering to clinical classifications based on guidelines and information derived from evidence-based reviews of relevant scientific literature.

The criteria for assessing the quality of exposure to occupational risk factors were structured in the same manner, providing progressive levels of evidence from both a qualitative perspective (e.g., insufficient, possible, probable, very probable, near certain) and a quantitative perspective (based on measures obtained through validated methods). Data concerning occupational risk factor exposure was collected from the INAIL first certificate linked to the report of denunciation.

3. Results

3.1. Descriptive Statistics

The sample of 104 reports of occupational diseases belonged to 61 workers, 57 males (93.4 %) and 4 females (6.6%), with a median age of 62 years (range 38-92 years, IQR 56-64). Among 104 reports, 36 included a single disease per worker (59.0%), 15 included two diseases for the same worker (24.6%), 4 included three diseases for the same worker (6.6%), 4 reports included four diseases for the same worker (6.6%) and finally 2 reports included five diseases for the same worker (3.3%).

The distribution by production sector showed that the services and construction sectors are the most represented (N = 22, 36.1% for both). Among the 22 cases in the service sector, 1 was a butcher in a butcher shop, 12 worked in the transport sector (bus and truck drivers), 4 worked in the garbage collection sector, 2 worked in food catering services, 2 in the cleaning sector and 3 in the logistic sector. Among the 22 cases in the construction sector, 3 worked in the plant engineering sector (electrical and hydraulic plant engineering), 17 worked in the civil construction sector (builders), 1 worked in the demolition sector. Secondly, the industrial and craft sectors are equally distributed (N = 6, 9.8% for both), followed by agriculture (N = 3, 4.9%) while the health sector is the least represented (N = 2, 3.3%). Most of the reports of denunciation are represented by patronage physicians (N = 49, 80.3%), while general practitioners and freelance physicians accounted for only 3.3% (N = 2). Reports presented by occupational physician accounted for 13.1% (N = 8).

3.2. Characterization and Risk Factors of Occupational Diseases

Table 1 presents the absolute number and percentage of occupational diseases reported in this study. Among the musculoskeletal diseases, lumbar intervertebral disc diseases (lumbar disc herniation 26%, lumbar spondylodiscopathy 13.5%) and shoulder pathologies (tendinitis of the supraspinatus 17.3%, periarthritis of the shoulder 3.8%) are most represented. Of the 15 cases of elbow tendinopathies, 10 are Epicondylitis, and 5 are mixed medial and lateral elbow tendinopathy.

Table 2 shows the risk factors linked to occupational disease reports. Microtrauma, incongruous postures of the upper limb (41.3%), and manual handling (39.4%) are the risk factors most involved in the pathogenesis of shoulder and spine diseases.

Table 3 presents the median age, interquartile range (IQR), and gender distribution for each reported occupational disease. Among the most prevalent musculoskeletal diseases, the median age of cases reported for lumbar disc herniation was 60 years (range 41-68 years). Of these cases,

Table 1. Absolute number and percentage of reported occupational diseases.

Reported occupational diseases N = 104		N (%)
Musculoskeletal diseases N = 95 (92%)	Bilateral rhizoarthrosis and bilateral radio-carpal arthrosis of the hands	1 (1.0%)
	Carpal tunnel syndrome	5 (4.8%)
	Cervical disc herniation	2 (1.9%)
	Degenerative meniscopathy	6 (5.8%)
	Periarthritis of the shoulder	4 (3.8%)
	Elbow tendinopathies	15 (14.4%)
	Lumbar disc herniation	27 (26.0%)
	Lumbar spondylodiscopathy	14 (13.5)
	Arthrosis of the hands	1 (1.0%)
	Quadriceps tendinopathy	1 (1.0%)
	Tendinitis of the long head of the biceps brachii	1 (1.0%)
	Tendinitis of the supraspinatus	18 (17.3%)
Noise induced occupational hearing loss N = 7 (6.7%)		7 (6.7%)
Pulmonary silicosis N = 1 (1.0%)		1 (1.0%)
Raynaud's phenomenon N = 1 (1%)		1 (1 %)

Table 2. Risk factors linked to the study's occupational disease reports.

Risk factors N = 104	N (%)
Microtrauma and incongruous postures of the upper limb	43 (41.3%)
Manual handling	41 (39.4%)
Microtrauma and incongruous knee postures	7 (6.7%)
Harmful noise	7 (6.7%)
Unknown risk factors (ICD-10 off-list diseases)	3 (2.9%)
Hand-arm vibration	2 (1.9%)
Free crystalline silica	1 (1.0%)

26 were men (96%) and 1 was a woman (4%). The median age for cases reported for tendinitis of the supraspinatus was 63 years (range 45-72 years). Of those cases, 15 were men (83%), and 3 were women (17%). For noise-induced occupational hearing loss, we identified 7 cases involving male workers with a median age of 63 years (range 50-65). The single case of pulmonary silicosis was a man aged 92 years.

3.3. Quality of Diagnosis

Table 4 presents the mean values of the total quality scores, calculated following the Spreeuwers' method, in the range 0-10. Quadriceps tendinopathy and noise-induced occupational hearing loss reports received good total quality scores (8.3 and 7.1, respectively). The worst mean quality score, 3.7, was related to Raynaud's phenomenon case.

