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Reviews, Commentaries, Perspectives

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La Medicina del Lavoro

Editorial

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Over a Century of Occupational Medicine Research in Italy: *La Medicina del Lavoro*'s Entire Digital Archive is Available Online

The Italian Society of Occupational Medicine and the Editorial Staff of *La Medicina del Lavoro* proudly announce that the entire collection since 1901 is available in digital format. One of the most exciting features of this digital archive is its powerful search capability. Users can now search articles by author's name, keywords, or words occurring in the text. Finding articles relevant to any searching and retrieving strategy is easy. Researchers can quickly find information from decades of research and studies without sifting through countless pages. The availability of this digital archive is a major step forward for research on the history of Occupational Medicine in Italy. It will allow researchers and practitioners to easily access past studies and build upon them to improve workplace safety and health outcomes. Additionally, it will be an invaluable resource for students just beginning their studies in occupational medicine. This online archive will provide an extensive collection of papers students can draw upon when writing their research papers.

Another significant benefit of having a fully searchable digital archive is that it enables researchers to track trends in Occupational Medicine over time. They can easily browse through decades worth of articles and see how research themes have evolved, identify areas where progress has been made, and evaluate areas where more work needs to be done. Furthermore, this new digital archive offers great convenience for readers who wish to access specific articles from past issues. Previously, scholars needing a copy of an article from a particular volume would have had to visit a library or request it through interlibrary loan, a very time-consuming process. The ability to retrieve individual articles as pdf files online offers users an efficient solution and saves them valuable time. We are excited about this new digital archive's possibilities for Occupational Medicine. The ability to access previous research papers and studies digitally will further support advancements in the field and contribute to a safer, healthier workplace for all.

In addition to the availability of *La Medicina del Lavoro*'s entire collection in digital format, we would like to add a comment regarding the shift towards using English as the primary language in scientific research articles. Over the past few years, there has been a gradual transition towards using English exclusively in academic and scientific publications, with only a few documents and obituaries remaining in the traditional Italian language. Such a shift has been associated with excellent bibliometrics performance, as evidenced by the sharp increase in the JIF (Journal Impact Factor) and Cite Score (Scopus) from 0.6 to around 3.0. We are eagerly awaiting the 2022 official scores, expected to be announced by Clarivate's JCR and Scopus by mid-June, which should confirm what seems to be a steady trend.

While it is important to acknowledge and preserve our national languages and cultural heritage, we cannot ignore that English has become the *lingua franca* of science and research worldwide. By adopting English as the primary language for academic research publications, Italian researchers can reach a wider audience, collaborate more effectively with international colleagues, and showcase their work globally. The effort to reach a wider audience is demonstrated by the availability of a mirror publication of each article on PMC (PubMed Central, a free full-text archive of biomedical and life sciences journal literature at the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM).

With reputable journals like *La Medicina del Lavoro* transitioning to English-only publications, Italian scientists have greater access to prominent platforms for sharing their research findings with a global audience. Therefore, we urge all researchers, practitioners, and students interested in occupational medicine to take advantage of this exciting new resource and explore the digital archive of *La Medicina del Lavoro*. We hope that it will provide valuable insights as we continue to work towards improving workplace health and safety outcomes in Italy and beyond. At the same time, while we recognize that this shift towards using English may be accompanied by some challenges related to preserving our cultural heritage, it ultimately benefits our scientific community.

By embracing this trend and publishing high-quality research articles in English-language, we can further enhance our researchers' international standing and contribute meaningfully to ongoing efforts to improve worldwide occupational health and safety outcomes. With good citation scores and a reputation for publishing high-quality research, we hope that *La Medicina del Lavoro* will continue attracting submissions from foreign authors, further cementing its position as a leading journal in occupational health and safety, moving towards an increasingly interconnected global community of researchers promoting collaboration and sharing knowledge across borders.

Whereas we left the Italian language, i.e., a tradition consolidated by over 110 annual volumes of our journal, we are reluctant to accept some innovations, such as using the internet to implement scientific research projects. We seldom accept web surveys for publication in our journal because of concerns about validity and data quality. Our journal strives to provide impartial scientific information on Occupational Medicine and leverages modern information technologies to achieve this goal. However, to ensure the credibility of papers that use web surveys, authors should avoid taking shortcuts that could affect the validity of findings. Construct validity of unvalidated questionnaires is a major handicap in web-based surveys. Getting consistent responses can be challenging due to varying vocabulary, internet literacy levels, and engagement among respondents. Inconsistency can lead to invalid responses and reduce the usefulness of collected data.

Selection bias is the main concern when using social media for recruitment, as it may exclude individuals who do not use these platforms. The snowball sampling technique often used in web surveys can be useful to recruit participants from a specific group that is otherwise difficult to reach. However, this technique can limit the sample variability if participants only recruit other people they have an affinity with. This issue can hinder the study's external validity, as the examined sample may not show the actual target population's characteristics. Control over response rates is challenging in online surveys, making it difficult to assess the representativeness of samples and evaluate nonresponse bias. Technical issues and other factors may also result in incomplete or skewed data or uncontrolled multiple responses from the same individuals. Another issue with social media-based surveys is poor data quality because of respondents' poor motivation and involvement. Some participants may skip questions or provide inaccurate answers because of a lack of interest, misunderstanding, or social desirability bias. Fake identities and declarations may lead to the contamination of specific study groups. Data privacy is also a concern when collecting personal information through social networks, as these platforms often share user data without consent. Altogether, such drawbacks might hamper our commitment to ensuring the highest scientific standard and integrity of research published in our journal.

The magazine became our official journal in 2015 after publishing important research in occupational medicine for over a century. We introduced progressive changes while respecting and adding value to its glorious history. Its entire archive is now fully digitalized, making it easier than ever for researchers to access invaluable information related to their work through a link available at the journal's site *La Medicina del Lavoro*. It could also be accessed from the homepages of the Italian Society of Occupational Medicine and Milan's State University (link: https://collezioni.unimi.it/dcb/rivlavoro/index.php) to benefit new generations of scholars who could continue to build up over the shoulders of the discipline's outstanding pioneers.

Antonio Mutti,
Direttore responsabile de La Medicina del Lavoro

Giovanna Spatari,
Presidente Società Italiana di Medicina del Lavoro

La Medicina del Lavoro

Reviews, commentaries, perspectives

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Still Unanswered Questions about SARS-CoV-2 Mortality and Future Directions for Occupational Medicine

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Keywords: COVID-19; Mortality; Workers; Personal Protective Equipment; Occupational Medicine

Summary

The article discusses a recent study on mortality attributable to COVID-19 in Italy and the need for further analysis. The study used a reliable methodology to estimate excess deaths due to the pandemic. However, there are still questions about the specific effects of COVID-19 compared to other factors, such as delayed or missing access to treatment for other illnesses. Analyzing the time course of excess deaths could reveal such effects. There are also open questions about how COVID-19 deaths are classified and reported, which could lead to over or under-diagnosing cases. The article notes that occupational physicians have played an important role in preventing the spread of COVID-19 among workers. A recent study found that personal protective equipment (PPE), particularly masks, effectively reduced the risk of infection among healthcare workers. However, it is still unclear whether Occupational Medicine should incorporate infectious diseases as a major concern or return to its historically agnostic attitude toward communicable diseases. More data on mortality from specific diseases will be needed for further analysis and understanding of the pandemic's effects on mortality rates in Italy.

In this journal issue, Alicandro et al. [1] publish an article on mortality attributable to the SARS-CoV-2 virus pandemic both in the total population and in the population of potentially working age (25-64 years). The methodology used to estimate expected cases[1], as in their previous works also in this journal [2-4], is the best available to date and certainly more adequate than other approaches based on the average mortality of recent years (e.g., an average of the five-year period 2015-2019). Just because the methodology used makes it possible to provide a reliable estimate of the overall effect of the pandemic event on mortality (excess of cases = observed deaths - expected deaths), it is time to deepen the analysis because it makes sense to ask some more specific questions, which *in fieri* are already highlighted in the discussion of Alicandro and coworkers' article.

The overall estimate of the pandemic effect refers to the joint effect of all factors, other than SARS-CoV-2 infection, that interacted with COVID-19 during the pandemic period, sometimes increasing the death numbers (e.g., the heat wave of summer 2022) other times by decreasing them (e.g., the anticipation of the seasonal effect of the flu) [1]. Is it possible to distinguish the various effects, at least the most significant and recognizable ones, which occurred during the period? Can we try to identify effects directly attributable to the virus? Can the effect of other causes (other risk factors) be estimated? For instance, the delayed or missing access to treatment reported by many professionals in specialties

[1]"*Expected deaths were obtained using over-dispersed Poisson regression models, fitted separately for men and women, including calendar year, age group, and a smoothed function of the day of the year as predictors*" [1] using 2011-2019 mortality data.

such as Cardiology, Oncology, and Diabetes care (and others) could imply consequences on the health status of the patients involved: some early reports suggest that there has been an increase in mortality from cardiovascular diseases, cancer, and diabetes during the COVID-19 pandemic period, which may be related to changes in healthcare delivery and access to care, as well as other factors such as public fear and anxiety [5, 6]. Did the reduction in screening activities already give rise to any consequences on the mortality levels observed? There is debate around all these questions, and answers are eagerly awaited.

The analysis of the time course of the difference between excess total mortality and COVID-19 deaths suggests the existence of these phenomena as an alternative to the virus (or that acted together). For example, when COVID-19 deaths are much higher than total excess deaths, some other disease (or more than one) must be decreased; when COVID-19 deaths are much lower than the total excess deaths, some other pathology (or more than one) must have increased due to some intervening factors other than the SARS-CoV-2 infection.

These and other considerations discount a fundamental question: while the total mortality does not allow for misunderstandings (between alive and dead) and does not appear to be characterized by reporting defects, it remains instead open the great question on what is meant by the term "COVID-19 deaths": to classify the deaths, they have been given definitions, methods, but as with any decision of this type, both conceptual questions (adequacy of the definition) and practical questions (operating methods with which information is collected and reported on the collection tools) remain open. Such decisions can lead to over- or under-diagnosing and certifying COVID-19 cases. Unfortunately, only hypotheses can be formulated to be verified (at least in part) once detailed data on mortality by individual pathologies becomes available.

The excess of deaths of the working age also deserves some reflections and insights about the trend over time. For example, the number of COVID-19 deaths is not available in the working age groups considered. Nor is it available a detailed monthly trend of the observed excesses. Therefore, it is difficult to identify underlying factors. Although small numbers imply a high variability, the ratio between the percentages of excesses among total and working-age populations indicates a drastic change in 2021 compared to 2020 and 2022, which deserves exploration. Just as the share of excess mortality between workers in the 25-64 age group and non-workers in the same group needs to be investigated, considering that weaker subjects could have already been excluded from working activities because of their health conditions and frailty.

Answering these questions will help occupational physicians critically analyze the paradigm shift observed during the COVID-19 pandemic, which has brought them into the context of Public Health as a particular branch of Community Medicine that deals with worker prevention. In other words, we should understand whether the occupational physicians' commitment has been useful and necessary or, rather, only a generous involvement in an inappropriate area, to which Occupational Medicine gave only marginal results. Indeed, the epidemic dynamic among HCWs closely followed that in their living community, arguing against significant occupational transmission. A study also published in this journal issue [7] analyzed the risk factors for SARS-CoV-2 infection among more than 3,700 un-vaccinated healthcare workers (HCWs) identified among more than 38,000 HCWs, making it possible to assess the effectiveness of personal protective equipment (PPE) without the vaccination's concomitant effect. Results showed that HCWs assigned to COVID-19 units were not at higher risk of infection, and that mask use was the most effective personal protective equipment (PPE) in reducing the risk of infection. PPE could play an active role in modulating viral load and boosting the immune response, especially in the pre-vaccinal period, such a mechanism being similar to the so-called "variolation" process, where people susceptible to smallpox were inoculated with a small amount, causing a mild infection and subsequent immunity. Mansour et al. study also found that FFP2/FFP3 masks were more protective than surgical masks during the second wave of the pandemic, whereas using facial shields, disposable gowns, and gloves was associated with an increased risk of infection [7].

Overall, these data provide food for thought on the actual importance of the occupational physician in countering the spread of the virus in the workplace, which only in some situations, such as in slaughterhouses, has proved to be an important factor in the spread of the virus among migrants subjected to overcrowded and precarious housing conditions [8].

The decision to consolidate or abandon the recent choices depends on the outcomes of this assessment, i.e., whether to incorporate infectious diseases into the major concerns of Occupational Health moving toward and consolidating a new role of Occupational Medicine within Public Health, or rather, returning to the substantially agnostic attitude of Occupational Medicine toward communicable diseases, documented by the over a century-old history of our journal accessible in digital format.

Whereas we can consider as achieved with a certain degree of confidence the objective of estimating the total burden of deaths brought about by the pandemic and the other factors that acted simultaneously with it, we are still at the beginning of the knowledge of the specific effects on mortality attributable to the single (or combined) risk factors (virus, heat wave, flu, delayed care) in action over these first three years of SARS-CoV-2 presence in our country. To leap in quality, it will be necessary to wait for further data, particularly the mortality from specific diseases.

Declaration of Interests: The Author declares no conflict of interest.

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La Medicina del Lavoro

Reviews, commentaries, perspectives

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Diversity & Inclusion: Fitness for Work Through a Personalized Work Plan for Workers with Disabilities and Chronic Diseases According to ISO 30415/2021

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Keywords: Fitness for Work; Reasonable Accommodation; ISO 30415-2021 Standard; Personalized Work Plan

Summary

The recent standard ISO 30415-2021 - Human resources management - Diversity and inclusion - was developed internationally within the technical committee ISO/TC 260 "Human resources management" (Working group WG 8 "Diversity and inclusion") and emphasizes the need for measures to create a work environment that is inclusive of diversity (e.g. in terms of health, gender, age, ethnicity, culture). Developing an inclusive work environment requires ongoing commitment and engagement from the entire organization regarding policies, processes, organizational practices, and individual behavior. As far as the role of occupational medicine is concerned, this direction can be supported by the correct management of disabled workers and workers with chronic pathologies that affect their fitness for duty. The "reasonable accommodation" is the way by which first the European Union and then the United Nations intended to support the inclusion of people with disabilities in the world of work. The Personalized Work Plan includes different approaches (organizational, technical, procedural) meant for modifying the work activity envisaged for the disabled worker or for any worker suffering from chronic diseases or dysfunctions. The adoption of the Personalized Work Plan implies the effort of redesigning the workstation, the work procedures, or even the planning of different micro and macro tasks etc., in order to prioritize the adaptation of the working environment to the worker, and to preserve the value of the worker's productivity according to the principle of reasonable accommodation.

1. Introduction

Several factors may lead to difficulties in placing or transferring a worker to a job based on their health condition. These reasons can negatively affect their access to the world of work, even for workers with certified occupational diseases or injuries, when they apply for a dedicated and safe job under the supervision of Public Health institutions. The recent standard ISO 30415-2021 - Human resources

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management - Diversity and inclusion - was developed internationally within the framework of the technical committee ISO/TC 260 "Human resources management" (Working group WG 8 "Diversity and inclusion") and emphasizes the need for measures in order to create a work environment that is inclusive of diversity (e.g. in terms of health, gender, age, ethnicity, culture) [1].

Universal values enshrined in the United Nations Convention on the Rights of Persons with Disabilities (CRPD), as well as the European directives, the ICOH ethical guidelines, the specific legal standards, and, recently, ISO 30415:2021 on Diversity & Inclusion, require employers to ensure that workers with any degree of pathology, disability or functional limitations can be placed and relocated into a work environment, that may be adequately and reasonably adapted to their specific health conditions. [2, 3] On this basis, many countries have each adopted specific legislation for the inclusion and integration of people recognized as disabled into the world of work through support services and targeted placement.

In Italy, it has been established that the employer – in order to fulfill his obligations – can draw on public support measures, which can be activated by the "National Institute for Insurance against Accidents at Work" (INAIL) for the reimbursement of expenses for the reintegration of workers who have been victims of accidents and illnesses. In particular, INAIL lines of intervention move along three axes: (i) overcoming and removing architectural barriers in the workplace; (ii) adapting and arranging of workstations; (iii) specific training and redesigning workplaces based on qualifications.

2. The International and National Context

2.1. ISO 30415:2021 Standard

In May 2021, the ISO (International Standard Organization) published the first International Certification on "Diversity & Inclusion", ISO 30415:2021. The words "Diversity and Inclusion" (D&I) contain an essential concept for all companies: the importance - and the need - to integrate and give value to people despite their diversity and specificity (by gender, age, ethnicity, culture, and health), creating a truly inclusive work environment. ISO 30415 calls on companies to initiate a process of continuous improvement of inclusive capabilities and enhancement of diversity.

ISO 30415 is aimed at small and large companies of all types (public, private, non-profit) and sectors and involves all corporate stakeholders starting from the company governance. The goal is to establish a series of principles, roles, actions, policies, processes, and measures that make it possible to enhance diversity and support the highest level of inclusiveness in the company.

The principles that permeate this directive, even though they go far beyond mere health aspects, overlaps well with occupational medicine's goals in integrating and reintegrating workers suffering from chronic and disabling diseases into the workplace.

2.2. The "Reasonable Accommodation"

Directive 2000/78/EC placed the protection of the equal dignity of all human beings at the heart of European Union policy, including equal treatment in terms of employment and working conditions and the removal of barriers that hinder the full inclusion of persons with disabilities.

The provision of "reasonable solutions," identified by art. 5 of the same Directive in order to effectively ensure equal treatment, provided for the adoption by employers of some measures aimed at arranging the workplace according to disability.

In line with the sensitivity outlined at the European level, the United Nations Convention "on the rights of persons with disabilities" – adopted in New York on 13 December 2006 – extended the scope of the obligation introduced by European Directive no. 2000/78/EC, which provides for "reasonable accommodations" in corporate bodies consisting of "necessary and appropriate modifications and adjustments" to ensure the "right to work of people with disabilities, on an equal basis with others".