The overall data relating to the 104 reported occupational diseases show that 72.1% of the reports (N = 75) have a sufficient total quality score (≥6). In contrast, 27.9% of the reports (N = 29) have an insufficient total quality score (<6). The mean total quality score for all musculoskeletal disorders reports (N = 96) was 6.0. Among musculoskeletal diseases (N = 95), the percentage with a mean total quality score ≥6 (N = 68) resulted to be 70.8%, while the percentage with a mean total quality score <6 (N = 27) resulted to be 29%.

3.4. Evidence by Violante's Criteria for the Quality of Diagnosis and Exposure Assessment

The evidence for the diagnosis was insufficient in 13.5% of the examined reports, possible in 7.5% of cases, probable in 7.5% of cases, very likely in 68.8%, and near-certain in 2.2% of cases (Figure 1). The evidence for exposure to risk factors was insufficient in 19.5% of the examined reports, possible in 63.5% of cases, and probable in 17.1%. No cases show a very likely or near-certain level of evidence of exposure (Figure 1).

The four physicians assigned a "very probable" level of evidence to ≥ 50% of the reported cases for the quality of diagnosis of the following diseases: bilateral

Table 3. Median age, IQR, and gender distribution for each class of the 104 reported occupational disease.

Suspected work-related diseases		N (%)	Median age	IQR	Gender
Musculoskeletal diseases N = 95 (92%)	Bilateral rhizoarthrosis and radio-carpal arthrosis	1 (1.0%)	68 years	-	1 F (100%)
	Carpal tunnel syndrome	5 (4.8%)	61 years	38-72	5 M (100%)
	Cervical disc herniation	2 (1.9%)	63.5 years	-	2 M (100%)
	Degenerative meniscopathy	6 (5.8%)	63 years	48-64	5 M (83.3%) 1 F (16.7%)
	Periarthritis of the shoulder	4 (3.8%)	57 years	52-60	3 M (75.0%) 1 F (25.0%)
	Epicondylitis	15 (14.4%)	63 years	50-68	14 M (93.3%) 1 F (6.7%)
	Lumbar disc herniation	27 (26.0%)	60 years	41-68	26 M (96.3%) 1 F (3.7%)
	Lumbar spondylodiscopathy	14 (13.5)	63 years	48-72	12 M (85.7%) 2 F (14.3%)
	Arthrosis of the hands	1 (1.0%)	63 years	-	1 M (100%)
	Quadriceps tendinopathy	1 (1.0%)	63 years	-	1 M (100%)
	Tendinitis of the long head of the biceps brachii	1 (1.0%)	64 years	-	1 M (100%)
	Tendinitis of the supraspinatus	18 (17.3%)	63 years	45-72	15 M (83.3%) 3 F (16.7%)
Noise induced occupational hearing loss		7 (6.7%)	63 years	50-65	7 M (100 %)
Raynaud's phenomenon		1 (1.0%)	63 years	-	1 M (100%)
Pulmonary silicosis		1 (1.0%)	92 years	92	1 M (100%)

Table 4. Mean values of the Total Quality Scores from Spreeuwer method (mean of the four evaluators) for 104 cases of suspected, mostly musculoskeletal (N=95 or 92%), work-related diseases.

Suspected work-related diseases			Spreeuwer's total quality score (mean)
Musculoskeletal diseases	Quadriceps tendinopathy	1 (1.0%)	8.3
	Lumbar spondylodiscopathy	14 (13.5)	6.9
	Arthrosis of the hands	1 (1.0%)	6.7
	Tendinitis of the long head of the biceps brachii	1 (1.0%)	6.7
	Degenerative meniscopathy	6 (5.8%)	6.3
	Tendinitis of the supraspinatus	18 (17.3%)	6.3
	Epicondylitis	15 (14.4%)	6.2
	Lumbar disc herniation	27 (26.0%)	5.7
	Periarthritis of the shoulder	4 (3.8%)	5.3
	Bilateral rhizoarthrosis and bilateral radiocarpal arthrosis	1 (1.0%)	5.0
	Carpal tunnel syndrome	5 (4.8%)	4.7
	Cervical disc herniation	2 (1.9%)	4.6
Noise induced occupational hearing loss		7 (6.7%)	7.1
Raynaud's phenomenon		1 (1.0%)	3.7
Pulmonary silicosis		1 (1.0%)	6.7