The sentence of the Court of Justice of the European Union (Second Section) of 11 April 2013, in which the judges ruled on an interpretative doubt stemming from Danish legislation regarding the extension of the notion, clarified that the term «disabled» in the Council Directive 2000/78/EC is to be interpreted as encompassing a pathological condition caused by a diagnosed illness which is curable or incurable, where such disease entails a limitation, resulting in particular from physical, mental or psychological impairments, which, in interaction with barriers of a different nature, may hinder a person's full and effective participation in professional life on an equal basis with other workers, and this limitation is of long duration.

In practice, this means that the measure of "reasonable accommodation" must be applied not only to those who are recognized as disabled and handicapped by specific public bodies in accordance with the legislation of each country but also to any worker affected by a disease that compromises their full fitness for work. It is, therefore, irrelevant whether the disability is certified, and in any case, there is no minimum threshold.

To reinforce this approach, we can read, in the act of accession of the European Union to the United Nations Convention on the rights of disabled persons, in December 2010 in art. 1: "Persons with disabilities are those with long-term physical, mental, intellectual or sensory impairments which, in interaction with various barriers, may hinder full and effective participation in society on an equal basis with others". Reasonable accommodation, therefore, makes it possible for a worker with a disability, who is qualified for a specific job position, to neutralize the disadvantage resulting from his or her state of health, allowing him to apply for a job and to carry out his work in conditions of equality with other workers.

In some countries, such as the United States and the United Kingdom, not only are there legal provisions (The Americans with Disabilities Act 1990 [4] and the UK Equality Act 2010 [5]), but also specific bodies have been created to implement these provisions specifically. For example, in the United States, the US Equal Employment Opportunity Commission-ADA (EEOC) and the Job Accommodation Network (JAN); in the UK, The Equality and Human Rights Co.

In different national legal contexts, the employer's legal obligations on "reasonable accommodation" can sometimes face obstacles related to privacy issues. For example, in some EU Member States, (Austria, the Czech Republic, Denmark, Estonia, France, Ireland, Norway, Portugal, and Sweden), the obligation to provide reasonable accommodation only arises when the employer is aware, or "should be aware", of the existence of the disability. Therefore, when the disability manifests, the employer is immediately subject to the obligation. However, it is unclear in which cases he "should have known" about it, as there are privacy laws and specific provisions for medical examinations as part of a health monitoring program by an occupational health profession. In Estonia, the obligation arises only when the employer receives a medical certificate. In Bulgaria and Luxembourg, the duty arises when the health services or public authorities inform the employer about the health situation and the need to find appropriate solutions. In other countries such as Cyprus, the Netherlands, Poland, and Spain, disclosure by the data subject is required [6].

In Italy, the Legislative Decree n. 81/2008 (establishing the Consolidated Act on health and safety at work, the TU 81 of 2008) [7] provides that the occupational physician issues a certificate of "fitness for duty" to be formally transmitted to the employer. However, the indications accompanying this certificate, which is not harmoniously specified in the national legislation, does not automatic oblige the employer to find reasonable accommodation for the worker.

3. The Centrality of the Occupational Physician

3.1. Fitness for Work

Worker disability is considered from different angles and assessed differently in different contexts. For example, the medico-legal commissions that recognize the state of disability have as their main objective to assess the residual working capacity, in its various aspects (psychic and relational activities, posture, locomotion and functionality of the limbs, movement capacity, complex or with particular types of work organization, etc.), above all in order to allocate a wide range of social, economic, rehabilitative benefits linked to the national insurance system. The Occupational Physician, on the other hand, is mainly concerned with making sure that the worker's physical and mental condition is not altered or, in the case of the disabled, aggravated by a hazard emanating from the work activity or the work environment, which consequently leads to prescriptions or restrictions on the worker' ability to work.

Fitness for work represents one of the main epicritic outcomes of the health surveillance carried out by the Occupational Health Physician based on the risks to which workers are exposed. The European directives from which the individual countries' regulations on occupational health and safety are derived never speak of fitness for work/Fitness for work. Directive 89/391/EEC [8] states that the employer must "adapt work to man" and not vice versa. The ICOH Code of Ethics [9] provides that the objectives of occupational medicine and the methods and procedures of health surveillance must be clearly defined, with the adaptation of the workplace to the worker being the primary concern.

As far as this activity is concerned, the international medical literature to date has not yet made a significant methodological contribution, especially in clarifying the contents of this important professional aspect of the daily practice of occupational physicians. Furthermore, the lack of specific definitions relating to the judgment of suitability for the specific job and the scarcity of EBM support from the international scientific literature make the Scientific Societies of Occupational Medicine guidelines even more important. In particular, the document called "Health Surveillance Guidelines" produced by the Italian Society of Occupational Medicine in 2017 [10] defines "fitness for duty" as the result of a "compatibility assessment" between two quantities: the state of health of the worker or the predisposition to the disease with respect to the risk profile given by the exposure to occupational hazards capable of directly causing, aggravating a disease or triggering a particular state susceptible to a pathological evolution.

In this definition, the assessment of the compatibility of the work environment with the human being is considered paramount and not the other way around. It follows that, in cases where the comparison of compatibility raises doubts, the assessment process to formulate the derived judgement of suitability must lead to finding adaptive solutions to the work environment before attention is focused on the limitations of the work.

The Occupational Physician, during the health surveillance activity, may have to express an opinion on whether or not workers with disabilities and significant impairments are suitable for the job as part of the health surveillance process. In this case, he or she must assess whether the work task, with its associated risks, is compatible with the conditions of the worker's biological validity and, if so, identify any regulations or limitations.

An important part of evaluating the conditions of "disability", which conditions limitation to the specific task, is that relating to the functioning of the organs and systems. In practice, the aforementioned "compatibility assessment" should not only concern the pathology itself but also what diseases produce in terms of reduction of expected functionality. More often, limited functionality is what most influences the judgment of compatibility with the risks of the specific job. The two elements (diagnosis and function) are cited by two different WHO documents, the ICD 11 [11] and the ICF [12]. Health conditions (diseases, ailments, injuries, etc.) are mainly classified in the ICD-11 (International Statistical Classification of Diseases and Related Health Problems), which provides an etiological reference model. In the ICF, on the other hand, functioning and disability are classified in the context of the health conditions that play the greatest role in assessing incapacity for work and working capacity.

It is, therefore, often necessary to evaluate some elements of the state of health relating to the psycho-physical integrity of the individual ("biological validity"), as in specific cases, elements relating to the "work ability".

The apparent difficulties related to the expression of fitness for work, which directly concerns the occupational physician, are flanked by those of the production manager, who is supposed to translate the indications emerging from the fitness for work certificate into daily operational practice. It is known how difficult it is to determine tasks and activities to be entrusted to workers with limitations to protect themselves from occupational risks while ensuring productive work. It is, therefore, necessary to develop methodological criteria, procedures and operational solutions for the reintegration of persons with disabilities, as well as the redesign of tasks, activities, working methods, and some other organizational aspects for persons with chronic diseases that require restrictions and prescriptions.

3.2. Personalized Work Plan to Express Fitness for Work for a Specific Job with Limitations

In our experience, an operational methodology that has proven very useful for reintegrating workers with pathologies/disabilities into the labor market is case management through personalized work plans [13, 14, 15, 16].

The Fitness for work (assessment of compatibility between the disability or chronic pathology and the workplace) is expressed through a work plan presented by the employer, based on the indications of the occupational physician, and taking into account the health/proneness of the worker, which modulates/avoids the activities/tasks of the job that could be harmful or aggravate the health condition of the worker, up to the limit of individual technical manipulations.

The assumptions underlying this methodological approach to the formulation of fit for work are essentially represented by the considerable difficulty, often associated with the lack of guarantees of maintaining productivity on the one hand and acceptability/professional satisfaction on the other, in moving the subjects with limitations/prescriptions on suitability for other tasks or different jobs, often less qualified also in terms of professional commitment, as is often the case, with a critical limitation thus being managed as incapacity and consequent job change. The work plan represents a detailed analysis, conducted with the help of procedures agreed upon with the technical figures involved (Responsible for safety, Human Resources, etc.), to verify the working conditions at risk, thus allowing a re-modulation of the activity based on the indications of the occupational physician. In practice, the activities that make up a given workplace can be redesigned by combining those that are still compatible with those that are made compatible through certain technical (e.g. PPE, changes to tools), organizational (e.g. times, routes, breaks) or procedural interventions.

To ensure both the effectiveness of the intervention and its continuity over time, the operating procedure involves the involvement of all company protagonists (including the occupational physician and the safety officer) as well as the workers themselves with significant impairments and partial unfitness. The role of the occupational physician in the reintegration into work is of fundamental importance in assessing the compatibility between the functional clinical condition and the risks and contents of the work activity.

The risk assessment at work represents a fundamental prerequisite for expressing any suitability for work for the relocation of workers with pathologies or disabilities through the work plan. Therefore, whenever possible (e.g., ergonomic risk assessment), individual workstations should be assessed with specific indications, e.g. ergonomic upper limb index, with a risk classification for the single anatomical districts (green-yellow-red for shoulder, elbow, wrist), NIOSH lifting index, highlighting which specific gesture or posture has the greatest impact.

Ultimately, it is considered necessary to provide at least the following activities: (i) classification of pathology and relative degree of functional impairment by the occupational physician in a multidisciplinary approach with professionals from other disciplines (orthopedists, oncologists, psychiatrists, surgeons, etc.); (ii) identification of a position/task/activity compatible with the health conditions among those available.

The personalized work plan drawn up starting from a Common Work Plan relating to the tasks to be performed, based on the worker's health conditions, is then finally submitted again to the opinion of the occupational physician, who might thus re-formulate a full fitness for work (specifying the reference to the personalized work activity plan).

The methodology for managing Fitness for work through verifying the compatibility of work plans is also reflected in the Guidelines for Health Surveillance of the Italian Society of Occupational Medicine (2017) [10], in the Resolution of the Tuscany

Region n. 421 of 04-16-2018 (Adoption of guidelines for the expression of the judgment of suitability of the Company Occupational Physician and the Commission under Article 41 paragraph 9 of Legislative Decree 81/08 and subsequent amendments on safety and health in the workplace) where in the attachment - Indications for Occupational Physicians and the commissions examining appeals under art. 41 paragraph 9 of Legislative Decree 81/08 where it reads: "*…the judgment of the Fitness for work can be expressed specifically to a personalized work plan, prepared for the worker by the employer in collaboration with the Occupational Physician, who avoids the inclusion of activities that could be harmful to the worker himself. This way, the expression of suitability judgments with limitations can be avoided. This initiative can be considered a good practice voluntarily adopted by the employer*" [17].

4. Conclusions

Based on our experience, the methodology of personalized work plans, through a multidisciplinary approach, helps the management of disabled and chronically ill workers with limitations in certain tasks and adopting reasonable adjustments. Furthermore, it can also contribute to the achievement of the International Certification on Diversity and Inclusion (ISO 30415:2021), at least in the section related to the achievement of adequate standards of management of health-related diversity.

It should be underlined that the work plan procedure should not be considered a one-off activity. On the contrary, the relocation of workers into work activities should be followed by subsequent and continuous monitoring in the context of health surveillance, from which further, more precise adjustments may result through medical feedback. In some cases, it is also necessary to evaluate the "work ability" and consider that there are examples and supports for an effective intervention [18-19].

For medium and large companies, it would be advisable to set up a professional figure who represents essential support for the job placement of people with disabilities and is an intermediary in managing work plans. This figure, called Disability Manager or Diversity Manager, would help to promote work placement in the environmental context, being in charge of preparing customized projects for people with disabilities and solving problems related to the working conditions of workers with disabilities, and supporting the organization to make the participation of pathological workers valid, safe and profitable.

Declaration of Interest: The authors declare no conflict of interest. AC, GG, RF, MC, and GS, are committed to maintaining transparency, integrity, and ethical values, for the betterment of global healthcare services they are responsible for.

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Factors Associated with SARS-CoV-2 Infection before Vaccination among European Health Care Workers

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Abstract

Background: *Health care workers (HCWs) were on the frontline of the current pandemic. We aimed at identifying determinants of SARS-CoV-2 infection and the effectiveness of personal protection equipment (PPE) worn by HCWs before vaccination.* **Methods:** *We abstracted data on SARS-CoV-2 infection based on positive PCR results and sociodemographic characteristics of 38,793 HCWs from public hospitals and public health authorities from 10 European centers. We fitted cohort-specific multivariate logistic regression models to identify determinants of infection and combined the results using random-effects meta-analyses.* **Results:** *The overall prevalence of infection before vaccination among HCWs was 9.58%. Infection was associated with the presence of selected symptoms; no association was found between sociodemographic factors and increased risk of infection. The use of PPE and particularly FFP2/FFP3 masks had a different protective effect during the first and second waves of the COVID pandemic.* **Conclusions:** *The study provides evidence that mask use was the most effective PPE in preventing SARS-CoV-2 infection among HCWs.*

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1. Introduction

During the COVID-19 pandemic, healthcare workers (HCWs) were employed on the frontline to guarantee patient care, having higher exposure to SARS-CoV-2 infection than the general population [1]. Following the WHO recommendations, an intense activity of contact tracing and management of SARS-CoV-2-positive HCWs was established in many health facilities since the very beginning of the pandemic. These protocols have achieved remarkable results in identifying the determinants of infections and, consequently, updating risk assessment evaluation and establishing effective prevention measures [2].

During the early stages of the pandemic, several studies highlighted the importance of the correct use of personal protection equipment (PPE), its efficacy in terms of protection [3], both for surgical masks and FFP 2/3 [4], and the high tolerance profile [5]. As a consequence, European governments put specific measures to improve supply chains and provisions of PPE during the SARS-CoV-2 pandemic [6, 7]. Nevertheless, the incorrect use of PPEs documented during the SARS outbreak in 2005 [8] has often been an issue of concern in the current pandemic. Even among experienced HCWs, the importance of the correct use of PPEs has generally been underestimated: the right donning and doffing procedures are not routinely followed [9]. Thus, the protective effect of PPE may vary widely. In such a scenario, assessing the maximum theoretical efficacy of different PPEs can be difficult, while measuring their effectiveness in the field is of great clinical and public health importance.

Despite the COVID-19 vaccination campaign, which started in Europe in December 2020, proved to be very effective in preventing severe and symptomatic SARS-CoV-2 cases [10, 11], breakthrough infections (BIs) after vaccination occurred all over the world, both in the general population and among HCWs [12]. Initially related to the waning of the humoral response [13-16] and to the appearance of new virus variants [17], they can also occur after booster dose administration [14]. Such circumstances further highlight the role of the main determinants of infection and the importance of additional preventive measures, especially PPE use, in minimizing the risk of infection for both unvaccinated and vaccinated subjects.

A detailed assessment of determinants of SARS-CoV-2 infection among unvaccinated HCWs, including the protection conferred by PPE, based on high-quality data and a proper methodology would inform prevention strategies in vaccinated subjects. We used the data on over 30,000 unvaccinated HCWs from 10 cohorts of HCWs to investigate the determinants of infection and the effectiveness of PPE worn by those who reported close contact with a confirmed SARS-CoV-2 case.

2. Methods

We use data from one cohort of HCWs employed in university hospitals and public health agencies from France (Paris), eight cohorts from Italy (Bologna, Brescia, Modena, Padua, Perugia, Trieste, Turin, and Verona), and one cohort from Romania (multicenter) to study the determinants of SARS-CoV-2 infection before vaccination, i.e., in the period March 2020-January 2021. Data on sociodemographic characteristics, PCR testing results, circumstances of contact with SARS-CoV-2 cases, symptoms, and use of PPEs were abstracted from medical surveillance records or collected using questionnaires. The PCR tests have been applied in screening surveillance, after a high-risk contact, or in case of symptoms onset. Both occupational and non-occupational sources of contact were considered.

The selected cohort characteristics (N=37,881, giving rise to 3,579 cases) included in the present analysis are described in Table 1.

These cohorts were mainly assembled during the first wave of the epidemic (March-July 2020) and are now included in the prospective follow-up. Data from the individual cohorts were harmonized; for several cohorts, de-identified data were pooled and analyzed centrally, for the others, harmonized data were analyzed at the local center.

The outcome of this analysis was infection with SARS-CoV-2 before vaccination, diagnosed with a positive PCR test. We first conducted a descriptive analysis of the outcome and explanatory variables.

Table 1. Characteristics of the cohorts of HCWs included in the analysis.

	Paris	Bologna	Brescia	Modena	Padua	Perugia	Turin	Trieste	Verona	Romania - Multicenter
N (%)	283 (0.75%)	1,579 (4.17%)	1,757 (6.63%)	5,922 (15.63%)	8,314 (21.95%)	3,196 (8.44%)	2,952 (7.79%)	4,397 (11.61%)	7,638 (20.16%)	1,843 (4.86%)
Positive cases	25 (8.83%)	70 (4.43%)	324 (18.45%)	595 (10.05%)	696 (8.37%)	164 (5.13%)	144 (4.88%)	462 (10.51%)	797 (10.43%)	302 (16.39%)
Institutions	Public hospital	Public hospitals and USL of Bologna	Public hospitals and USL of Brescia	University Hospital of Modena	University Hospital of Padua	Perugia's General Hospital	University Hospital of Turin	University Hospital of Trieste	University Hospital of Verona	Public health authorities & institutes, GPs, and hospitals
Source of data	PPEC	OHS records	OHS records	OHS records	OHS records; regional database	OHS records	OHS records	OHS records	OHS records; regional database	Active recruitment
From **To**	Mar 2020 Dec 2020	Mar 2020 Jan 2021	Apr 2020 Jan 2021	Mar 2020 Dec 2020	Mar 2020 Dec 2020	Mar 2020 Dec 2020	Mar 2020 Aug 2020	Mar 2020 Dec 2020	Mar 2020 Dec 2020	Aug 2020 Jan 2021

PPEC = Prospective post-exposure cohort; OHS = Occupational health surveillance.