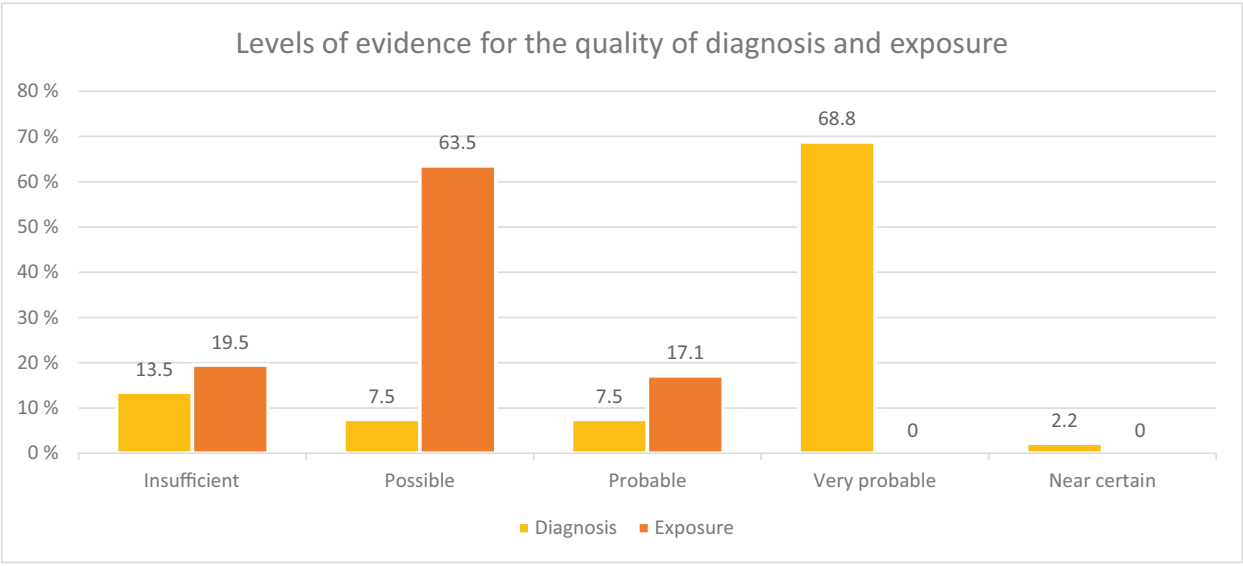

Figure 1. Levels of evidence for the quality of diagnosis (orange bars) and exposure (yellow bars) following Violante's criteria.

rhizoarthrosis and bilateral radio-carpal arthrosis of the hands, cervical disc herniation, degenerative meniscopathy, epicondylitis, lumbar disc herniation, lumbar spondylodiscopathy, noise-induced occupational hearing loss, osteoarthropathies (wrist, elbow, shoulder), pulmonary silicosis, quadriceps tendinopathy, tendinitis of the long head of the biceps brachii, tendinitis of the supraspinatus. In these cases, symptoms

were present, clinical findings were present, and written documentation of a reference test was assumed to be the "gold standard" for each disease.

The level of evidence according to Violante's criteria for diagnosis was deemed "insufficient" in several reported cases of these diseases: lumbar disc herniation (18.5%), supraspinatus tendinitis (11.1%), elbow tendinopathies (11.7%), noise-induced occupational hearing loss (21.5%), degenerative meniscopathy (16.7%), carpal tunnel syndrome (35%), and Raynaud's phenomenon (100%). In only a few reported cases was the level of evidence for diagnosis considered "near certain" for lumbar disc herniation (3.7%), lumbar spondylodiscopathy (7.1%), and supraspinatus tendinitis (5.6%) due to the documentation of surgical intervention. Detailed data on the level of evidence for each diagnosis can be found in the supplementary material (Table S1).

The four physicians assigned a "possible" level of evidence, per Violante's Criteria, to ≥ 50% of the reported cases regarding the quality of exposure to risk factors for the following conditions: bilateral rhizoarthrosis, bilateral radio-carpal arthrosis of the hands, cervical disc herniation, degenerative meniscopathy, periarthritis of the shoulder, elbow tendinopathies, lumbar disc herniation, lumbar spondylodiscopathy, noise-induced occupational hearing loss, tendinitis of the long head of the biceps brachii, and supraspinatus tendinitis. No case of reported occupational disease has been assigned a "very probable" or "near certain" level of evidence in evaluating the quality of exposure to risk factors. Extensive data on the level of evidence for the quality of exposure are available in the supplementary material (Table S1).

4. Discussion

The current study indicates that the quality of the reports is generally adequate (72%). However, further improvement can be made by refining the assessment of exposure to risk factors and enhancing the collection of non-occupational history. Inadequate medical histories also hinder the identification of non-occupational causes for the same disease. While some typical occupational diseases, such as occupational hearing loss, demonstrated good quality of reporting, several musculoskeletal disorders and Raynaud's phenomenon exhibited a low mean quality score (<6). This discrepancy may be attributed to the multifactorial nature of these diseases. The quality of diagnosis and reporting could be improved by gathering data on other potential non-occupational causes and obtaining a comprehensive medical history of the patient.

The level of evidence for diagnosis predominantly resulted in a very probable estimation (68.8%), mainly when specific symptoms, clinical findings, and written documentation of a reference test, considered the gold standard, are available. Conversely, the poor performance in assessing exposure to risk factors suggests that, despite a clearly defined disease, a lack of documentation regarding exposure prevents establishing a clear cause-effect relationship. In most cases, the reports included administrative employment documentation, job title, and written information about the work that could at least qualitatively suggest exposure. Although the quality of diagnosis and the work history is adequate for establishing a causal link in the MALPROF system, the absence of precise information on exposure to specific occupational risk factors may impact the accuracy of causal attribution. A written evaluation conducted by a safety professional, including a documented exposure assessment or an appropriate checklist, could enhance this aspect. A job-exposure matrix can be used when such data are unavailable, or only the job title is included in the report. Furthermore, it would be beneficial to consider epidemiological criteria, where the evidence of exposure can reach a high level of probability. In this regard, data on occupational exposures serve as critical information for establishing a relationship between specific job tasks and the emergence of an occupational disease.