Subsequently, we conducted cohort-specific logistic regression analyses with the PCR result as a dependent variable to estimate odds ratios (OR) and the corresponding 95% Confidence Intervals (CI). In the second step, cohort-specific results were combined using random-effects meta-analyses; heterogeneity between cohort-specific results was tested using the I^2 method [15]. We conducted additional analyses on the use of PPEs separately for the first (March 2020-July 2020) and the second wave of the pandemic (August 2020-January 2021). The statistical package STATA V. 16.1 was used for the analysis.

The study was part of the Orchestra project. It was approved by the Institutional Review Boards of the Italian Medicine Agency (AIFA) and the Italian National Institute of Infectious Diseases "L. Spallanzani". Local Institutional Review Boards approved individual cohorts as appropriate.

3. Results

A total of 38,793 HCWs from the ten cohorts were included in the analyses. The distribution of subjects in each cohort according to the outcome, the explanatory variables, the distribution of symptoms, and the use of PPE according to the outcome are provided in Table 2.

Overall, 3,716 cohort members were infected during the study period (9.58%); this proportion varied from 4.43% to 17.29% in the individual cohorts.

The results of the meta-analysis on determinants of infection before vaccination are reported in Table 3, and the corresponding results for the individual cohorts are reported in Supplementary Table 1.

Infection was not associated with the sex, age, or job title of HCWs. Among the symptoms, fever, ache, fatigue, anosmia, cough, and ageusia were strongly associated with SARS-CoV-2 infection. In particular, the OR of infection was 4.63 (95% CI 1.70-12.65) for those with fever compared to those without it. The results also showed that those who did not report any contact with SARS-CoV-2 cases had a higher chance of being infected than those who reported contact with colleagues (OR=7.08; 95% CI 2.25-22.32) (Table 3).

The results of the analysis on the use of PPE are reported in Table 4, and the corresponding results for different waves of SARS-CoV-2 infection are reported in Supplementary Table 2.

Use of surgical masks (OR=0.51; 95% CI 0.39-0.65), and FFP2/FFP3 masks (OR=0.43; 95% CI 0.32-0.57) showed significant protection against SARS-CoV-2 infection. However, eye protection/face shield use did not appear to be protective (OR=1.65; 95% CI 1.22-2.24). FFP2/FFP3 mask use was more protective during the second wave of the SARS-CoV-2 pandemic (August 2020-January 2021, OR=0.27; 95% CI 0.17-0.43) than during the first wave.

4. Discussion

Among more than 38,000 HCWs, we reported results on more than 3,700 un-vaccinated HCWs who tested positive for SARS-CoV-2 between March 2020 and January 2021. Sex, age, and job title were not associated with infection, and HCWs assigned to COVID-19 units were not at higher risk of infection. Anosmia was the most predictive symptom, and mask use was the most effective PPE in reducing the risk of infection.

The heterogeneity in infection rates found among HCWs in these institutions demonstrates the wide range of circumstances of infection among hospitals, even within a single country. Such variability is unsurprising, as local policies differed significantly between institutions and have altered fast throughout the pandemic as PPE access, capacity, and understanding of transmission have shifted.

In fact, throughout much of 2020, the World Health Organization (WHO) held tight to the idea that SARS-CoV-2 spreads through relatively large "respiratory" droplets that are expelled by infected people while coughing, sneezing, or speaking and stressed the importance of washing hands and disinfecting surfaces. It took many months for the Agency to acknowledge that the virus transmission is sustained by aerosols that can spread widely and linger in the air [18]. Higher SARS-CoV-2 infection rates were usually seen in centers from areas with corresponding higher population rates [19]. In particular, observations from Spain showed that the epidemic dynamic among HCWs closely followed that in the community, arguing against significant

Table 2. Selected characteristics of HCWs included in the analysis.

	Paris (%)	Bologna (%)	Brescia (%)	Modena (%)	Padua (%)	Perugia (%)	Turin (%)	Trieste (%)	Verona (%)	Romania-Multicenter (%)
Sex										
Men	28.3%	29.5%	22.0%	29.3%	31.3%	35.1%	29.5%	31.1%	30.8%	17.5%
Women	71.7%	70.5%	78.0%	70.7%	68.7%	64.9%	70.5%	68.9%	69.2%	82.5%
Age group										
18-29	26.1%	13.5%	12.4%	18.3%	14.7%	3.5%	11.2%	6.8%	17.7%	6.4%
30-39	33.9%	30.8%	21.1%	27.4%	23.6%	24.7%	18.4%	17.9%	26.8%	12.7%
40-49	20.9%	25.8%	28.1%	21.7%	20.5%	19.9%	28.2%	26.2%	18.7%	3.1%
50+	19.1%	29.9%	38.4%	32.6%	41.2%	51.9%	42.2%	49.2%	36.7%	50.2%
Job title										
Administration	12.3%	1.3%	7.16%	5.3%	8.2%	6.8%	5.1%	6.2%	7.9%	3.1%
Physician	35.9%	20.6%	22.3%	31.2%	33.5%	29.2%	29.6%	14.3%	34.6%	72.2%
Nurse	29.5%	28.8%	48.8%	35.8%	35.95	37.5%	40.4%	40.7%	33.6%	13.3%
Technician	0.0%	2.5%	9.7%	3.4%	6.6%	12.3%	0.0%	5.2%	8.7%	9.8%
Other HCW	1.6%	46.7%	11.9%	24.4%	15.8%	14.3%	24.8%	33.6%	15.3%	22.3%
Source of contact										
Colleague	57.6%	48.8%	51.9%				56.0%			
Outside workplace	11.3%	4.2%	8.1%				5.1%			
No contact (screening)	0.0%	0.4%	14.2%				0.0%			
Patients	31.1%	46.5%	25.8%				38.9%			
High-risk contact with COVID cases										
No	0.0%		83.9%				0.0%			81.3%
Yes	100.0%		16.1%				100.0%			18.7%
Dedicated to COVID patients										
No	64.7%		54%				92.9%			
Yes	35.3%		46%				7.1%			
Symptoms										
No symptom	40.1%	83.7%	57.9%				41.9%			6.0%*
At least one symptom	59.9%	16.3%	42.1%				58.1%			94.0%*

Table 2 (*Continued*)

	Paris (%)	Bologna (%)	Brescia (%)	Modena (%)	Padua (%)	Perugia (%)	Turin (%)	Trieste (%)	Verona (%)	Romania-Multicenter (%)
Fever	10.9%		9.4%				2.3%			40.1%*
Dyspnoea	7.7%		5.5%				1.0%			25.8%*
Diarrhoea	14.2%		6.7%				2.2%			17.2%*
Sore throat	15%		27.3%				6.5%			34.4%*
Headache	36.1%		27.7%				1.5%			47.7%*
Myalgia / arthralgia	20.1%		22.8%							46.7%*
Fatigue / malaise	30.3%		15.4%				0.9%			68.9%*
Anosmia or hyposmia	5.5%		0.4%				0.4%			52.0%*
Cough	20.4%		24.0%				10.0%			42.4%*
Ageusia or hypogeusia			2.0%				0.5%			42.0%*
Other symptoms	30.3%		0.6%							
Use of PPE										
Surgical masks	0%	70.3%	27.4%				72.2%			93.3%**
FFP2/FFP3 masks	0%	24.2%	41.3%				7.5%			68.2%**
Eye protection/Face shield		3.0%	7.8%				16.9%			70.8%**
Isolation/disposable gowns		4.7%	8.4%				15.0%			58.9%**
Gloves		28.2%	27.8%				43.9%			86.4%**

** Adjusted for gender and age (categorical).*
*** Adjusted for gender, age (categorical), and job title.*
CI, confidence interval; OR, odds ratio; Ref, reference category; empty cell, not available.

Table 3. Determinants of infection before vaccination – Results of the meta-analysis.

Characteristic [Centers included in the pooled analysis]	OR (95% CI)	I^2
Sex [All]		
Men	Ref	
Women	1.00 (0.92-1.09)	29.1%
Age [All]		
10-yr increase	0.96 (0.89-1.05)	88.1%
Job Title [All] *		
Administration	Ref	
Physician	1.00 (0.82-1.21)	35.0%
Nurse	1.21 (0.87-1.69)	79.7%
Technician	0.98 (0.80-1.20)	13.9%
Other HCW	1.35 (0.93-1.94)	78.0%
Source of contact [Fr-Pa, It-Bo, It-Br, It-To] **		
Colleague	Ref	
Family/friends or outside the workplace	2.07 (0.78-5.50)	60.4%
Patients	1.28 (0.63-5.29)	87.9%
Unknown (screening, symptomatic HCW)	7.08 (2.25-22.32)	57.9%
High-risk contact with COVID cases [It-Br, Ro-Mc] **		
No	Ref	
Yes	1.17 (0.89-1.53)	0.0%
Dedicated to COVID patients [Fr-Pa, It-Br, It-To] **		
No	Ref	
Yes	1.18 (0.95-1.46)	0.0%
Symptoms [Fr-Pa, It-Br, It-To] *		
No symptom	Ref	
Fever	4.63 (1.70-12.65)	85.7%
Dyspnoea	1.45 (0.31-6.82)	85.3%
Diarrhoea	0.58 (0.35-0.96)	0.8%
Sore throat	0.99 (0.52-1.89)	55.9%
Headache	1.59 (0.81-3.11)	43.2%
Ache [i.e., Muscle (myalgia) and/or Joint (arthralgia)]	2.60 (1.80-3.78)	0.0%
Fatigue and/or malaise	2.77 (1.22-6.28)	50.1%
Loss of smell (Anosmia)	8.24 (3.48-19.51)	0.0%
Cough	2.61 (1.23-5.57)	85.1%
Changes or loss in taste (Ageusia)	4.41 (1.87-10.39)	0.0%

** Adjusted for gender and age (categorical).*
*** Adjusted for gender, age (categorical), and job title.*
CI, Confidence Interval; OR, odds ratio; Ref, reference category; empty cell, not available.

Table 4. Use of PPE: Results of pooled data (CI=confidence interval; OR=odds ratio, adjusted for cohort, sex, age (categorical), and job title; Ref reference category.

PPE	OR (95% CI)
Surgical masks	
No	Ref
Yes	0.51 (0.39-0.65)
FFP2/FFP3 masks	
No	Ref
Yes	0.43 (0.32-0.57)
Eye protection/Face shield	
No	Ref
Yes	1.65(1.22-2.24)
Isolation/disposable gowns	
No	Ref
Yes	1.93 (1.43-2.60)
Gloves	
No	Ref
Yes	1.27 (0.98-1.66)

occupational transmission [20]. In addition, the different geographic location of the centers involved explains the different infection rates also because of the asynchronous nature of the pandemic. Especially in Italy, regions considered the epicenter of the virus spread were more involved in the first wave, while others were more affected in the following waves. Male gender and advanced age represent well-known risk factors for the severity of COVID-19 [21]. The present study did not find an increased risk of infection according to age and gender. These results align with the available literature where age does not show a clear pattern with the risk of infection, while gender findings often disagree [19, 22]. Moreover, in a seroprevalence study conducted in a large health center in Italy, age and gender were not associated with the risk of seropositivity, not even evaluating part of the cohort after five months [23].

Unlike other studies [24-26], we have not found differences in the risk of infection across HCW job titles, possibly because of the long observation period and the onset and diffusion of different SARS-CoV-2 variants with a higher infection rate [27]. Many prevalence studies, based on either PCR or serology, also reported no difference in risk of infection according to job title [23, 28]. These data partially overlap with those used in our previous publication. We suggested that the lack of a clear pattern of risk according to job categories indicates that all HCWs were at comparable risk of becoming infected, even if we consider HCWs who worked in COVID-19 departments [19], consistently with the multiple sources of exposure to SARS-CoV-2 reported by HCW, whether from infected patients or colleagues, but also with individuals outside the workplace that do not directly depend on HCW's job title.

Our analysis confirms that either surgical or FFP2/3 masks are the most effective PPE in reducing SARS-CoV-2 transmission. Scientific evidence supports their role in infection control [19, 29, 30]. Besides their mechanical barrier function, some studies [31, 32] suggest their active role in modulating viral load and boosting the immune response, especially in the pre-vaccinal period. This mechanism is similar to the so-called "variolation" process, where people susceptible to smallpox were inoculated with a small amount, causing a mild infection and subsequent immunity. In particular, we found that FFP2/FFP3 masks were more protective than surgical masks during the second wave of the COVID pandemic, which is an original result of our study. This result may be derived from two factors. First, the virus has changed, resulting in multiple variants with different physical and transmissibility properties. In this view, a recent study by Riediker et al. [33] highlighted that for Delta and Omicron variants, surgical masks were not effective in most public settings, while correctly fitted FFP2 respirators still provided sufficient protection. Several other studies on SARS-CoV-2 variants suggest that higher viral load and increased infectivity were likely to contribute to the rapid spread of the Delta variant of SARS-CoV-2, the dominant variant during the second wave of the epidemic [34]. The Delta variant seems more stable in aerosol than the original form of the virus, which may explain the greater relevance of face-filtered masks compared to surgical ones. On the other hand, another critical aspect is that during the second wave of the epidemic, PPE shortage was no longer an issue, and mask-wearing was strongly required, so the lack of compliance with the rules by the HCW would be less justified.

On the contrary, an initial reading of our results indicates that using facial shields, disposable gowns, and gloves is associated with an increased risk of infection. This counterintuitive finding is attributable to the extensive use of these PPEs, mainly in departments with higher infection rates. These results are confirmed by the increased risk of infections for HCWs dedicated to COVID-19 patients.

Notable is the strong association we detected between increased risk of infection and fevers, muscular or joint aches, anosmia, and ageusia. Those findings are consistent with the scientific literature on other populations of COVID-19 patients [35, 36].

The large sample size and the collection of sociodemographic information from occupational health records or regional databases are strengths of our study. However, our analysis suffers from some limitations, including the retrospective nature of the data and the different health surveillance protocols throughout our cohorts. In particular, variations in PPE access, reuse, and types offered between centers raise the possibility of measurement error, which could have masked our ability to detect an association between PPE use and SARS-CoV-2 infection. In addition, data sources and symptoms' classification varied among cohorts. As shown in Table 2, not all cohorts recorded data concerning the type/risk of contact and the use of PPE. Also, some centers conducted statistical analyses internally while others shared raw data. This heterogeneity was partially resolved by subsequent harmonization of the data. Nevertheless, these differences may have affected the generalizability of the results.

Moreover, the multicentric nature of the study, while significantly increasing the size of the analyzed sample, makes it more difficult to compare and may have partially affected the accuracy of the infection rate data. Furthermore, because we did not compare the viruses of cases and contacts, we cannot state with certainty which contact caused the infection.

5. Conclusions

In this study, we present findings that evaluate predictors of SARS-CoV-2 transmission, which are important to limit the risk of infection inside and outside the workplace. Mask wear should be compulsory in hospital settings to ensure the safety of both HCWs and patients. Even among vaccinated subjects, PPEs remain an important set of instruments, and proper usage should be emphasized. It would be desirable to conduct more research on the combined usage of PPEs under various SARS-CoV-2 transmission scenarios. Models of prospective public health actions that could have prevented the epidemic and early recommendations for using surgical masks would be extremely useful in the future.

Supplementary Materials: The following are available: Supplementary Tables 1A, 1B, and 2.

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

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APPENDIX

SUPPLEMENTARY Table 1a. Determinants of infection before vaccination – results by cohort.

	France-Paris	Italy-Bologna	Italy- Brescia	Italy-Modena	Italy-Padua
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Sex					
Men	Ref	Ref	Ref	Ref	Ref
Women	0.56 (0.24-1.34)	1.12 (0.67- 1.88)	0.91 (0.75-1.11)	0.86 (0.73- 1.01)	1.06 (0.91- 1.23)
Age					
10-yr increase	1.00 (0.68-1.44)	1.13 (0.89- 1.43)	1.07 (0.99-1.17)	1.01 (0.95- 1.07)	0.97 (0.92- 1.03)
Job Title *					
Administration	Ref	Ref	Ref	Ref	Ref
Physician	0.84 (0.22-5.63)	0.71 (0.35- 1.40)	0.91 (0.63-1.31)	2.11 (1.26- 3.54)	1.12 (0.80- 1.56)
Nurse	0.80 (0.19-4.06)	1.06 (0.59- 1.90)	0.74 (0.53-1.03)	3.59 (2.17- 5.96)	1.57 (1.15-2.14)
Technician		1.02 (0.23- 4.57)	0.89 (0.59-1.33)	1.80 (0.91- 3.54)	1.17 (0.77- 1.77)
Other HCW	1.12 (0.27-5.64)		0.77 (0.49-1.21)	2.63 (1.56- 4.43)	2.30 (1.66- 3.18)
Source of contact **					
Colleague	Ref	Ref	Ref	Ref	Ref
Family/friends or outside workplace		1.02 (0.29-3.59)	3.02 (2.10-4.33)		
No opportunity of contact		17.34 (3.48- 86.41)	4.93 (3.82-6.38)		
Patients	1.97 (0.74-5.29)	0.96 (0.51-1.80)	2.30 (1.79-2.95)		
High-risk contact with COVID cases **					
No	Ref	Ref	Ref	Ref	Ref
Yes			1.05 (0.66-1.65)		
Dedicated to COVID patients **					
No	Ref	Ref	Ref	Ref	Ref
Yes	2.16 (0.77-6.40)		1.13 (0.90-1.43)		
Symptoms*					
No symptom	Ref	Ref	Ref	Ref	Ref
Fever	3.42 (0.90-13.46)		2.71 (1.70-4.30)		
Dyspnoea	3.16 (0.68-14.88)		0.41 (0.19-0.85)		
Diarrhoea	0.79 (0.19-2.85)		0.48 (0.26-0.86)		
Sore throat	1.75 (0.40-7.60)		0.66 (0.45-0.98)		
Headache	0.63 (0.15-2.34)		1.56 (1.07-2.28)		
Ache (i.e., Muscle ache (myalgia) and/or Joint ache (arthralgia))	1.95 (0.48-8.38)		2.63 (1.78-3.88)		
Fatigue and/or malaise	1.47 (0.32-6.33)		2.05 (1.067-3.94)		

	France-Paris	Italy-Bologna	Italy- Brescia	Italy-Modena	Italy-Padua
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Loss of smell (Anosmia)	14.50 (3.21-19.51)				
Cough	0.98 (0.25-3.43)		2.21 (1.55-3.16)		
Changes or loss in taste (Ageusia)			4.81 (1.62-14.29)		
Other symptoms	6.88 (1.89-29.90)				

** Adjusted for gender and age (categorical).*
*** Adjusted for gender, age (categorical), and job title.*
CI, confidence interval; OR, odds ratio; Ref, reference category; empty cell, not available.