Our results further confirm that several factors—such as a lack of understanding of the dose-response relationship between exposure levels and detrimental effects on target organs, coupled with a lack of data on exposure to specific risk factors—can influence the attribution of a causal link in suspected work-related diseases. Additionally, our study emphasizes that the quality of reports is often insufficient due to inadequate detail in certification.

Possible explanations for this phenomenon include the non-mandatory assessment of non-professional risk factors, lack of time, and the absence or incompleteness of documentation regarding exposure to risk factors. This underscores the need to increase the number of reports from occupational physicians who prioritize risk assessment and the etiological diagnosis of occupational diseases. Moreover, adherence to standardized collection systems for occupational diseases, such as MAREL provided by the national compensation system (INAIL), could enhance the quality assessment of the causal link between exposure to occupational risk factors and the development of multifactorial diseases. To accomplish this goal, it is essential to establish a network of occupational medicine clinics that workers can access upon referral from general practitioners, occupational physicians, and other specialists.

Data on professional exposures, along with the specific details characterizing them (level and type of exposure, use of any personal protective equipment, causal link), represent central information and the added value of the Marel system. This data facilitates the integration of information collected by the MALPROF system, which enables the determination of causal links between illness and work history concerning sectors of economic activity and professional qualifications, though not relating to specific exposure agents. In MAREL, a team of experts categorized the "exposure agent" variable into four macro-groups: biological agents, biomechanical overload agents, chemical agents, physical agents, jobs, and psychosocial risk factors. Each macro-category lists specific exposure agents, totaling 439 names.

4.1. Limitations and Strengths of the Study

Some limitations affect the current study: first, the small sample size of the analyzed occupational disease reports. Applying the criteria proposed by Spreeuwers and Violante to a larger number of reports may allow for attributing a specific quality level to the evaluation of the disease and the exposure. It would also provide a clear framework for linking a particular disease to workplace exposure, considering non-occupational factors that may be causally relevant. Second, the Spreeuwers performance indicators were developed for two occupational diseases: noise-induced hearing loss and occupational adjustment disorder. The Spreeuwers criteria have also been applied and adapted in our study to evaluate musculoskeletal disorders and pulmonary silicosis. Therefore, validating the Spreeuwers criteria for application across all types of occupational pathologies is essential. The strengths of our study include using standardized methods to evaluate the quality of occupational disease diagnosis and providing clear criteria for establishing a causal role. Moreover, our study offers specific recommendations for improving the quality of diagnosis and reporting. In contrast, most studies only observe that the recognition and reporting of occupational diseases is inadequate, without addressing the issues that require quality improvement.

5. Conclusions

Knowledge of diagnostic criteria, case definitions, and national or international evidence-based guidelines is necessary for occupational physicians' daily practice. The results of this quality assessment study could help the clinical figures involved in the prevention, diagnosis, and reporting of occupational diseases to improve and facilitate the reporting process, focusing their attention on an in-depth collection of all performance indicators, especially on the assessment of exposure to risk factors and non-occupational history. The training and periodical updating of physicians in the field of etiological diagnosis and the promotion of a culture of prevention in the workplace, including medical staff in hospitals, should be considered to reach better quality standards.

It will be interesting to follow a new data collection system like MAREL implemented in INAIL. Here, the homogeneous and systematic collection of information from more specialized centres can produce massive amounts of information of great utility for knowledge and prevention. It also allows for the consideration of cases of pathology that, by their nature or their particular relationship with unrecognized professional risk factors, are not yet listed in the tables or in the lists of current rules.

Supplementary Materials: The following are available in the online version: Table S1: The level of evidence for diagnosis and exposure as a percentage of the total, following Violante's criteria.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. Due to the observational nature of our research, no formal approval of the Institutional Review Board or the Ethics Committee of Sardinia was required, as no additional procedure or therapeutic medication was involved.

Informed Consent Statement: Not applicable.

Declaration of Interest: The authors declare no conflict of interest.