Supplementary Table 1b. Determinants of infection before vaccination – results by cohort.

	Italy-Perugia	Italy-Turin	Italy-Trieste	Italy-Verona	Romania-Multicenter
Characteristics*	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Sex					
Men	Ref	Ref	Ref	Ref	Ref
Women	0.93 (0.73- 1.20)	0.92 (0.66-1.28)	1.00 (0.83- 1.21)	1.18 (1.02- 1.37)	1.14 (0.81-1.59)
Age					
10-yr increase	0.89 (0.80- 0.99)	0.97 (0.84-1.12)	0.81 (0.75- 0.88)	1.13 (1.07- 1.19)	0.78 (0.70-0.87)
Job Title *					
Administration	Ref	Ref	Ref	Ref	Ref
Physician	1.15 (0.66- 2.03)	0.79 (0.39-1.60)	0.69 (0.45- 1.05)	1.05 (0.77- 1.42)	0.79 (0.39-1.57)
Nurse	0.93 (0.53- 1.63)	0.72 (0.39-1.41)	0.84 (0.58- 1.22)	1.85 (1.39- 2.47)	1.30 (0.62-2.73)
Technician	0.91 (0.48- 1.72)		0.64 (0.37- 1.13)	1.08 (0.75- 1.55)	0.59 (0.27-1.32)
Other HCW	1.90 (1.07- 3.38)	0.80 (0.40-1.63)	0.83 (0.57- 1.21)	1.84 (1.35- 2.50)	0.62 (0.17-2.18)
**Source of contact ** **					
Colleague	Ref	Ref	Ref	Ref	Ref
Outside workplace					
No contact					
Patients		0.67 (0.43-1.05)			
**High-risk contact with COVID cases ** **					
No	Ref	Ref	Ref	Ref	Ref
Yes					1.24 (0.88-1.72)
**Dedicated to COVID patients ** **					
No	Ref	Ref	Ref	Ref	Ref
Yes		1.28 (0.70-2.32)			
Symptoms*					
No symptom	Ref	Ref	Ref	Ref	Ref
Fever		9.88 (5.87-16.65)			

Table S1b (*Continued*)

Characteristics*	Italy-Perugia	Italy-Turin	Italy-Trieste	Italy-Verona	Romania-Multicenter
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Dyspnoea		3.04 (1.16-8.00)			
Diarrhoea		1.22 (0.34-4.29)			
Sore throat		1.42 (0.70-2.90)			
Headache		3.36 (1.11-10.17)			
Myalgia/ arthralgia)					
Fatigue/malaise		6.35 (2.29-17.61)			
Anosmia		5.87 (1.83-18.80)			
Cough		4.95 (3.48-7.03)			
Ageusia		2.89 (0.66-12.66)			
Other symptoms					

** Adjusted for gender and age (categorical).*
*** Adjusted for gender, age (categorical), and job title.*
CI, confidence interval; OR, odds ratio; Ref, reference category; empty cell, not available.

Supplementary Table 2. Use of PPE– results by pandemic wave.

	1st wave Brescia and Turin	2nd wave Bologna, Brescia, and Turin
	OR (95% CI)	OR (95% CI)
Surgical masks		
No	Ref	Ref
Yes	0.52 (0.38-0.71)	0.58 (0.37-0.91)
FFP2/FFP3 masks		
No	Ref	Ref
Yes	0.90 (0.60-1.36)	0.27 (0.17-0.43)
Eye protection/Face shield		
No	Ref	Ref
Yes	1.03 (0.72-1.48)	4.25 (2.13-8.50)
Isolation/disposable gowns		
No	Ref	Ref
Yes	1.03 (0.72-1.48)	1.97 (1.05-3.69)
Gloves		
No	Ref	Ref
Yes	1.37 (0.99-1.89)	1.12 (0.66-1.90)
Centers		
Italy-Bologna		Ref
Italy-Brescia	4.24 (3.09-5.81)	6.44 (3.91-10.59)
Italy-Turin	Ref	0.61 (0.08-4.72)

CI, confidence interval; OR, odds ratio; Ref, reference category; empty cell, not available.

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Mesothelioma Risk among Construction Workers According to Job Title: Data from the Italian Mesothelioma Register

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Keywords: Mesothelioma; Construction Workers; Italian Mesothelioma Register; Job Title

Abstract
Background: *An increased risk of mesothelioma has been reported in various countries for construction workers. The Italian National Mesothelioma Registry, from 1993 to 2018, reported exposure exclusively in the construction sector in 2310 cases. We describe the characteristics of these cases according to the job title.* **Methods:** *We converted into 18 groups the original jobs (N=338) as reported by ISTAT codes ('ATECO 91'). The exposure level was attributed to certain, probable, and possible in accordance with the qualitative classification of exposure as reported in the Registry guidelines. Descriptive analysis by jobs highlights the total number of subjects for every single job and certain exposure, in descending order, insulator, plumbing, carpenter, mechanic, bricklayer, electrician, machine operator, plasterer, building contractor, painter, and laborer.* **Results:** *The cases grow for plumbing in 1993-2018, while, as expected, it decreased for the insulator. Within each period considered, the most numerous cases are always among bricklayers and laborers; these data confirm the prevalence of non-specialized "interchangeable" jobs in the Italian construction sector in the past.* **Conclusions:** *Despite the 1992 ban, the construction sector still presents an occupational health prevention challenge, and circumstances of asbestos exposure may still occur due to incomplete compliance with prevention and protection measures.*

1. Introduction

Despite the gradual introduction of bans in various countries, asbestos exposure in the construction sector remains a serious risk factor for workers assigned to various tasks due to the widespread use of asbestos in building materials during a large part of the last century, from the 1930s to the 1990s. Moreover, a lack of awareness also of indirect or secondary asbestos exposure may have affected several types of workers, such as carpenters, electricians, plumbers, bricklayers and welders. With regard to cases of malignant mesothelioma (MM) exposed in construction, the widespread interchangeability of jobs among workers should be emphasized; this is especially true in small and medium construction companies, where recognizing different risk profiles is difficult. Furthermore, construction activities are normally performed without the use of personal protective equipment for the respiratory tract.

According to the existing Italian ban, currently potentially exposed construction workers are among the only workers involved in the reclamation work, but a large amount of asbestos in situ is still present in construction and represents a dangerous risk factor for those who carry out maintenance of old buildings [1-5]. In Italy, data from I ISTAT (The Italian National Institute of Statistics) reported

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497,709 firms in the construction sector and 1,355,917 workers in the same sector in 2020 [6]. An increased risk of MM has been reported in various countries for both construction workers and asbestos removal workers, mainly concerning levels and circumstances of asbestos exposure in the past and genetic aspects [7-20].

For Belgian non-manual workers in the construction industry, asbestos-related mesothelioma mortality is significantly higher than in manual workers (SMR: 260; 95%CI: 149-422 vs. SMR: 227; 95% CI: 168-302) [21].

In the Netherlands, the estimated overall risk ratio of mesothelioma among men in construction from 1990-2000, based on the population-at-risk from 1947-1960, was 5.1. In the construction industry, many carpenters and laborers worked with asbestos cement products, commonly used in the second half of the last century. Craftsmen such as electricians and mechanical engineers were most likely to be exposed to asbestos while handling, removing, and repairing asbestos lagging [22].

Regarding the risk of mesothelioma for individual jobs, several reports have accumulated evidence from various countries regarding maintenance workers, pipefitters, and electricians who were exposed to a higher cumulative dose of asbestos fibers [23]. In the period 2011-2015, the Korea Workers' Compensation and Welfare Service (KCOMWEL) approved claims for malignant mesothelioma in the construction sector with job classifications such as plumber, slate roof painter, building maintenance and repairman, interior product installer, worker repairing a roof, duct installer, building construction supervisor, building demolition worker, electric equipment installation and repairman, electricity, and cable setting man, and elevator installer [24].

Dement (2009) studied construction and craft workers employed at the Department of Energy nuclear sites in the USA and found significant excess mortality for mesothelioma with an SMR of 5.93, (95%CI 2.56-11.68) [25]. These data were confirmed in the subsequent follow-up in a sample of 24,086 workers with an SMR of 6.38 [26]. High risks of mesothelioma have also been reported for elevator construction workers [27], drywall construction workers [28], and asbestos removal workers [4]. Mesothelioma cases occurring during the home renovation were also described [29, 30]. Franzblau's (2020) [31] study of asbestos-containing materials in abandoned residential dwellings demolished between 2014 and 2017 in Detroit confirmed that asbestos was used in a variety of common construction materials and found asbestos-containing materials in flooring, roofing, siding, and duct insulation as well as in pipe insulation, cement, siding, flooring, roofing, sealants, caulks, and glazes. The type of asbestos generally present was chrysotile. This study confirms an existing asbestos risk for workers and the general population during renovation/demolition work.

Recently, De Bono (2021) conducted an analysis of the incidence of mesothelioma in the Ontario workforce (1983-2016) and found a hazard ratio of 2.38 (95%CI: 2.03-2.78) among construction workers. Rates were particularly elevated for insulators, pipefitters, plumbers, and carpenters. Estimates were elevated for construction trades workers in the following subgroups: forepersons, carpenters, brick and stone masons, plasterers, painters, insulators, and pipefitters [32]. Scarselli (2016) [33] used a nation-wide occupational exposure registry (SIREP) to provide summary statistics on the level and extent of occupational exposure to asbestos fibers in Italy between 1996 and 2013, during the removal and disposal of asbestos-containing materials. The study confirmed that many construction workers have exposure levels above the action limit established by national legislation (0.01 f/cc) and, in a very limited fraction of cases, exceed the current EU limit (0.1 f/cc). No information about air measurement (fibers/cm3) was available, especially in the years before 1992.

The Italian National Mesothelioma Registry (ReNaM) analyzed the occupational history of affected people and found that the construction sector was the main source of asbestos exposure in recent years [34]. As reported in a recent paper [35], ReNaM collected 31,572 incident MM cases from 1993 to 2018, and occupational exposure was reported for 3,574 who had worked in the construction sector. Exposure exclusively in the construction sector involved 2,310 cases; only those classified in code 45 of the Italian classification of economic activities 'ATECO 1991' were considered, including all subsectors, sectors, and tasks [36].

This study describes the characteristics of MM cases recorded by the Italian registry (ReNaM) among construction workers by individual tasks according to the job title.

2. Methods

Data were collected by ReNaM, a national epidemiological surveillance system characterized by a network of regional operating centers ('Centri Operativi Regionali': COR) established in all 20 Italian regions through a systematic active search of MM over the entire national territory with standard criteria for active case search, diagnosis classification, and qualitative assessment of asbestos exposure. ReNaM obtained occupational and residential histories of exposure and lifestyle habits by interviewing affected subjects (or next of kin) through a standardized questionnaire. Asbestos exposure was categorized as "occupational" (with three degrees of certainty: "definite", "probable", "possible") or "non-occupational" (in-house, environmental, and other non-occupational–such as leisure-time-related activities). "Unlikely" exposure was assigned to subjects whose information was inadequate or asbestos exposure could be reasonably ruled out [37].

Subjects with occupational exposure exclusively in the construction sector (code 45 of the Italian classification of economic activities 'ATECO 1991') [36] were analyzed. As reported in a previous paper [35], the occupational codes by the Italian classification of economic activities 'ATECO 1991' [36], 'CLASSIFICAZIONE DELLE PROFESSIONI ISTAT 1991' [38], were based upon the salaried reporting system of the industry to which the examinee belonged. Some workers performed more than one task, which resulted in different circumstances of asbestos exposure. For this analysis, we converted the ISTAT codes ('ATECO 91') into the reported tasks of the building sector's national collective labor agreement for the construction sector in 2010 [39], modified concerning possible asbestos exposure. The original tasks (N=338), which included both skilled workers and laborers, were merged into 17 groups by experienced technical staff in the construction industry: the 'National Joint Body for Training, Safety and Employment Services (FORMEDIL)' [40], as shown on Supplementary Table 1.

Qualitative assessment of retrospective exposure is a key element in identifying subjects exposed to asbestos and examining the association between asbestos exposure and mesothelioma occurrence [41]. Quantitative data on asbestos exposure, i.e., information about measurement (fibers/cm3) at the workplace for any subjects, are not available in ReNaM. The exposure level for the analyses was attributed to certain, probable and possible in accordance with the qualitative classification of exposure as reported in the ReNaM guidelines according to responses and information collected from the patient through a standardized questionnaire evaluated by industrial hygienists [37] and in agreement with the literature [17, 41].

- Certain occupational exposure was attributed to subjects whose work involved using asbestos or materials containing asbestos.
- Probable occupational exposure was attributed to subjects who had worked in a firm where asbestos was used but whose exposure could not be documented with the frequency of direct or bystander asbestos exposure.
- Possible occupational exposure was attributed to subjects who had worked in an economic sector where asbestos had been used together with the frequency of direct or bystander asbestos exposure, such as typical tasks, work practices, and materials used over time.

The data analyzed refer to the incidence period 1993-2018. Descriptive analysis, the arithmetic means of the year of first exposure, duration of exposure (the time period from the year exposure began to the year exposure ended), and latency (the time period from the year exposure started to the year of MM diagnosis) were calculated for each job of construction workers with STATA 12 software (College Station, TX: StataCorp LP).

3. Results

Among 2,310 cases with exclusive asbestos exposure in the construction sector, the mean duration of exposure reported was 30.9 years (SD 371.4,

Table 1. Distribution of cases by job and qualitative assessment of exposure (column and row percentages).

Job	Certain exposure			Probable exposure			Possible exposure			Total		
	N	% by job	% by qualitative exposure	N	% by job	% by qualitative exposure	N	% by job	% by qualitative exposure	N	% by job	% by qualitative exposure
Building contractor technical surveyor	77	5.1	55.7	18	8.6	13.04	43	7.1	31.1	138	5.9	100
Miner, Fochino, bricklayer in the tunnel	-	-	-	-	-	-	-	-	-	-	-	-
Asphalter, Stonecutter, Paver, railway roadman	12	0.8	70.5	1	0.4	5.8	4	0.6	23.5	17	0.7	100
Bricklayer, foreman	710	47.4	65.07	88	42.3	8.06	293	48.4	26.8	1091	47.2	100
Carpenter, Blacksmith, Welder, Tinsmith	98	6.5	71.01	14	6.7	10.1	26	4.2	18.8	138	5.9	100
Plasterer, prefabricated packager, cement builder	4	0.2	57.1	2	0.9	28.5	1	0.16	14.2	7	0.3	100
Tiler, Plasterer	16	1.06	44.4	4	1.9	11.1	16	2.6	44.4	36	1.5	100
Insulator	80	5.3	95.2	3	1.4	3.5	1	0.16	1.12	84	3.6	100
Glazier	1	0.06	20.0	-	-	-	4	0.6	80.0	5	0.2	100
Plumbing and heating, plumbing, refrigeration, fountain	196	13.09	83.05	26	12.5	11.01	41	6.7	17.3	263	11.3	100
Electrician, elevator operator	74	4.9	65.4	9	4.3	7.9	30	4.9	26.5	113	4.8	100
Painter, Plasterer	36	2.4	55.3	6	2.8	9.2	23	3.8	35.8	65	2.8	100
Cleaner	2	0.1	100	-	-	-	-	-	-	2	0.08	100
Diver	-	-	-	-	-	-	-	-	-	-	-	-
Mechanic	24	1.6	70.5	5	2.4	14.7	5	0.8	14.7	34	1.4	100
Machine operator	34	2.2	65.3	5	2.4	9.6	13	2.1	25.0	52	2.2	100
Labourer	132	8.8	50.0	27	12.9	10.2	105	17.3	39.7	264	11.4	100
Various[1]	1	0.06	100	-	-	-	-	-	-	1	0.04	100
	-	100	-	-	100	-	-	100	-	-	100	100
Total	1497	-	64.8	208		9.0	605	-	26.1	2310	-	100

[1] *Upholsterer, Armed Forces, Chemical Plant Worker, Verifier, Farmer, Sander, Metallurgical Worker.*

range 1-68 years), the mean latency was 47.8 years (SD 11.8, range 11-82), the mean age at onset of exposure 22.5 years (SD 8.5, range 9-66) and mean age at diagnosis 70.3 years (SD 9.9, range 29-97 years).

Among the 2,310 mesothelioma cases, the most represented jobs are bricklayer, laborer, plumber, building contractor, carpenter, electrician, and insulator. If the single jobs with exposure classified as certain are considered, the ranking shows bricklayer, plumber, laborer, carpenter, insulator, building contractor, and electrician (Table 1).

Table 1 shows that 64% of all cases were classified with certain exposure. Considering the total number of subjects for every single job and certain exposure among the 18 jobs in descending order, we find insulators, plumbers, carpenters, mechanics, bricklayers, electricians, machine operators, plasterers, building contractors, painters, and laborers. For all these jobs, more than 50% of the subjects in the register were classified with certain exposure.

From the distribution of individual jobs according to the year of exposure beginning, 52% of cases started work between 1924 and 1960. Considering each job individually, the most frequent exposure beginning in 1924-1960 was bricklayer, tiler, laborer, and painter. If exposure started in 1961-1991, the most frequent jobs were machine operator, mechanic, electrician, and building contractor (Table 2).

According to the distribution of individual jobs within the initial exposure periods, in each of the three periods considered, the largest percentage is represented by the bricklayers, while that of the laborers remains stable (Table 2).

The number of cases grows in the three periods considered especially for plumber, while as expected it decreases for insulator in the last period (Table 3).

Within each period of incidence considered the most numerous cases are always among bricklayers and among laborers, except in the period 2011/2018 where the most numerous are thermohydraulic workers (Plumbing and heating, plumbing, refrigeration, fountain) (Table 3).

4. Discussion

Our findings on an extensive series of Italian cases of mesotheliomas show that the use of asbestos led to exposure in many different activities in the construction industry. The widespread risk indicates the difficulties of safely handling asbestos in this occupational sector. Among the cases registered during 1993-2018 by the Italian mesothelioma register, 16.2% of all occupational exposures concerned construction workers [34]. The results are consistent with available data related to mesothelioma in the construction sector in other countries. In addition, several studies report the excess risk of mesothelioma in various jobs in the construction sector, as shown in Supplementary Table 2 [42-77].

These studies provide evidence that workers who experienced essentially intermittent and indirect exposure to asbestos are at increased risk of asbestos-related diseases, i.e., mesothelioma [25]. In the past, the construction industry was a major consumer of raw asbestos for insulation and asbestos cement products. All construction workers may have been exposed when working in contaminated spaces in the early stages of construction phases.

Building construction workers, such as electricians, masons, and carpenters, who do not work directly with asbestos-containing materials were and may still be sufficiently exposed to asbestos-related diseases [11, 17, 25]. Another peculiar characteristic of the construction sector is the temporary nature of the work and the workplace, especially in recent years with frequent improvised work practices and frequent self-employment as small self-employed entrepreneurs who are both employers and workers [78].

Construction workers who install asbestos-containing materials were and may be exposed during the cutting and drilling of building materials such as cement pipes or tiles. Especially in the past, these materials were not labeled as hazardous, and users did not wear respiratory protective masks capable of filtering out tiny fibers; thus, some of these secondary users have developed asbestos-related diseases [11].

In Italian companies in the construction sector, each worker often performs more than one job in the same environment. Before the ban in 1992, when working near colleagues engaged in other processes, a worker could have been involved in using asbestos or asbestos-containing materials or near insulation workers while asbestos was sprayed.

Table 2. Distribution of cases by job and year of exposure beginning (column and row percentages).

	1924-1960			1961-1991			1992-2010			Total	
Job	**N**	**% by job**	**% by year of beginning**	**N**	**% by job**	**% by year of beginning**	**N**	**% by job**	**% by year of beginning**	**N**	**% by job**
Building contractor technical surveyor	57	41.3	4.6	77	55.7	7.1	4	2.8	21.05	138	100
Miner, Fochino, bricklayer in the tunnel	-	-	-	-	-	-	-	-	-	-	-
Asphalter, Stonecutter, Paver, railway roadman	6	35.2	0.4	11	64.7	1.02	-	-	-	17	100
Bricklayer, foreman	654	59.9	53.6	433	39.6	40.4	4	0.3	21.05	1091	100
Carpenter, Blacksmith, Welder, Tinsmith	66	47.8	5.4	71	51.4	6.6	1	0.7	5.2	138	100
Plasterer, prefabricated packager, cement builder	3	42.8	0.2	4	57.1	0.3	-	-	-	7	100
Tiler, Plasterer	20	55.5	1.6	16	44.4	1.4	-	-	-	36	100
Insulator	38	45.2	3.1	46	54.7	4.2	-	-	-	84	100
Glazier	3	60.0	0.2	2	40.0	0.1	-	-	-	5	100
Plumbing and heating, plumbing, refrigeration, fountain	127	48.2	10.4	132	50.1	12.3	4	1.5	21.05	263	100
Electrician, elevator operator	47	41.5	3.8	66	58.4	6.1	-	-	-	113	100
Painter, Plasterer	33	50.7	2.7	30	46.1	2.8	2	3.07	10.5	65	100
Cleaner	-	-	-	1	50.0	0.09	1	50.0	5.2	2	100
Diver	-	-	-	-	-	-	-	-	-	-	-
Mechanic	13	38.2	1.06	20	58.8	1.8	1	2.9	5.2	34	100
Machine operator	16	30.7	1.3	36	69.2	3.3	-			52	100
Labourer	137	51.8	11.2	125	47.3	11.6	2	0.7	10.5	264	100
Various[1]	-	-	-	1	100	0.09	-	-	-	1	100
	-	-	100	-	-	100	-	-	100	-	-
Total	1220	52.8	-	1071	46.3	-	19	0.8	-	2310	100

[1] *Upholsterer, Armed Forces, Chemical Plant Worker, Verifier, Farmer, Sander, Metallurgical Worker.*

Moreover, in some geographic areas of Italy, several occupational groups (e.g., plumbers, insulators, pipe fitters, carpenters, and electricians) employed in the construction sector can have worked in different industrial settings other than in the maintenance and refurbishment of buildings. For instance, in the coastal area of Northeastern Italy (Trieste-Monfalcone), where shipbuilding and ship repairing were the predominant industrial activities in the past, construction workers can have been exposed, sometimes accidentally, to asbestos during other work activities in the shipyards, due to the extensive use of asbestos-containing materials for insulation and fire protection.

Regardless of the level of exposure, Table 1 shows that the 2,130 occasions of exposure are distributed

Table 3. Distribution of cases by job and incidence year (column and row percentages).

	1993-2000			2001-2010			2011-2018			Total	
Job	**N**	**% by job**	**% by incidence year**	**N**	**% by job**	**% by incidence year**	**N**	**% by job**	**% by incidence year**	**N**	**% by job**
Building contractor technical surveyor	18	13.04	6.9	63	45.6	5.7	57	41.3	6.01	138	100
Miner, Fochino, bricklayer in the tunnel	-	-	-	-	-	-	-	-	-	-	-
Asphalter, Stonecutter, Paver, railway roadman	-	-	-	8	47.05	0.7	9	52.9	0.9	17	100
Bricklayer, foreman	102	9.3	39.2	540	49.4	49.0	449	41.1	47.3	1091	100
Carpenter, Blacksmith, Welder, Tinsmith	18	13.04	6.9	69	50.0	6.2	51	36.9	5.3	138	100
Plasterer, prefabricated packager, cement builder	1	14.2	0.3	3	42.8	0.2	3	42.8	0.3	7	100
Tiler, Plasterer	5	13.8	1.9	16	44.4	1.4	15	41.6	1.5	36	100
Insulator	18	21.4	6.9	46	54.7	4.1	20	23.8	2.1	84	100
Glazier	4	80.0	1.5	1	20.0	0.09	-	-	-	5	100
Plumbing and heating, plumbing, refrigeration, fountain	22	8.3	8.4	108	41.06	9.8	133	50.5	14.02	263	100
Electrician, elevator operator	11	9.7	4.2	53	46.9	4.8	49	43.3	5.1	113	100
Painter, Plasterer	11	16.9	4.2	27	41.5	2.4	27	41.8	2.8	65	100
Cleaner	1	50.0	0.3	-	-	-	1	50.0	0.1	2	100
Diver	-	-	-	-	-	-	-	-	-	-	-
Mechanic	3	8.8	1.1	17	50	1.5	14	41.1	1.4	34	100
Machine operator	5	9.6	1.9	28	53.8	2.5	19	36.5	2.0	52	100
Labourer	41	15.5	15.7	122	46.2	11.07	101	38.2	10.6	264	100
Various[1]	-	-	-	1	100	0.09	-	-	-	1	100
	-	-	100	-	-	100	-	-	100	-	-
Total	260	1.1	-	1102	47.7	-	948	41.03	-	2310	100

[1] *Upholsterer, Armed Forces, Chemical Plant Worker, Verifier, Farmer, Sander, Metallurgical Worker.*

47% among bricklayers, 11% among plumbers and laborers, 6% among carpenters and building contractors, followed by 4.8% among electricians and finally 3.6% among insulators. These data confirm the prevalence of non-specialized "interchangeable" jobs. Of all the jobs analyzed, 64.8% are classified as having certain exposure. For the jobs for which 50% and more are classified as certain exposure, the most frequent are, in decreasing order, the following: insulators, plumbing workers, carpenters, asphalters, mechanics, machine operators, electricians, and bricklayers (Table 1).

As shown in Table 1, the beginning of considered exposures ranged between 1924-1960 in 52.8% of cases versus 46.3% in 1961-1991. As expected, the cases with the starting year of exposure between

1992/2010 dropped drastically after the law banning asbestos. From the analysis for single jobs, the highest percentage of initiation of exposure in the period 1961/1991 is among machine operators, asphalters, mechanics, and electricians.

This study, although it analyzes qualitatively classified exposures, confirms that some of the job of the construction sector, such as insulators and thermo-hydraulic workers (plumbing and heating, plumbing, refrigeration, fountain), continues to be a source of a certain level of exposure (Table 1) [48]. Studies of plumbers showed that many do not recognize the friable asbestos materials they still sometimes encounter [12, 17, 79]. Analyzing the percentages of each job by the period of beginning exposure, both in 1924-1960 and in 1961-1991, the highest percentages are among bricklayers, plumbing workers, and laborers are stable at around 11% (Table 2). From the analysis by periods of incidence (Table 3), while, as expected, the insulator cases decreased in the two periods 2001-2010 and 2011-2018, in plasterers and painters remained stable, and in plumbers increased from 41.1 to 50.5%. The low percentage (1.1%) of cases in this sector in the incidence period 1993-2000 is likely to be due to the start of the registry activities in 1993 only in a few regions. From the analysis of the jobs in the three incidence periods 1993-2000, 2001-2010, and 2011-2018 (Table 3), the highest percentages are always for bricklayers and laborers. Only in the most recent 2011-2018 are plumbing workers in second place after bricklayers (47.3%) with 14.02% and before laborers (10.6%).

The data on building contractors confirm the structuring of the construction sector into small self-employed companies where the role of entrepreneur and construction worker coincide and indicate that historic exposures are still producing cases. The excess mortality results for masons and carpenter-welders confirm the wide diffusion of asbestos in construction work and the various contiguous processes in unconfined environments with secondary or indirect exposure [18].

Despite the high number of cases considered at the national level, the major limitations of our study must be highlighted. The exposure assessment is qualitative, and the ability to identify the specific modalities is not entirely consistent among regional registries. Recall bias cannot be excluded due to the collection of data on exposures even many years their occurrence at the time of diagnosis of the disease; however, this possible bias was minimized by the structured questionnaire used, and our analyses are based on job title and exposures reported in the cases' questionnaires evaluated by expert industrial hygienists.

About the validity of qualitative exposure assessment, it could reflect the different expertise of the evaluators in the different regional registers (COR) and the different level of confidence of exposure data based on questionnaires and a priori knowledge, also based on the different local and territorial realities in the construction sector. However, only analysis by region would help highlight misclassifications.

It must be highlighted that the study on such a large number of cases was made possible by the ReNaM, the epidemiological systematic surveillance system for public health purposes, which provides important information to improve knowledge on malignant mesotheliomas, such as monitoring the evolution of its incidence in high-risk occupations and economic sectors, as the construction industry. In addition, it provides data on the trends of the mesothelioma epidemic. It is a valuable tool for identifying and controlling the potential and unknown sources of asbestos exposure in cases.

5. Conclusions

In conclusion, our data, in consideration of the long latency of this pathology, confirm that both specialized (skilled) and unspecialized (unskilled) workers in Italian construction industry, still after the banning asbestos law, frequently especially in the past decades, remained uninformed and untrained in dealing with asbestos exposure as previously evaluated in other countries [79]. Although asbestos has been banned and safety measures have been implemented in Italy since 1992, a large amount of asbestos remains in situ in many older buildings, and construction workers might be still at risk of asbestos exposure and its associated occupational diseases. During building repair, renovation, maintenance and demolition that involves the disturbance of settled dust, when building materials ultimately wear out and must be replaced, the process of removing asbestos-containing materials can lead to further significant exposure [11, 33].

In the course of renovation activities, especially of old houses, the presence of asbestos-containing materials might not be known, and the danger underestimated. The construction sector still presents an occupational health prevention challenge as it involves a large number of relatively small employers, multiemployer construction sites and a highly mobile workforce, mostly from foreign countries. In this sector, circumstances of exposure to asbestos may still occur due to incomplete compliance with prevention and protection measures. Construction workers must be informed and educated about the risks of indirect past and possible current asbestos exposure, being often unable to identify the asbestos materials handled and/or to recall a substantial asbestos exposure [43]. Unfortunately, non-complete compliance regarding the correct use of personal protection devices, safety procedures and best practices is still frequent today among construction workers. The results, although in agreement with the previously descriptive studies, suggest the importance of analytical studies to confirm and define on time the association for specific job and mesothelioma risk. Moreover, they point out the importance to educate labourers regarding safe work practices, mandatory use of personal protective equipment included, and that all cases of mesothelioma still occurring in construction workers should be identified as a professional disease [13, 35] from a public health perspective.

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Informed Consent Statement: Not applicable.

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

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APPENDIX

Supplementary Table 1. Conversion table for converting ISTAT codes into ReNaM building code.

Occupational code (ISTAT 1991)*	Occupational code (ISTAT 2011)	Proposal of ReNaM Tasks from national collective labour agreement Construction 2010 CCNL - Formedil (modified for asbestos exposure)	ReNaM building code
1213	1213	Building contractors, builders, engineers, architects, surveyors, technicians, real estate agents, office workers, warehouse workers, caretakers, guardians, etc.	1. Building contractor technical surveyor
1223	1223		
	1313		
2216	2216		
	2221		
3125	3135		
3345	3152		
41	41		
	4312		
	6111	Fireman, shimmer, miner	2. Miner
	6112	Stonemason, marble worker, stone cutter, asphaltist	3. Asphalter, stonecutter, paver, railway roadman
6121	6121	Bricklayers	4. Bricklayer
6122	6122		
6123	6123	Carpenters in iron, wood, scaffolding, shipowner, railway shipowner, etc.	5. Carpenter
6124	6124		
6125	6125		
6126	6126	Road paver, asphalter	3. Asphalter, stonecutter, paver, railway roadman.
	6127	Packaging prefabricated fitter, cement, liming, plasterer	6. Prefabricated packaging cementist plaster
6131	6131	Paver, tiler	7. Cladding installer
6132	6132		
6133	6133	Plasterer	6. Prefabricated packaging cementist plaster
6134	6134	Waterproofing, thermal and acoustic insulation, insulator	8. Insulator
6135	6135	Glazier	9. Glazier
6136	6136	Plumbing and heating, pipe makers, plumbers, etc.	10. Thermo-hydraulic, tubist, welder
6137	6137	Electricians, splicers, wire guards, etc.	11. Electrician
	6138	Fabricators	5. Carpenter

Occupational code (ISTAT 1991)*	Occupational code (ISTAT 2011)	Proposal of ReNaM Tasks from national collective labour agreement Construction 2010 CCNL - Formedil (modified for asbestos exposure)	ReNaM building code
6141	6141	Painters, plasterers, etc.	12. Painter
	6142	Facade cleaner	13. Cleaner
6142		Parquet installer for synthetic floors	7. Cladding installer
6143		Facade cleaner	13. Cleaner
	6151	Cleaning workers	13. Cleaner
	6152	Sewer maintenance technician	10. Thermo-hydraulic, tubist, welder
6212	6212	Welders, tinsmiths	10. Thermo-hydraulic, tubist, welder
6213	6213		
6214	6214	Iron carpentry fitters	5. Carpenter
	6215	Elevator operators	11. Electrician
	6216	Underwater works, diver etc.	14. Diver
	6217	Welders	10. Thermo-hydraulic, tubist, welder
6236		Mechanics	15. Mechanic
6238		Painters	12. Painter
7424		Truck drivers, earthmoving machinery operators, concrete mixers, cranes, forklifts, drilling machines, etc.	16. Machine operator
7441	7441		
7442	7442		
7443	7443		
7444	7444		
8621	8424	Unqualified labourers, civil road construction etc.	17. Labourer
8622	8422		
8629			

**Used in the ReNaM softwar.*

Supplementary Table 2. Summary of cancer studies showing excess risk of mesothelioma in various job tasks of the construction sector.

Construction trade	Author (Year)Reference
Labourers, builders, handymen, other construction workers	Coggon (1995), Goldberg (2006), Rake (2009), Pukkala (2009), Roland (2010), Stocks (2011), Roelofs (2013), Järvholm (2014), Ringen (2015) (2019), De Bono (2021), Migliore (2022) [14,17,32,42-50].
Electricians	Fear (1996), Kang (1997), Robinson (1999), McDonald (2001),Koskinen (2002), Engholm (2005), Rake (2009), Stocks (2011), Roelofs (2013), Järvholm (2014), Ringen (2015), Mazurek (2017), Ringen (2019), De Bono (2021), Migliore (2022) [9,11,14,17,26,32,44,47,48,50,51-55].
Carpenter and iron carpenter	Teta (1983), Firth (1993), Coggon (1995), Robinson (1996), Kang (1997), McDonald (2001), Dement (2003), Rake (2009), Roland (2010), Stocks (2011), Roelofs (2013), Ringen (2015), Plato (2016), Ringen (2019), De Bono (2021) [14,25,32,44,47-49,52,54,56-58].