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References

1. Health and Safety Executive (HSE) Achieving the Revitalizing Health and Safety Targets. Statistical Note on Progress Measurement 2001.
2. Ross DJ. Ten Years of the SWORD Project. Surveillance of Work-Related and Occupational Respiratory Disease. *Clin. Exp. allergy J Br Soc Allergy Clin Immunol.* 1999;29:750–753. Doi: 10.1046/j.1365-2222.1999.00557.x.
3. Cherry NM, Meyer JD, Holt DL, Chen Y, McDonald JC. Surveillance of Work-Related Diseases by Occupational Physicians in the UK: OPRA 1996-1999. *Occup Med. (Lond).* 2000;50:496–503. Doi: 10.1093/occmed/50.7.496
4. Esterhuizen TM, Hnizdo E, Rees D, et al. Occupational Respiratory Diseases in South Africa--Results from SORDSA, 1997-1999. *S Afr Med J.* 2001;91:502–508.
5. Karjalainen A, Aalto L, Jolanki R, Keskinen H, Makinen I, S.A. *Occupational Diseases in Finland in 1999*; Helsinki: Finnish Institute of Occupational Health, 2001.
6. Hauptverband der Gewerbliche Berufsgenossenschaften (HVBG) *Geschafts - Und Rechnungsergebnisse Der Gewerblichen Berufsgenossenschaften. Sankt Augustin: Hauptverband Der Gewerblichen Berufsgenossenschaften*; 2003.
7. Matte TD, Hoffman RE, Rosenman KD, Stanbury M. Surveillance of Occupational Asthma under the SENSOR Model. *Chest* 1990;98:173S-178S. Doi:10.1378/chest.98.5_supplement.173s.
8. Centre for Occupational and Environmental Health at the University of Manchester The Health and Occupation Reporting Network (THOR) Available online: http://www.medicine.manchester.ac.uk/coeh.
9. Bonneterre V, Bicout D, Bernardet C, Dupas D, de Clavière C, de Gaudemaris R. [The National Occupational illness surveillance and Prevention Network (RNV3P)and health monitoring]. *Sante Publique*. 2008; 20 Suppl 3:S201-10. Doi: 10.3917/spub.083.0201
10. Methodologies to Identify Work-Related Diseases: Review of Sentinel and Alert Approaches | Safety and Health at Work EU-OSHA.
11. Verbeek J. When Work Is Related to Disease, What Establishes Evidence for a Causal Relation? *Saf. Health Work*. 2012;3:110–116. Doi:10.5491/SHAW.2012.3.2.110
12. Commission of the European Communities *Commission Recommendation of 19/09/2003 Concerning the European Schedule of Occupational Diseases. Report No.: C (2003) 3297*; Brussels, 2003.
13. Blandin MC, Kieffer CLC. *Occupational Diseases in 15 European Countries*; Paris: Eurogip, 2002.
14. Blandin MC, Kieffer CLC. *Survey on Under-Reporting of Occupational Diseases in Europe*; Report no. Euro-gip-03/E.: Paris: Eurogip, 2002.
15. Coggon, D. Monitoring Trends in Occupational Illness. *Occup Environ Med.* 2001;58:691–693. Doi: 10.1136/oem.58.11.691
16. Azaroff LS, Levenstein C, Wegman DH. Occupational Injury and Illness Surveillance: Conceptual Filters Explain Underreporting. *Am J Public Health*. 2002; 92:1421–1429, Doi: 10.2105/ajph.92.9.1421
17. Curti S, Sauni R, Spreeuwers D, et al. Interventions to Increase the Reporting of Occupational Diseases by Physicians. *Cochrane database Syst. Rev.* 2015:CD010305. Doi: 10.1002/14651858.CD010305.pub2
18. Porru S, Carta A, Toninelli E, Bozzola G, Arici C. Reducing the Underreporting of Lung Cancer Attributable to Occupation: Outcomes from a Hospital-Based Systematic Search in Northern Italy. *Int Arch Occup Environ Health*. 2016;89:981–989. Doi: 10.1007/s00420-016-1135-5
19. Campo G, Papale A, Baldasseroni A, et al. The Surveillance of Occupational Diseases in Italy: The MALPROF System. *Occup Med. (Lond).* 2015;65: 632–637. Doi:10.1093/occmed/kqv167