Table S2 (*Continued*)

Construction trade	Author (Year)Reference
Plumber, plumbing and heating engineers, pipefitters	Teta (1983), Malker (1985), Cantor (1986), Malker (1990), Engholm (1995), Coggon (1995), Kang (1997), Teschke (1997), McDonald (2001), Engholm (2005), Goldberg (2006), Pukkala (2009), Rake (2009), Roland (2010), Stocks (2011), Roelofs (2013), Järvholm (2014), Ringen (2015), Plato (2016), Mazurek (2017), Ringen (2019), De Bono (2021), Migliore (2022) [11,14,17,32,42-50,52,54-56,59-64].
Brickmasons, stonemasons, bricklayers	Firth (1993), Teschke (1997), Pukkala (2009), Roland (2010), Roelofs (2013), Järvholm (2014), Plato (2016), De Bono (2021) [17,32,45,46,48,57,59,64].
Sheet metal	Engholm (1995), Stern (1997), Kang (1997), Teschke (1997), Engholm (2005), Goldberg (2006), Dement (2009), Roland (2010), Roelofs (2013), Järvholm (2014), Welch (2015), Plato (2016), Mazurek (2017), Ringen (2019) [11,17,25,43,46,48,49,52,55,59,64-67].
Insulators	Selikoff (1964) (1979), Malker (1987), Selikoff (1992), Kang (1997), Järvholm (1998), McDonald (2001), Koskinen (2002), Ulvestad (2004), Engholm (2005), Roelofs (2013), Järvholm (2014), Plato (2016), Mazurek (2017), De Bono (2021) [9,11,17,32,48,52,54,55,59,68-73].
Painters	Malker (1987), Kang (1997), Teschke (1997), Engholm (2005), Pukkala (2009), Rake (2009), Järvholm (2014), Plato (2016), De Bono (2021), Migliore (2022) [11,17,32,44,45,50,52,59,64,70].
Welders	Becker (1999), Goldberg (2006), Pukkala (2009), Roland (2010), Roelofs (2013), MacLeod (2017) [43,45,48,74-76].
Crane operators	Järvholm (2014) [18].
Wood workers	Järvholm (2014) [18].
Drivers	Järvholm (2014) [18].
Foremen	Järvholm (2014) [18].
Concrete workers	Järvholm (2014) [18].
Floor layers	Järvholm (2014) [18].
Refrigeration repairers	Järvholm (2014) [18].
Construction managers	Coggon (1995), Mazurek (2017) [42,55].
Plasterers	Coggon (1995), De Bono (2021) [32,42].
Architects and surveyors	Coggon (1995) [42].
Foreperson: other construction trades occupations	Plato (2016), De Bono (2021) [32,59].
Operating engineer	Ringen (2019) [49].
Scaffolders	Stocks (2011) [47].
Roofers	Stern (2000), Migliore (2022) [50, 77].

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A Relative Importance Index Approach to On-Site Building Construction Workers' Perception of Occupational Hazards Assessment

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Abstract

Background: *The construction industry has a high percentage of work-related injuries and fatalities. Workers' perception of occupational hazards exposure can be a proactive management tool in knowing the state of construction site safety performance. This study assessed the hazard perceptions of on-site construction workers in Ghana.* **Methods:** *Using a structured questionnaire, data was collected from 197 construction workers at live building sites in the Ho Municipality. The data were analyzed using the Relative Importance Index (RII) approach.* **Results:** *The study revealed that on-site construction workers perceived ergonomic hazards as the most frequent, followed by physical, phycological, biological, and chemical hazards. Long working hours had the highest overall RII ranking, followed by bending or twisting back during task performance, manual lifting of objects or loads, scorching temperatures, and lengthy standing for prolonged periods. The importance level of the RII revealed that long working hours and bending or twisting back during task performance were perceived as the most severe hazards.* **Conclusions:** *Given the adverse health effects of working for long hours, the management of Ghanaian construction industries needs to reinforce the legislation on working hours to safeguard workers' occupational health. Safety professionals can use the study's findings to improve safety performance in the Ghanaian construction industry.*

1. Introduction

The construction industry has an unarguably high percentage of work-related injuries and fatalities and considered one of the most dangerous industries to work in [1-3]. A disproportionate number of injuries and accidents in the construction industry have been linked to employee's perception of hazards and their associated risk. Meng and Chan [4] found a significant positive effect of individual risk perception toward safety performance among construction workers in China and Hong Kong. Improved employees' safety perception among Ghanaian construction workers enhanced and sustained their awareness and commitment to organizational health and safety practices [5]. Assessing the hazard

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exposure perception of the construction workforce is a critical step in knowing about safety issues and enhancing safety management at construction sites [6-7].

The hazard perception assessment approach has been used to determine the most critical hazards causing accidents and to design decision-aid systems for the construction industry [8-9]. Currently, little is known about the predictive factors contributing to construction workers' occupational accidents and injuries in the Ghanaian construction industry [10]. Also, the country lacks a robust institutional framework and poor enforcement of health and safety policies governing construction activities [11]. Furthermore, proper accident investigation is limited to prevent the repetition of the same accident on-site [12]. Hazard perception assessment among construction workers can be a useful predictive tool for managing occupational health and safety in the Ghanaian construction industry. Employees' shared perceptions regarding occupational hazards in the workplace is a snapshot of the prevailing state of safety in an organization [13-14].

According to Fatonade and Allotey [15], most accidents and injuries in Ghanaian construction sites emanate from a failure to identify hazards. Given the tremendous mediating effect of hazard perception on the construction industry's health and safety, more attention must be paid to its influence on employees' workplace safety. Hence, knowledge about the hazards associated with construction activities is a necessary foundation upon which safety management systems can be built. Assessing the hazard exposure perception of the construction workforce may be a vital proactive accident management tool to enhance construction site safety management. The objective of this study is to determine the perceived frequency of exposure to hazards of building construction workers and use it as a determinant of potential risk. The findings of this study can be interpreted in the same way as the epidemiology of work-related injuries in the construction industry [8], where knowledge about the most frequent hazard of exposure can be used to prioritize preventive actions.

2. Methods

2.1 Study Area

The study was conducted in the Ho Municipality which has a human population of 180,420 and covers a total land area of 587 km^2 and located between latitudes 6°20″N and 6°55″N and longitudes 0°12′E and 0° 53′E [16]. The municipality shares boundaries with Adaklu and Agotime-Ziope Districts to the South, Ho West District to the North and West, and the Republic of Togo to the East. The construction market in the municipality continues to expand and is ranked as the fifth-biggest employer out of 21 industrial activities due to increased infrastructural needs of facilities, such as homes, shops, schools, hospitals, and office spaces. To cater for the demand in construction activities, there is a need for a healthy workforce hence the need to look into occupational exposure to hazards.

2.2 Questionnaire Design and Development

According to Carter and Smith [7], most construction hazards remain unrecognized regardless of project type and location. Jeelani et al. [6] study also mentioned that workers might not know what hazards to expect and look out for due to uncertainty and diversity across projects and situations. Therefore, potential hazards related to building construction were identified, adapted, and modified from these studies [2, 3]. The modification was necessary as different project types (e.g., high-rise, residential, and municipal projects) have different hazards. The characteristics of building construction activities in the study area were adequately considered in the selection of the questions.

The survey questionnaire was organized into demographic aspects and hazard perceptions based on the frequency of exposure. The demographic part of the questionnaire dealt with characteristics such as gender, age group, last level of formal education, job specialty, and experience in the construction industry. The most recognized classification of construction-related hazards is biological, chemical, physical, ergonomic, and psychological [17, 18]. Respondents were asked to rate their hazard perception based on the frequency of exposure to the selected indicators of recognized hazards during construction activities on a five-point Likert scale varying from "Never" (1 = not expected to occur but still possible), "Seldom" (2 = not likely to occur under normal circumstances), "Sometimes" (3 = possible or known to occur), "Frequently" (4 = common occurrence) and "Always" (5 = continual or repeated experience) for the current hostel facility project being undertaken in the second part of the questionnaire. The questionnaire was programmed into the KoBoCollect Android smartphone application and pretested at construction sites to build the confidence of the research assistants in using the electronic tool for the data collection.

2.3 Determination of Sample Size

The sample size was estimated using a formula developed by Yamane [19]. It was calculated as:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the population size, and e is the level of precision. Using a confidence level of 95%, a level of precision of 5% (0.05), and a population size (N) of 258, the sample size (n) of 156 was obtained. The total number of respondents in each of the study companies and those that participated were 80 (60), 61 (55), 60 (42), and 57 (40) for sites 1, 2, 3, and 4, respectively. The number of respondents interviewed were, however, increased to 197 respondents because site supervisors allowed for the face-to-face administering of questionnaires to workers who were not busy outside the agreed schedule. The respondents were drawn from the site's list of workers using a simple random sampling approach.

2.4 Sampling Procedure and Data Collection

Four (4) ongoing hostel construction facilities for a Higher Institution of Learning (HEI) in the municipality were chosen because they represented most of the typical construction activities, including building, steel fixing, plastering, tiling, painting, glazing, electrical and sanitary installations. Also, the construction sites had almost all the artisans involved in building construction at the site providing easy accessibility to the different specialties in the building construction industry. In addition, most of the workers were permanent staff, and the temporal staff had a short-term contract with the companies involved in the construction. The casual workers selected had worked alongside the permanent and temporal staff for at least three months and were considered to have had sufficient time to be accustomed to their coworkers and the safety climate of the construction sites, given the largely transient nature of the construction workforce. The site supervisors were informed and requested to brief the workers about the study objectives to facilitate the process of data collection after permission had been obtained from the companies to conduct the survey.

Data were collected from the on-site building construction workers in May 2022. The structured questionnaire was completed through face-to-face administering of the questionnaire with the help of research assistants. The direct administration of the questionnaire was employed due to the low literacy levels of most artisans in the construction industry in Ghana, particularly in the Ho Municipality [20, 21]. Therefore, the research assistants explained the content of the questionnaire in the Ewe local language, which is widely spoken in the municipality and adopted as the lingua franca to the respondents who could not to read and understand the English language. Oral informed consent was obtained from each participant before interviewing. A 100% completion of the questions with each participant was ensured through the mandatory response setting to the KoboToolbox.

2.5 Data Analysis

2.5.1 Relative Importance Index (RII)

The Relative Importance Index (RII) was used to prioritize the indicators in this study. The RII is one of the most reliable approaches for rating variables using a structured questionnaire on a Likert scale [22]. The RII approach has been used in previous studies to rank construction-related exposure to hazards [23]. The RII was calculated using the following equation:

$$\text{Relative Importance Index } (RII) = \frac{\sum \omega}{A * N}$$

where ω is the weighting given to each factor by the respondent (ranging from 1 to 5 in this study), A is the highest weight (i.e., 5 in this study), and N is the total number of respondents (i.e., 197 in this study). The relative importance index ranges from 0 to 1, with the highest RII indicating the maximum hazard perception of exposure from construction-related activities. The RII of values have been classified into: High (H) (0.8≤RI≤1), High-Medium (H-M) (0.6≤RI<0.8), Medium (M) (0.4≤RI<0.6), Medium-Low (M-L) (0.2≤RI<0.4), and Low (L) (0≤RI<0.2) to determine the important levels of attributes assessed [24, 25].

3. Results

All the 197 participants were males, and most of them were masons (n=44; 22.34%), laborers (n=34; 17.26%), painters (n=26; 13.20%), carpenters (n=25; 12.69%), steel benders (n=19; 9.64%), electricians (n=16; 8.12%), plumbers (n=14; 7.11%), and tilers (n=9; 4.57%) (Table 1). Most participants were between the ages of 21 to 30 years, followed by ages 31 to 40 years, ages 41 to 50 years, ages 18 to 20 years, ages 51 to 60 years, and the least number of participants were above 60 years. Regarding work experience of participants were 25.38% (n=50) of the participants had been in construction work for more than 20 years, 24.87% (n=49) for 6-10 years, 19.80% (n=39) for 1-5 years, 16.24% (n=32) for 11-15 years, and 13.71% (n=27) for 16-20 years. Overall, the participants with more than 10 years of work experience were about 55 % (Table 1). Permanent workers formed the majority of the participants (n=91; 46.19%), followed by temporal (n=76; 38.58%) and casual (n=30; 15.23%) workers. In terms of educational levels, 44.16% (n=87) of the workers participants reported having completed Junior High School (JHS), 36.04% (n=71) attained secondary, technical, or vocational education, 9.14% (n=18) reported having completed tertiary education, 8.63% (n=17) had attained primary education, and 2.03% (n=4) reported below primary or no formal form of education.

Table 2 indicates that most of the participants reported having heard of occupational hazards before (n=161; 81.73%), with their major sources of information emanating from the workplace (n=141; 87.58%), colleagues (n=93; 57.76%), radio (n=43; 23.71%), television (n=33; 20.50%), posters/banners (n=13; 8.07%), and school (n=7; 4.35%). Access to Personal Protective Equipment (PPE) among the participants was high (n=173; 87.82%) with the frequency of use in the order of often (n=66; 33.50), sometimes (n=64; 32.49%), always (n=30; 15.23%), rarely (n=10; 5.08%), and never (n=3; 1.52%) (Table 2).

The category and overall ranking of RII and the level of importance of each of the factors considered under the five types of hazards in this study are presented in the supplementary material (ST1). Regarding physical hazards, extreme hot temperature, sand dust, elevated noise, cement dust, and sun burns-sun exposure/ultraviolet radiation had the highest RII and were perceived to be of High-Medium importance level of exposure to the participants. Exposure to insects at the workplace had the highest RII under the biological hazard category and was ranked as a High-Medium importance level. Most of the biological hazards were perceived to be of Medium-Low importance level. The factors with the highest RII for the category of chemical hazards were irritant and/or allergic contact dermatitis with cement, gases, vapors, fumes, dust, or mist from burning of waste materials, and gases, vapors, fumes, dust, or mist from using pesticides sprayed to control or eliminate foliage, respectively (ST1). The chemical hazards were generally perceived as of Medium and Medium-Low importance level. Bending or twisting back during the performance of a task had the highest RII for ergonomic hazards and a High importance level. The rest of the factors considered under ergonomic hazards had a

Table 1. Demographic characteristics of study participants.

Characteristics	No.	%
Job specialty		
Mason	44	22.34
Laborer	34	17.26
Painter	26	13.20
Carpenter	25	12.69
Steel Bender	19	9.64
Electrician	16	8.12
Plumber	14	7.11
Tiler	9	4.57
Trusses Installer	3	1.52
CCTV and alarm Installer	2	1.02
Concrete Mixer Operator	1	0.51
Glass worker	1	0.51
Store keeper	1	0.51
Scaffolder	1	0.51
Welder	1	0.51
Years of work experience		
1-5 years	39	19.80
6-10 years	49	24.87
11-15 years	32	16.24
16-20 years	27	13.71
Above 20 years	50	25.38
Age group of participants		
18-20	19	9.64
21-30	84	42.64
31-40	57	28.93
41-50	22	11.17
51-60	13	6.60
Above 60	2	1.02
Form of employment		
Permanent	91	46.19
Temporal	76	38.58
Casual	30	15.23
Highest educational level of participants		
Below primary	4	2.03
Primary	17	8.63
Junior High School	87	44.16
Secondary/Technical/Vocational High School	71	36.04
Tertiary	18	9.14

Table 2. Knowledge of occupational hazards and access to personal protective equipment.

Have you heard of occupational hazard before?	No.	%
Yes	161	81.73
No	36	18.27
Where did you hear of occupational hazard?		
Workplace	141	87.58
Colleagues	93	57.76
Radio	43	26.71
Television	33	20.50
Poster	13	8.07
School	7	4.35
Do you have access to personal protective equipment?		
Yes	173	87.82
No	24	12.18
How often do you use the PPE?		
Always	30	15.23
Often	66	33.50
Sometimes	64	32.49
Rarely	10	5.08
Never	3	1.52

relatively high RII, and all were perceived to be of High-Medium importance level except lengthy sitting for prolonged periods that recorded a relatively low RII and Medium importance level. The psychological hazard category had the highest RII for long working hours, which had High importance level, followed by tight schedule for work and excessive workload, with both recording a High-Medium importance level (ST1).

The RII ranking for the 10 topmost factors in descending order were: long working hours (0.837), bending or twisting back during the performance of the task (0.810), manual lifting of objects/loads (0.797), extreme hot temperature (0.780), lengthy standing for prolonged periods (0.771), work with neck bent and twisted (0.760), tight schedule for work (0.709), repetitive lifting of heavy things(0.706), forced to overreach for equipment, tools and instruments (0.697), and repetitive carrying of heavy things (0.687). Ergonomic hazards variables were the most dominant among the 10 topmost factors. The importance level of the factors considered was perceived to be Medium (n=21), Medium-Low (n=20), High-Medium (n=16), and High (n=2). Long working hours and bending or twisting back during the performance of tasks were the two attributes that had High importance level. None of the 59 factors evaluated fell under the Low importance level. The average RII of the five types of hazards analyzed in this study recorded the highest RII for ergonomic hazards (0.708), followed by physical hazards (0.498), psychological hazards (0.460), biological hazards (0.411), and chemical hazards (0.408) (Figure 1).

4. Discussion

In this study, long working hours as a construction hazard of high importance level is aligned with prior research in other countries [26-28]. In Ghana. Enshassi et al. [27] found long, 27 working hours [28] to have the highest overall RII ranking among 28 factors associated with job stressors in the Palestinian construction industry. Rezaeian et al.

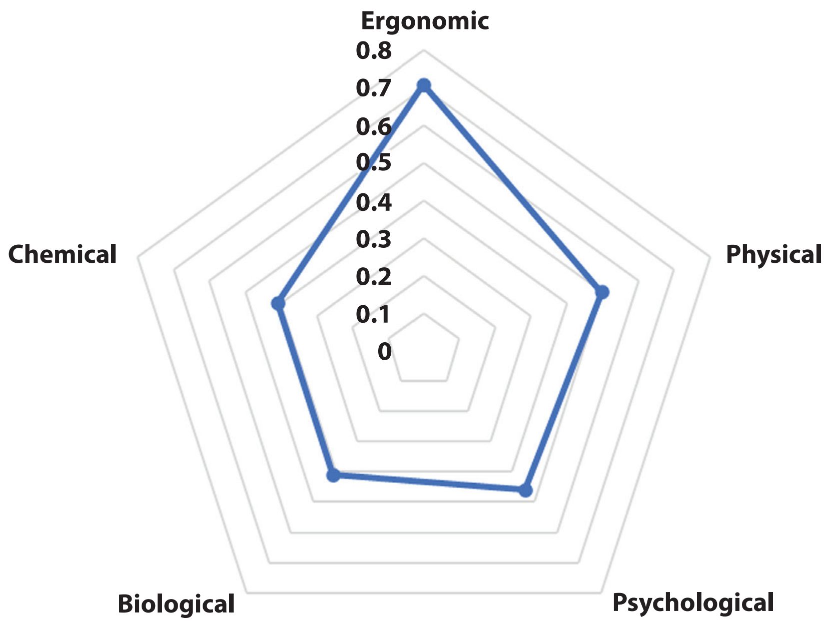

Figure 1. The average Relative Importance Index (RII) of the hazards assessed.

[26] found that most construction workers work long hours due to unachievable project completion deadlines in New South Wales (NSW), Australia. Long working hours were found by Ayarkwa et al. [28] to be the main barrier to the retention of females in the Ghanaian construction industry. Managers often use longer hours to cope with work overload and job demands [29]. The labor law of Ghana allows for voluntary overtime work, and workers may have been encouraged to take it due to the financial incentives leading to longer working hours. Otoo et al. [30] identified overtime pay to form a significant proportion of the income of Ghanaian workers. Tiwary et al. [31] made a similar observation for construction workers in India, where overtime pay encouraged long working hours among construction workers.

Excessive workload and tight schedules as the leading cause of psychological stress among construction workers are corroborated by previous studies [23, 27]. Indeed, Fordjour et al. [23] found tight deadline pressure and excessive workload to be first and second, respectively, in the overall RII ranking of 42 construction work-related psychological risk factors in Ghana. Rezaeian et al. [26] opined that most psychosocial problems in the construction industry result from unfeasible terms of project execution deadlines. In Ghana, delays in project execution have a critical effect on constructional budgetary allocation [32], and completing a project within the stipulated time frame is considered a critical factor for project success. Timely execution of projects to avoid the consequences associated with delays in completion by the construction firms may have influenced the long working hours, tight schedule for work, and excessive workload.

Construction, by its very nature, is physically demanding and requires, among other things, manual handling, bending and twisting, working in awkward or cramped positions, reaching away from the body and overhead, repetitive movements, and climbing and descending [33-35]. The physical nature is further aggravated by the pervasive labor-intensive approach in Ghana, where most of the work is conducted manually due to the low level of mechanization [33]. Manual material handling is considered one of the most physically demanding operations and a significant contributor to workers' exposure to ergonomic hazards [18, 34, 35]. Manual handling at construction sites offers a high risk of exposure to repetitive movements, forceful exertions, and awkward motions for extended durations, which are highly unsafe from an ergonomic viewpoint [35]. Manual material handling may account for this study's high-medium importance level of ergonomic factors, given the low reliance on machinery in the Ghanaian construction industry. The findings of this study are corroborated by other studies [33, 34] that also found manual handling as a significant contributor to ergonomic hazards among construction workers.

Construction workers are susceptible to heat stress because of hot weather, the physically demanding nature of work, and frequent, intense, and prolonged exposure to sunlight [36, 37]. Even within an indoor environment where workers are sheltered from direct sun exposure, the heavy workloads increase construction workers' risk of heat stress, particularly in the absence of mechanical ventilation [36]. Construction workers are at a high risk of heat stress-related disorders, including excessive sweating, dizziness, intense thirst, fatigue, dexterity, impaired concentration, visual acuity, and slippery palms secondary to sweating [36, 37]. The respondents in this study may have experienced the symptoms of heat stress due to their longer durations of exposure to higher temperatures, given the high RII for long working hours, which may account for the high RII of hot temperatures for physical hazard. Dust and noise were ranked 1st and 3rd as major environmental impacts of building construction activities in the Ho Municipality [24]. Their high RII under physical hazard reflects the environmental conditions in building construction sites. Non-adherence to Personal Protective Equipment (PPE) use by construction workers due to hot weather conditions [20] may have increased workers' exposure to dust and noise hazards.

Irritant and allergic contact dermatitis with cement as a major chemical hazard can be attributed to construction workers' non-adherence to using Personal Protective Equipment (PPE), especially protective clothing. In a previous survey, on-site construction workers were found to rarely use protective clothing because it makes them feel too hot during work [20]. Lissah et al. [38] identified the practice of open burning as an approach frequently used for waste management in the Ho Municipality. The burning of waste releases smoke and toxic fumes into the atmosphere. Construction workers may be exposed directly to the smoke and fumes, which can cause discomfort, such as breathing difficulties and eye irritation. The average cost of one-time manual weeding is higher than herbicide application per the same hectare in Ghana [39]. Common health symptoms such as headache, dizziness, catarrh, burning eyes, skin rashes, itching, and chest pain are associated with chemicals used to control vegetation [39]. The associated health implications of herbicide use may have influenced on-site construction workers' high perception of chemical hazard. Puddles of water at construction sites are prime breeding grounds for mosquitoes. The breeding of mosquitoes from stagnant water and other pests at construction sites was found by Ayarkwa et al. [40] to be a concern to construction practitioners because it affects employees' health. Ghana is considered an endemic malaria country, and the health implications associated with mosquito bites may have influenced on-site construction employees' perception as a biological hazard of high to medium importance level.

5. CONCLUSIONS

This paper focused on the hazard perception of exposure of on-site construction workers employing of quantitative analysis. The findings from the study revealed that on-site workers perceived ergonomic hazards as the most frequently encountered, followed by physical, psychological, biological, and chemical. Long working hours and bending or twisting back during the performance of tasks were the two attributes that were perceived to be of high recurrence and importance level at construction sites. Overall, the findings of this study highlight the hazard perception of exposure of construction workers as critical to assessing of potential risks in construction sites. This study revealed the need for promoting the integration of hazard perception of exposure by individuals into the health and safety of management practices in construction sites in the Ghanaian construction industry for improved safety performance.

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Appendix

Supplementary material (ST1). Relative Importance Index of hazards associated with construction activities.

Hazards	RII	RII Category Ranking	RII Overall Ranking	Importance level
Physical				
Extreme hot temperature	0.780	1	4	H-M
Sand dust	0.641	2	14	H-M
Elevated noise	0.638	3	15	H-M
Cement dust	0.626	4	16	H-M
Sun burns-sun exposure/ultraviolet radiation	0.607	5	17	H-M
Vibration	0.547	6	20	M
Extreme cold temperature	0.522	7	21	M
Slippery finish to the floor	0.477	8	24	M
Stepping on sharp objects (e. g., protruding nails)	0.474	9	25	M
Tripping, slipping, cuts, and falling	0.462	10	26	M
Inadequate ventilation	0.450	11	30	M
Inadequate lighting	0.445	12	32	M
Colliding with or being hit by sharp and/or protruding objects	0.425	13	34	M
Hit by a falling object	0.351	14	48	M-L
Hit by a moving object	0.350	15	49	M-L
Ultraviolet radiation from welding and cutting	0.340	16	51	M-L
Fall from height	0.324	17	52	M-L
Biological				
Exposure to insects at the workplace	0.648	1	13	H-M
Exposure to rodents at the workplace	0.459	2	27	M
Pricked by plants	0.459	2	27	M
Venomous animals and insects bite/sting at the workplace	0.442	3	33	M
Nonvenomous animal/insect bites/stings at the workplace	0.408	4	38	M
Fungi(mold)	0.385	5	42	M-L
Contact with the blood or body fluid of co-workers	0.380	6	44	M-L
Free-roaming dogs	0.356	7	47	M-L
Contact with co-workers diagnosed with communicable diseases	0.297	8	54	M-L
Being kicked or gored by an animal	0.276	9	55	M-L
Chemical				
Irritant and/or allergic contact dermatitis with cement	0.492	1	22	M
Gases, vapors, fumes, dust, or mist from the burning of waste materials	0.452	2	29	M
Gases, vapors, fumes, dust, or mist from using pesticides sprayed to control or eliminate foliage	0.413	3	35	M
Burns from chemicals	0.410	4	36	M

Table S1 (*Continued*)

Gases, vapors, fumes, dust, or mist from using adhesives and resins	0.409	5	37	M
Gases, vapors, fumes, dust, or mist from painting-particularly paint spraying	0.399	6	39	M-L
Gases, vapors, fumes, dust, or mist from using polish removers, paint removers, and paint thinners	0.382	7	43	M-L
Gases, vapors, fumes, dust, or mist from using oil from lubricants used in metal cutting operations	0.372	8	45	M-L
Gases, vapors, fumes, dust, or mist from welding and flame cutting	0.347	9	50	M-L
Ergonomic				
Bending or twisting back during the performance of a task	0.810	1	2	H
Manual lifting of objects/loads	0.797	2	3	H-M
Lengthy standing for prolonged periods	0.771	3	5	H-M
Work with neck bent and twisted	0.760	4	6	H-M
Repetitive lifting of heavy things	0.706	5	8	H-M
Forced to overreach for equipment, tools, and instruments	0.697	6	9	H-M
Repetitive carrying of heavy things	0.687	7	10	H-M
The awkward posture of the body	0.686	8	11	H-M
Repetitive pushing, pulling and moving of heavy things in wheelbarrow	0.677	9	12	H-M
Lengthy sitting for prolonged periods	0.485	10	23	M
Psychological				
Long working hours	0.837	1	1	H
Tight schedule for work	0.709	2	7	H-M
Excessive workload	0.605	3	18	H-M
Market risks and competition	0.588	4	19	M
Inadequate assistants/helpers	0.454	5	28	M
Isolation and lone working	0.448	6	31	M
Intimidation from colleagues	0.397	7	40	M-L
Tarnished reputation where you are accused of negligence	0.388	8	41	M-L
Verbal assaults from clients	0.365	9	46	M-L
Aggressive behavior from clients	0.365	9	46	M-L
Workplace bullying	0.315	10	53	M-L
Physical assaults from clients	0.276	11	55	M-L
Sexual harassment from clients	0.239	12	56	M-L

High (H) (0.8≤RI≤1), High-Medium (H-M) (0.6≤RI<0.8), Medium (M) (0.4≤RI<0.6), Medium-Low (M-L) (0.2≤RI<0.4), and Low (L) (0≤RI<0.2).

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Evaluation of Sleep Quality, Work Stress and Related Factors in Hospital Office Workers

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Keywords: Sleep Quality; Work Stress; Hospital; Office Worker

Abstract

Background: *Occupational factors, working conditions, age, gender, exercise, acquired habits, and stress affect a person's sleep quality. The aim of this study was to investigate sleep quality, work stress, and related factors among office workers in a hospital.* **Methods:** *This cross-sectional study was conducted with office workers actively working in a hospital. A questionnaire consisting of a sociodemographic data form, the Pittsburgh Sleep Quality Index (PSQI), and Swedish Demand-Control-Support Scale were used to assess the participants.* **Results:** *The mean of PSQI score was 4.32±2.40 and 27.2% of the participants had poor sleep quality. In the multivariate backward stepwise logistic regression analysis, it was found that shift workers were 1.73 times (95% CI: 1.02-2.91) more likely to have poor sleep quality, and a one-unit increase in work stress score increased the risk of having poor sleep quality by 2.59 times (95% CI: 1.37-4.87). An increase in age was found to decrease the risk of poor sleep quality in workers (OR=0.95; 95% CI: 0.93-0.98).* **Conclusion:** *This study suggests that reducing workload and increasing work control as well as enhancing social support will be effective in preventing sleep disturbances. It is important, however, in terms of providing guidance for hospital employees in planning future measures to improve working conditions.*

1. Introduction

Occupational factors, working conditions, age, gender, exercise, acquired habits, and stress could affect a person's sleep quality. Although many factors, such as sociodemographic and occupational characteristics, could affect the prevalence of sleep disorders, very common among healthcare workers [1]. Sleep disorders can lead to decreased immunity, adaptability, anxiety, depression, and other physical and mental disorders [2]. It has also been found that sleep disorders are associated with diseases, occupational accidents, and long-term health problems; It has been shown to affect both qualities of life and productivity [3]. Shift work patterns are becoming an increasingly common concept in many occupations in modern society. One-fifth of the working population is estimated to perform a job at different working hours or night [4]. Shift work can be performed in three shifts of 8 hours each and in two shifts beginning in the morning and ending at midnight. According to the International Labour

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Organization's (ILO) Night Work Convention, which came into force in 1995, the night shift is defined as "work performed during a period of not less than 7 hours, including from midnight to 5 a.m." [5]. Shift work is mandatory for 24-hour health care service, and night shifts are more common than in other sectors [6]. Sleep disturbance is a common problem among night shift workers. As a result of the disruption of circadian rhythms caused by shift work, the quality, and quantity of sleep decrease [7]. It has been determined that the night shift can affect not only their personal health but also the quality of their work, their psychological health, and the treatment of their patients and may cause related accidents.

Due to many factors in the working environment, workers are exposed to stress and experience physical, mental, and social changes due to their stress. Organizational factors such as work schedules and shift systems are among the causes of stress in the workplace. While continuous daytime work is the least stressful, shift workers are the most stressed. Failure to participate in regular activities due to shift work, inability to engage in regular social and community activities, and decreased job satisfaction can lead to stress [8]. The shift work system has been reported to cause stress and decrease workers' ability to cope [9]. There is a bidirectional relationship between poor sleep quality and stress. Stressful work environments lead to sleep problems [10]. Researchers have found that nurses from various medical departments are more likely to experience poor sleep quality due to work stress. Work stress has been found to affect job satisfaction and sleep quality among employees. Chronic work stress can lead to weakness, anxiety, depression, and other psychological problems that affect sleep quality [11, 12]. Most of the studies investigating sleep quality in hospital employees were conducted on nurses and doctors, and poor sleep quality was found [13-15]. When we think of shift work in health sector, the first groups that come to mind are healthcare workers, such as nurses and physicians, and office workers also work in shifts. The number of studies that have been conducted on office workers in hospitals is insufficient. In developing countries such as Turkey, hospital office workers do not come to mind among the priority groups among healthcare workers. For this reason, the employee health practices of hospital office workers are ignored. The aim of this study was to investigate sleep quality, work stress, and related factors among office workers in hospitals.

2. Methods

2.1. Study Settings and Population

This cross-sectional study was conducted between August 2022 and October 2022 with 512 office workers working at the Cerrahpaşa School of Medicine Hospital. The participants included the medical secretary, data entry, and administrative staff. The study questionnaire was administered to face-to-face hospital employees who attended a periodic health examination. No sample selection was made, and it aimed to reach the entire population. Of the 512 office workers working at the hospital, about 368 people attended the periodic health examination and agreed to participate in the study. Thus, 71.8% of the individuals in the study population could be reached. Written informed consent was obtained from each individual participant in the study. Inclusion criteria included registered office workers with more than one year of work experience. The study had no exclusion criteria. The night shift group included those who worked for at least five hours after midnight. On the other hand, the day shift group included those who worked for at least eight hours between 8 a.m. and 11 p.m. Working in night shift office workers, the group works in rotation. Those working in shifts of at least 1 year were included.

2.2. Research Instruments

A questionnaire consisting of a sociodemographic data form, the Swedish Demand-Control-Support Scale (DCSQ), and the Pittsburgh Sleep Quality Index (PSQI) were used to obtain information in the study. The sociodemographic data form included questions on individual characteristics, lifestyle, and occupational data in the first section. In the second section, DCSQ is used to evaluate the work stress of the participants. The DCSQ, conducted in Turkish by Yücel et al., is a widely used scale to evaluate psychological demands, decision-making freedom, and social support in the workplace. The scale consists of three main subsections. It includes five questions for workload, six for work control (skill utilization and freedom of decision), and six for social support. Response options for the subdivisions of workload, skill utilization, and freedom of decision consist of "frequently, sometimes, rarely, and never" responses. For social support, options include "totally agree, partially agree, partially disagree, and completely disagree". In the scale evaluation, the answers were coded between 1-4 Likert, and the total score of the relevant subsection is obtained by summing the scores of each subsection with higher values indicating higher psychological demands (range 5-20), higher decision latitude (range 6-24), and higher social support at work (range 6-24). All scale scores were calculated by summing up the respective unweighted item scores after appropriate reverse scoring of item 4 (overtime work) and item 9 (variety of work). High scores indicate a high workload, work control, and social support. Work stress was evaluated as the ratio of workload to work control [16]. In the third section, PSQI is used to evaluate sleep quality. The PSQI is a measure of subjective sleep quality. The PSQI was developed by Buysse et al. in 1989 [17]. The validity and reliability studies for the Turkish version were carried out by Ağargün et al. bjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disorders, hypnotic drugs, and daytime function, seven factors were rated on a 4-point Likert scale from 0 (no difficulties) to 3 (very difficult). The cumulative score of each factor was the total score of the PSQI, with the total score ranging from 0 to 2l. The higher the score, the worse the sleep quality. Scores greater than five indicated poor sleep quality [18].

2.3. Data Analysis

The data were analyzed by using SPSS v24.0 (SPSS Inc., Chicago, IL, USA). In descriptive analyses, number and percentage values for categorical variables and mean and standard deviation values are presented for continuous variables. Continuous variables are expressed as the mean ± standard deviation, and categorical variables are expressed as the frequency and percentage. In comparing two groups of continuous variables, Student's t-test and Mann–Whitney U test were used in independent groups. Categorical data were compared by the chi-square test. As a result of these two-variable analyses, the independent variables found to be related to sleep quality were included in the backward stepwise logistic regression analysis model, and multivariate analysis was performed. The relationship of the variables determined to be related to sleep quality in the backward stepwise logistic regression analysis with the subcomponents of sleep quality was evaluated with the Pearson correlation test and Student's t-test. The results were considered significant at $p<0.05$.