20. Campo G, Leva A, Montanari P, Papale AG. di LM. *MALPROF 2019-2020 - L'undicesimo Rapporto INAIL – Regioni Sulle Malattie Professionali*; 2023.
21. Decree of the President of the Republic (DPR) No. 1124 of 30 June 1965 (Decreto 30 Giugno 1965 n. 1124 – Testo Unico Delle Disposizioni per l'assicurazione Obbligatoria Contro Gli Infortuni Sul Lavoro e Le Malattie Professionali).
22. Spreeuwers D, de Boer AGEM, Verbeek JHAM, van Beurden MM, van Dijk FJH. Diagnosing and Reporting of Occupational Diseases: A Quality Improvement Study. *Occup Med. (Lond).* 200;58:115–121. Doi: 10.1093 /occmed/kqm146.
23. Violante FS. Criteria for Diagnosis and Attribution of an Occupational Musculoskeletal Disease. *Med Lav.* 2020;111:249–268. Doi:10.23749/mdl.v111i4.10340
24. Palmer K, Walker-Bone K, Linaker C, et al. The Southampton Examination Schedule for the Diagnosis of Musculoskeletal Disorders of the Upper Limb. *Ann Rheum Dis.* 2000;59:5–11. Doi: 10.1136/ard.59.1.5.
25. Alonso-Coello P, Schünemann HJ, Moberg J, et al. GRADE Evidence to Decision (EtD) Frameworks: A Systematic and Transparent Approach to Making Well Informed Healthcare Choices. 1: Introduction. *BMJ*. 2016;353:i2016. Doi:10.1136/bmj.i2016
26. Alonso-Coello P, Oxman AD, Moberg J, et al. GRADE Evidence to Decision (EtD) Frameworks: A Systematic and Transparent Approach to Making Well Informed Healthcare Choices. 2: Clinical Practice Guidelines. *BMJ*. 2016;353:i2089. Doi:10.1136/bmj.i2089
27. Walker HK, Hall WD, Hurst JW. *Clinical Methods: The History, Physical, and Laboratory Examination*; Eds.; Boston, 1990; ISBN 0-409-90077-X.
28. Sackett DL. The Rational Clinical Examination. A Primer on the Precision and Accuracy of the Clinical Examination. *JAMA*. 1992;267:2638–2644.
29. KuijerPPFM,VerbeekJH,SeidlerA,etal.Work-Relatedness of Lumbosacral Radiculopathy Syndrome: Review and Dose-Response Meta-Analysis. *Neurology*. 2018;91: 558–564. Doi: 10.1212/01.wnl.0000544322.26939.09
30. van der Molen HF, Foresti C, Daams JG, Frings-Dresen MHW, Kuijer PPFM. Work-Related Risk Factors for Specific Shoulder Disorders: A Systematic Review and Meta-Analysis. *Occup Environ Med.* 2017; 74:745–755. Doi: 10.1136/oemed-2017-104339
31. Verbeek J, Mischke C, Robinson R, et al.. Occupational Exposure to Knee Loading and the Risk of Osteoarthritis of the Knee: A Systematic Review and a Dose-Response Meta-Analysis. *Saf Health Work*. 2017;8: 130–142. Doi: 10.1016/j.shaw.2017.02.001
32. Pauling JD, Hughes M, Pope JE. Raynaud's Phenomenon-an Update on Diagnosis, Classification and Management. *Clin Rheumatol.* 2019;38:3317–3330. Doi: 10.1007/s10067-019-04745-5
33. Hulshof CTJ, Pega F, Neupane S, et al. The Prevalence of Occupational Exposure to Ergonomic Risk Factors: A Systematic Review and Meta-Analysis from the WHO/ILO Joint Estimates of the Work-Related Burden of Disease and Injury. *Environ Int.* 2021;146:106157. Doi: 10.1016/j.envint.2020.106157
34. Siemiatycki J, Lavoué J. Availability of a New Job-Exposure Matrix (CANJEM) for Epidemiologic and Occupational Medicine Purposes. *J Occup Environ Med.* 2018;60:e324–e328. Doi: 10.1097/JOM.0000000000001335
35. Aekplakorn W, Suriyawongpaisal P, Methawikul, T. The Diagnosis and Reporting of Occupational Diseases: The Performance of Physicians in Thailand. *Southeast Asian J Trop Med Public Health*. 2002; 33:188–192.
36. Campo G, Mattioli S, Cocco P, et al. Marel: From the Network of Occupational Medicine Consultation Centres to the Analysis of Occupational Exposure Data. *Med Lav.* 2018;108:5–12. Doi: 10.23749/mdl. v108i1-S.6971
37. Shofer S, Haus BM, Kuschner WG. Quality of Occupational History Assessments in Working Age Adults with Newly Diagnosed Asthma. *Chest*. 2006;130: 455–462. Doi:10.1378/chest.130.2.455.

Table S1. Level of evidence for diagnosis and exposure as percentage from the total, following Violante's criteria

	Level of evidence for diagnosis (%)						Level of evidence for exposure (%)					
	Evaluator	**Insufficient**	**Possible**	**Probable**	**Very probable**	**Near certain**	**Evaluator**	**Insufficient**	**Possible**	**Probable**	**Very probable**	**Near certain**
Bilateral rhizoarthrosis and bilateral radio-carpal arthrosis of the hands, n. 1 (1%)	1	0	0	0	100	0	1	0	100	0	0	0
	2	0	0	0	100	0	2	0	100	0	0	0
	3	0	0	0	100	0	3	0	100	0	0	0
	4	0	0	0	100	0	4	0	100	0	0	0
	Mean	**0**	**0**	**0**	**100**	**0**	**Mean**	**0**	**100**	**0**	**0**	**0**
Carpal tunnel syndrome, n.5 (4.8%)	1	20	20	20	40	0	1	60	40	0	0	0
	2	40	0	20	40	0	2	60	40	0	0	0
	3	40	0	20	40	0	3	60	40	0	0	0
	4	40	20	0	40	0	4	60	40	0	0	0
	Mean	**35**	**10**	**15**	**40**	**0**	**Mean**	**60**	**40**	**0**	**0**	**0**
Cervical disc herniation, n. 2 (1.9%)	1	0	0	0	100	0	1	0	50	50	0	0
	2	0	0	0	100	0	2	0	50	50	0	0
	3	0	0	100	0	0	3	0	50	50	0	0
	4	0	0	50	50	0	4	0	50	50	0	0
	Mean	**0**	**0**	**37,5**	**62,5**	**0**	**Mean**	**0**	**50**	**50**	**0**	**0**
Degenerative meniscopathy, n.6 (5.8%)	1	16,7	0	0	83,3	0	1	16,7	50	33,3	0	0
	2	16,7	0	0	83,3	0	2	16,7	50	33,3	0	0
	3	16,7	0	16,7	66,7	0	3	16,7	50	33,3	0	0
	4	16,7	0	0	83,3	0	4	33,3	33,3	33,3	0	0
	Mean	**16,7**	**0**	**4,18**	**79,15**	**0**	**Mean**	**20,85**	**45,83**	**33,3**	**0**	**0**
Periarthritis of the shoulder, n.4 (3.8%)	1	0	25	50	25	0	1	25	75	0	0	0
	2	0	50	25	25	0	2	25	75	0	0	0
	3	0	50	25	25	0	3	25	75	0	0	0
	4	0	75	0	25	0	4	25	75	0	0	0
	Mean	**0**	**50**	**25**	**25**	**0**	**Mean**	**25**	**75**	**0**	**0**	**0**

Elbow tendinopathies, n. 15 (14.8%)	1	0	20	0	80	0	1	20	66,7	13,3	0	0
	2	6,7	13,3	0	80	0	2	20	66,7	13,3	0	0
	3	20	6,7	13,3	60	0	3	20	73,3	6,7	0	0
	4	20	6,7	0	73,3	0	4	26,7	60	13,3	0	0
	Mean	**11,68**	**11,68**	**3,33**	**73,33**	**0**	**Mean**	**21,675**	**66,68**	**11,65**	**0**	**0**
Lumbar disc herniation, n. 27 (26%)	1	14,8	11,1	14,8	55,6	3,7	1	29,6	55,6	14,8	0	0
	2	22,2	3,7	18,5	51,9	3,7	2	33,3	51,9	14,8	0	0
	3	18,5	14,8	11,1	51,9	3,7	3	33,3	55,6	11,1	0	0
	4	18,5	22,2	0	59,3	0	4	29,6	51,9	18,5	0	0
	Mean	**18,5**	**13,0**	**11,1**	**54,7**	**2,8**	**Mean**	**31,45**	**53,75**	**14,8**	**0**	**0**
Lumbar spondylodisco-pathy, n.14 (13.5%)	1	0	0	0	92,9	7,1	1	0	85,7	14,3	0	0
	2	0	0	7,1	85,7	7,1	2	0	85,7	14,3	0	0
	3	0	0	7,1	78,6	14,3	3	0	92,9	7,1	0	0
	4	0	0	0	100	0	4	0	85,7	14,3	0	0
	Mean	**0**	**0**	**3,55**	**89,30**	**7,13**	**Mean**	**0**	**87,5**	**12,5**	**0**	**0**
Noise-induced occupational hearing loss, n.7 (6.7%)	1	14,3	0	0	85,7	0	1	14,3	57,1	28,6	0	0
	2	14,3	0	0	85,7	0	2	14,3	57,1	28,6	0	0
	3	14,3	0	14,3	71,4	0	3	14,3	57,1	28,6	0	0
	4	42,9	0	0	57,1	0	4	14,3	57,1	28,6	0	0
	Mean	**21,45**	**0**	**3,58**	**74,98**	**0**	**Mean**	**14,3**	**57,1**	**28,6**	**0**	**0**
Arthrosis of the hands, n.1 (1%)	1	0	0	0	100	0	1	0	100	0	0	0
	2	0	0	0	100	0	2	0	100	0	0	0
	3	0	0	0	100	0	3	0	100	0	0	0
	4	0	0	0	100	0	4	0	100	0	0	0
	Mean	**0**	**0**	**0**	**100**	**0**	**Mean**	**0**	**100**	**0**	**0**	**0**
Pulmonary silicosis, n.1 (1%)	1	0	0	0	100	0	1	100	0	0	0	0
	2	0	0	0	100	0	2	100	0	0	0	0
	3	0	0	0	100	0	3	100	0	0	0	0
	4	0	0	0	100	0	4	100	0	0	0	0
	Mean	**0**	**0**	**0**	**100**	**0**	**Mean**	**100**	**0**	**0**	**0**	**0**

Table S1 (*Continued*)

	Level of evidence for diagnosis (%)						Level of evidence for exposure (%)					
	Evaluator	**Insufficient**	**Possible**	**Probable**	**Very probable**	**Near certain**	**Evaluator**	**Insufficient**	**Possible**	**Probable**	**Very probable**	**Near certain**
Quadriceps tendinopathy, n.1 (1%)	1	0	0	0	100	0	1	0	0	100	0	0
	2	0	0	0	100	0	2	0	0	100	0	0
	3	0	0	0	100	0	3	0	100	0	0	0
	4	0	0	0	100	0	4	0	0	100	0	0
	Mean	**0**	**0**	**0**	**100**	**0**	**Mean**	**0**	**25**	**75**	**0**	**0**
Raynaud's phenomenon, n.1(1%)	1	100	0	0	0	0	1	0	0	100	0	0
	2	100	0	0	0	0	2	0	0	100	0	0
	3	100	0	0	0	0	3	0	0	100	0	0
	4	100	0	0	0	0	4	0	0	100	0	0
	Mean	**100**	**0**	**0**	**0**	**0**	**Mean**	**0**	**0**	**100**	**0**	**0**
Tendinitis of the long head of the biceps brachii, n.1 (1%)	1	0	0	0	100	0	1	0	100	0	0	0
	2	0	0	0	100	0	2	0	100	0	0	0
	3	0	0	0	100	0	3	0	100	0	0	0
	4	0	0	0	100	0	4	0	100	0	0	0
	Mean	**0**	**0**	**0**	**100**	**0**	**Mean**	**0**	**100**	**0**	**0**	**0**
Tendinitis of the supraspinatus, n.18 (17.3%)	1	11,1	5,6	0	77,8	0	1	11,1	72,2	16,7	0	0
	2	11,1	0	5,6	83,3	0	2	5,6	72,2	22,2	0	0
	3	11,1	5,6	11,1	66,7	5,6	3	5,6	77,8	16,7	0	0
	4	11,1	5,6	0	83,3	0	4	5,6	72,2	22,2	0	0
	Mean	**11,1**	**4,2**	**4,18**	**77,78**	**1,4**	**Mean**	**6,98**	**73,6**	**19,45**	**0**	**0**

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Ricordo di Alessandro Berra (1930-2024)

Lo scorso 23 dicembre è mancato, all'età di 94 anni, il Professor Alessandro Berra. Nato ad Acqui Terme (Alessandria) il 21 luglio 1930, dopo aver compiuto gli studi classici presso il Liceo "Carlo Alberto" di Moncalieri, si laureò in Medicina e Chirurgia presso l'Università di Torino nel novembre 1954, a pieni voti e con dignità di stampa per la sua Tesi.

Successivamente acquisì, presso l'Università di Torino e sempre a pieni voti, le specializzazioni in Medicina del Lavoro, in Malattie dell'Apparato Respiratorio, in Radiologia e in Igiene. Abilitato alla Libera Docenza in Medicina del Lavoro con Decreto Ministeriale del 1961, fu Assistente negli Istituti di Medicina del Lavoro di Padova (1957-1965) e Torino (1965-1973). Sempre a Torino, fu Primario Ospedaliero di Medicina del Lavoro al CTO (1974-1986) e all'Ospedale Maggiore San Giovanni Battista (1986-1987). Fu poi Direttore dei Servizi Sanitari di FIAT AUTO (1987-2005) e Consulente Sanitario di FIAT GROUP AUTOMOBILES (2006-2008). Nel 2007 fu eletto Presidente dell'Associazione Piemontese e Aostana di Medicina e Igiene del Lavoro (APAMIL), poi Sezione Piemonte-Val d'Aosta della Società Italiana di Medicina del Lavoro e Igiene Industriale (SIMLII), di cui è stato nominato Socio Onorario nel 2011.

Il Professor Berra è stato, per più di 50 anni, uno dei protagonisti della Medicina del Lavoro italiana. Era un uomo complesso. A partire dal nome: Alessandro all'anagrafe e negli Atti ufficiali, Alessio per chi ha lavorato con lui, Franco per tutti gli altri. Complesso è stato il suo cammino formativo: quattro specializzazioni, tutte collegate al suo interesse scientifico e clinico prevalente: le affezioni di natura professionale dell'apparato respiratorio. Complesso era il suo carattere: elitario, ma accogliente; sofisticato, ma disponibile; irascibile, ma gentile. Era un uomo che ha vissuto la sua vita fuori dagli schemi ordinari. Per questo non sempre era capito e non da tutti era amato. Complesso il suo iter professionale: dopo una brillante quindicinale attività universitaria (queste le parole con cui lo descriveva il Professor Massimo Crepet, Direttore dell'Istituto di Medicina del Lavoro dell'Università di Padova: "Nei molti anni in cui l'ho avuto collaboratore ho potuto ben conoscere ed apprezzare le sue ottime qualità di intelligenza pronta e vivace e di passione per il lavoro di ricerca, che gli hanno consentito di acquisire esperienza notevole ed approfondita nel campo della Medicina del Lavoro") decise di percorrere strade più pragmatiche, come Primario Ospedaliero di Medicina del Lavoro e infine Direttore Sanitario di un'Azienda complessa come la FIAT.

La sua attività era infatti caratterizzata da un pragmatismo a volte spiazzante, anche se, ogni tanto, si lanciava in una delle sue imprese conoscitive che sapeva prive di uno sbocco pratico: era quello che lui chiamava "l'arte per l'arte". Aveva una cultura vasta ed eclettica, una razionalità al limite dell'ostinazione, una memoria prodigiosa, un'intelligenza acuta e veloce, una visione dei problemi spesso un passo avanti.

Se i suoi allievi dovessero associare un argomento al ricordo del Professor Berra, probabilmente cite-

rebbero lo studio delle 'piccole vie aeree'. Negli anni Settanta, fu tra i primi in Italia a riconoscerne l'importanza per la prevenzione delle pneumopatie professionali. Sebbene ricerche successive abbiano ridimensionato questa linea di ricerca, all'epoca era un approccio innovativo che perseguì con entusiasmo, dotando di strumenti all'avanguardia il laboratorio di Fisiopatologia Respiratoria.

Aveva una continua curiosità e un continuo bisogno di conoscenza e di documentazione (l'ossessione per la "bibliografia", che ha trasmesso a coloro che hanno lavorato con lui). E, questo, in ogni campo: nella vita professionale a al di fuori di questa, applicando il "metodo scientifico" anche ai piaceri della vita. Poche persone, forse, possono essere descritte, come lui, da queste parole dello scrittore americano James A. Michener: "The master in the art of living makes little distinction between his work and his play, his labor and his leisure, his mind and his body, his information and his recreation, his love and his religion. He hardly knows which is which. He simply pursues his vision of excellence at whatever he does, leaving others to decide whether he is working or playing. To him, he's always doing both".

Canzio Romano