2.4. Ethical Considerations

The study was approved by the Cerrahpaşa School of Medicine Hospital Ethics Committee at Istanbul University-Cerrahpaşa (Date: 04.05.2021 No: 94540).

3. Results

The study included 368 hospital office workers, mostly men (70.9%, n=261). The mean age of the participants was 37.27±4.2 years. The mean body mass index (BMI) was 26.74±8.8. Of the participants, 68.8% (n=253) were married. Regarding occupational characteristics, 63% (n=232) had ten or more years of working experience. When participants were compared by sleep quality, female gender, singles, and shift workers had a significantly higher frequency of poor sleep quality. In contrast, the mean age and total working time was significantly lower among workers with poor sleep quality (Table 1).

When comparing participants' mean work stress scores as a function of their sleep quality, the mean work stress scores of employees with poor sleep quality were significantly higher than those with good sleep quality, while the social support score was significantly lower ($p<0.001$, $p=0.001$, and $p=0.014$, respectively) (Table 2).

Table 1. Individual, lifestyle, and occupational characteristics and sleep quality of hospital office workers.

		Total (n=368, 100%)		PSQI≤5 (n=268, 72.8%)		PSQI>5 (n=100, 27.2%)		p
Age (mean±SD)		37.27	(±4.2)	38.41	(±8.10)	34.22	(±9.89)	**<0.001**
Gender (n, %)	Female	107	(29.1)	70	(65.4)	37	(34.6)	**0.041**
	Male	261	(70.9)	198	(75.9)	63	(24.1)	
Marital status, n (%)	Married	253	(68.8)	200	(79.1)	53	(20.9)	**<0.001**
	Single	115	(31.3)	68	(59.1)	47	(40.9)	
Education (n, %)	Primary School	75	(20.4)	58	(77.3)	17	(22.7)	0.541
	High School	184	(50.0)	130	(70.7)	54	(29.3)	
	University	109	(29.6)	80	(73.4)	29	(26.6)	
Shift work (n, %)	Yes	180	(48.9)	122	(67.8)	58	(32.2)	**0.033**
	No	188	(51.1)	146	(77.7)	42	(22.3)	
Total working time, y (mean±SD)		11.85	(±6.7)	12.53	(±6.43)	10.03	(±7.09)	**0.002**
Weekly working time, h (mean±SD)		44.47	(±1.5)	44.46	(±1.56)	44.50	(±1.51)	0.821
BMI (mean±SD)		26.74	(±8.8)	26.82	(±3.90)	26.52	(±4.85)	0.540

BMI: Body mass index.

Table 2. Relationship between DCSQ scores and sleep quality among hospital office workers.

	Total (n=368) (mean±SD)	PSQI≤5 (n=268, 72.8%) (mean±SD)	PSQI>5 (n=100, 27.2%) (mean±SD)	p
Workload	12.88(±3,06)	12.54(±3.14)	13.8(±2.67)	**<0.001***
Work control	15.42(±3.69)	15.59(±3.68)	14.97(±3.69)	0.153*
Social support	19.60(±4.02)	19.91(±3.95)	18.76(±4.12)	**0.014***
Work stress	0.89(±0.36)	0.86(±0.34)	0.99(±0.38)	**0.001°**

**Student's t-test, °Mann-Whitney U test.*

When we compared the mean scores of PSQI sub-parameters according to shift work status, the mean scores of sleep duration, effective sleep habits, and total PSQI score were found to be statistically significantly higher in shift workers (p=0.010, p=0.006, p=0.014, respectively) (Table 3).

The final model obtained from the multivariate backward stepwise logistic regression analysis created with the variables determined to be associated with sleep quality in the binary analyzes is presented in the table. Accordingly, age, gender, marital status, shift work, total working time and stress score were included in the first step of the analysis. In the second step, the total working time; in the third and last step, it was exited from the marital status regression model. In the final model, it was found that shift workers were 1.73 times (95% CI: 1.02-2.91) more likely to have poor sleep quality, and a one-unit increase in work stress score increased the risk of having poor sleep quality by 2.59 times (95% CI: 1.37-4.87). An increase in age was found to decrease the risk of poor sleep quality in workers (OR =0.95; 95% CI: 0.93-0.98) (Table 4).

A weak positive correlation was found between workload and subjective sleep quality, sleep duration, sleep disturbance, daytime functions, and total sleep quality score. On the other hand, a weak negative correlation was found between the social support score and subjective sleep quality and daytime functions. In addition to that, a weak positive correlation was found between the total stress score and daytime functions and total sleep quality score (Table 5).

Table 3. Pittsburgh Sleep Quality Index (PSQI) score for hospital office workers.

	Total (n=368) (mean±SD)	Shift worker (n=180, 49%) (mean±SD)	Daytime worker (n=188, 51%) (mean±SD)	P*
Subjective sleep quality	0.93(±0.63)	0.97(±0.70)	0.88(±0.55)	0.177
Sleep latency	0.98(±0.88)	1.10(± 0.92)	0.86(±0.83)	**0.010**
Sleep duration	0.73(±0.66)	0.71(±0.72)	0.76(±0.59)	0.523
Habitual sleep efficiency	0.17(±0.49)	0.240.59	0.10(±0.36)	**0.006**
Sleep disturbance	1.04(±0.61)	10.5(±0.60)	10.4(±0.63)	0.843
Use of sleep medications	0.06(±0.37)	0.09(±0.48)	0.03(±0.22)	0.115
Daytime dysfunction	0.40(±0.66)	0.47(±0.75)	0.35(±0.55)	0.082
Global PSQI	4.32(±2.40)	4.63(±2.79)	4.01(±1.91)	**0.014**

**Student's t-test.*

Table 4. Multivariate analysis with a backward stepwise regression model of factors associated with sleep quality.

		Step 1		Step 2		Step 3* (Final model)	
		OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Age		0.97 (0.93-1.01)	0.103	**0.96 (0.93-0.99)**	**0.020**	**0.95 (0.93-0.98)**	**0.001**
Gender	*Female*	1.66 (0.94-2.93)	0.079	1.66 (0.94-2.92)	0.079	1.71 (0.98-3.01)	0.061
	Male (ref)						
Marital status	*Single*	1.61 (0.91-2.86)	0.105	1.61 (0.91-2.86)	0.101	-	-
	Married (ref)						
Shift work	*Yes*	1.63 (0.96-2.77)	0.073	1.63 (0.96-2.76)	0.069	**1.73 (1.02-2.91)**	**0.041**
	None (ref)						
Total working time (years)		1.00 (0.95-1.05)	0.912	-	-	-	-
Stress total score		**2.51 (1.33-4.75)**	**0.005**	**2.51 (1.33-4.74)**	**0.005**	**2.59 (1.37-4.87)**	**0.003**

**R^2= 0.084 (Cox&Snell), 0.124 (Nagelkerke).*

4. Discussion

This study evaluated sleep quality, work stress, and related factors in hospital office workers. The results of this study showed that all participants had a mean PSQI score of 4.32±2.40, and 27.2% had poor sleep quality. Besides, it revealed that poor sleep quality was more common in females, singles, and shift workers, while participants with poor sleep quality had a lower mean age and total working time. In studies conducted with nurses, the PSQI score was 6.80±3.39 in Spain, 6.0±2.130 in Japan, and 9.10±2.78 in China [19-21]. Studies in the literature report that the quality of sleep is poor in studies conducted on healthcare workers [22-26]. In a study conducted in Saudi Arabia, 42.3% of healthcare workers were found to have poor sleep quality [26]. In this study, it was found that the frequency of those who had PSQI scores and poor sleep quality was lower, and it is suggested that the possible reason for this is the different occupational groups of the participants in this study.

In this study, married participants were found to have better sleep quality than single participants. Consistent with our study, in the study conducted by Bingöl, single nurses had poorer sleep quality than married nurses [27]. Furthermore, other studies on this subject have also shown that the sleep quality of married healthcare workers is better than that of single healthcare workers [22, 28]. In the study conducted by Üstün et al., it was seen that the reason for the good sleep quality of the nurses was

Table 5. The relationship between PSQI and the subdimensions of the DCSQ scores.

		Workload	Work control	Social support	Work stress
Subjective sleep quality	r	**0.216**	0.032	**-0.126**	0.084
	p	**<0.001**	0.542	**0.016**	0.106
Sleep latency	r	0.094	-0.010	0.002	0.045
	p	0.071	0.853	0.975	0.389
Sleep duration	r	**0.138**	0.052	0.029	0.074
	p	**0.008**	0.322	0.582	0.158
Habitual sleep efficiency	r	0.054	0.006	0.002	-0.034
	p	0.302	0.902	0.962	0.519
Sleep disturbance	r	**0.125**	0.066	-0.016	0.028
	p	**0.016**	0.205	0.759	0.593
Use of sleep medications	r	0.021	0.066	0.027	0.081
	p	0.694	0.205	0.602	0.119
Daytime dysfunctions	r	**0.217**	-0.090	**-0.203**	**0.207**
	p	**<0.001**	0.085	**<0.001**	**<0.001**
Global PSQI	r	**0.213**	0.002	0.082	**0.129**
	p	**<0.001**	0.967	0.116	**0.013**

(Pearson correlation test), r→correlation coefficient.

that the majority (61.9%) were single and that those who were married had children aged four years and older (with low care burden) [28]. These findings suggest that the level of sleep quality should not be evaluated only with marital status; they should be evaluated together with factors such as having children, the number of night shift workers, and the department where they work.

Although the effects of gender on sleep quality in healthy adults are controversial in the literature, it has been stated that women may have more sleep problems, albeit partially. Some studies have found that men have better sleep quality [29, 31]. It is supposed that the reason for lower sleep quality in women is that they have other social obligations besides the workplace factor and that factors such as housework and children increase sleep problems.

Studies have shown that sleep quality is poor in workers younger than 35 and improves with age [27]. In addition, nurses' ability to cope with sleep problems has increased with age [32]. It is thought that the improvement of sleep quality with the advancement of age is because young nurses work in more intensive departments, work night shifts more frequently, and want more time to rest as they age.

Consistent with the literature, this study found that sleep quality increased over working year [27]. It has been concluded that this situation negatively affects the quality of sleep because those who are new in their professional life are usually employed in night shift work and busy healthcare facilities, and their coping skills are insufficient. In this study, 'age' may have been a confounding factor in the poorer sleep quality of participants with fewer total working years. In this study, it was found that the sleep quality of younger participants was worse. The fact that a low number of total working years was removed from the model in the regression analysis, but age remained, supports this.

Sleep disturbance is a common problem among night shift workers. Consistently with the literature, we found that night shifts are more likely to have poor sleep quality than day shifts [33, 34]. Nurses working night shifts had low sleep efficiency, sleep disorders, daytime dysfunction, and longer sleep latency [35]. In addition, the sleep-wake cycle is negatively impacted by shift work. As such, sleep is more likely to be disrupted in the daytime, which may result in shorter sleep periods. This was in line with previous studies indicating that specific characteristics of night shift work can lead to poor sleep quality. Consistent with these results, shift workers had a long time to fall asleep and a lower score for effective sleep habits in this study. Furthermore, in the retrospective stepwise regression model, the risk of poor sleep quality was 1.73 times higher in shift workers than in day workers.

In particular, the health sector includes many factors that cause stress, such as the difficulty of serving patients who experience intense stress and the frequent occurrence of stressful events in the daily work of those working in this sector. While work stress increases sleep disturbance, sleep disturbance also causes employees to perceive work stress more with mechanisms such as concentration problems [36]. In this study, it was found that the mean workload and work stress score of the participants with poor sleep quality was higher, the social support score was lower, and a 1-unit increase in the work stress score in the backward stepwise regression model increased the risk of poor sleep quality by 2.59 times (95% CI: 1.37-4.87). Similarly, in the study by Elevainio et al., sleep problems were significantly more severe in the group with a high mean work stress score [37]. A cohort study with a two-year follow-up stated that there was a correlation between occupational characteristics such as workload, control, social support, and sleep disorders.

Other studies have reported that sleep problems occur when the workload is high, but work control is not solely related to sleep [38, 39]. This finding is consistent with the view that the sense of motivation and mastery increases, and the tension-generating effect of a high workload decreases when both workload and work control are high compared to the workload-control model. In the Karasek model, social support is a variable that reduces the effect of work stress. In this study, as in other studies, low social support was associated with sleep problems [39].

The study has a few limitations. As the first main limitation, a causal relationship between sleep quality and related factors could not be established since this study was descriptive and cross-sectional. Secondly, only self-reported subjective measures were used in this study, and all data were collected using self-report questionnaires, which may affect the results. Thirdly, non-occupational determinants of sleep quality, such as caffeine intake and drug use, were not asked. Fourthly, this study was conducted in a university hospital in Turkey, and hospital office workers working in this hospital were included. Because of this reason, the generalization cannot be made. However, apart from these limitations, this study is the first to investigate sleep quality, work stress, and related factors among hospital office workers in Turkey.

5. Conclusions

In this study, it was found that 27.2% of hospital office workers had poor sleep quality; poor sleep quality was more common in single and shift workers as well as in female gender, and the mean age and total working time were lower in participants with poor sleep quality. In addition, it was found that the increase in shift work and work stress score increased the risk of poor sleep quality, whereas increasing age decreased the risk. Determining the relationship between potential risk factors in the work environment and sleep disorders is necessary for worker health. The results of this study suggest that reducing workload and increasing work control as well as enhancing social support will be effective in preventing sleep disturbances. It is important, however, in terms of providing guidance for hospital employees in planning future measures to improve working conditions.

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The Impact of Lower Extremity Fatigue on Lower Quadrant Dysfunction and Health Profile in Hairdressers

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Key words: Lower Extremity Fatigue; Hairdressers; Lower Quadrant; Health Profile

Abstract

Background: *Although lower extremity pain and fatigue are important conditions for hairdressers, such occupational issues are poorly documented. This study aimed to determine lower extremity fatigue and related factors in hairdressers.* **Methods:** *The study population consisted of at least 18 years old individuals working as hairdressers. Lower Extremity Fatigue was assessed with 2 questions containing a 5-point Likert scale. A numerical fatigue rating scale was used to assess general fatigue level, a visual analog scale was used to assess occupational satisfaction, Nottingham Health Profile (NHP) was used to assess health profile, and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to assess lower quadrant pain profile.* **Results:** *In the assessment of lower extremity pain, a statistically significant difference was found between Fatigue and Non-fatigue groups in the lower back (p=0.011), left knee (p=0.012), right (p=0.017) and left (p=0.012) lower leg parameters. In the lower extremity Weighted Scores, there was no significant difference between the fatigue and non-fatigue groups in the pelvis (p=0.365), right upper leg (p=0.153), left upper leg (p=0.156), right knee (p=0.054) but there were significant differences in the lower back (p=0.002), left knee (p=0.023), right lower leg (p=0.006) and left lower leg (p=0.017). The difference in the Energy, Pain, and Physical Mobility sub-dimensions of the Nottingham Health Profile of the hairdressers in the 'Fatigue Group' was at a significant level.* **Conclusions:** *In conclusion, the rate of lower extremity fatigue found in hairdressers in the present study was quite high, and lower extremity fatigue was associated with lower extremity pain and health profile.*

1. Introduction

Although hairdressing is a common profession worldwide, the activities of hairdressers in working life continue to be one of the least studied areas within the scope of occupational health [1]. When the daily workload of hairdressers is assessed, it is stated that it is at a high and severe level due to the lack of breaks [2]. Hairdressers usually carry out these workloads indoors and in standing positions for long periods of time. Therefore, hairdressing is one of the occupational groups in which physical force is highly needed. Conditions such as intensive use of awkward work postures, strenuous, excessive shoulder movements, physical force, mechanical loads on joints, repetitive motion, and long working hours may lead to poor performance in the long term and health problems in the future for people that work at hair salons [3, 4, 5].

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Compared to other occupational groups, work-related musculoskeletal diseases of hairdressers are quite frequent. It is stated that work-related musculoskeletal diseases are seen at a rate of approximately 75% in hairdressers in developed and developing countries. Circumstances that cause this are related to ergonomic problems due to working while standing with an inappropriate posture and features of inappropriate posture [6, 7, 8]. These complaints experienced in the working life negatively affect the employees' work efficiency and quality of life. It is stated that the effect of work-related musculoskeletal diseases with the psychosocial factors of the profession and work environment is increasing. Some studies have shown an association with occurrence of musculoskeletal disorders and lower job satisfaction. For example, those who enjoy their work almost all the time have been reported to be 2.5 times more likely to have back pain compared to those who almost never take pleasure in their work [9]. Decreases in job satisfaction are generally associated with physiological problems such as anger, tension, anxiety, and depression [8, 10].

Fatigue may occur in the lower extremity muscles following changes in neuromuscular control, and a decrease in voluntary muscle activation due to activity is defined as fatigue [11]. Occupational fatigue has been studied in many pieces of research in different occupational groups with concepts such as general fatigue, lower extremity fatigue, and fatigue with discomfort and pain [12]. Fatigue is also an important occupational condition for hairdressers. According to data from a study conducted in the USA, the prevalence of general body fatigue in hairdressers is 59% [13]. Studies examining the causes of occupational fatigue have concluded that prolonged standing is associated with general fatigue, especially in the lower extremities. It has been revealed that this is related to the limitation of blood circulation in the leg region and the muscles remaining in the static position [14, 15]. It has been reported that intervention studies such as wearing prophylactic compression stockings to reduce work-related venous pooling and edema yield positive results in reducing fatigue and pain and improving quality of life [16].

In the literature, work-related musculoskeletal disorders are mostly seen in the upper extremities in hairdressers, so the studies in this area mostly research the upper extremity [17,18]. There is no study examining the lower extremity fatigue of hairdressers. In addition, the number of studies on lower extremity pain and health profile in hairdressers is not sufficient. The purpose of this study was to examine the relationship between lower extremity fatigue, and lower extremity pain and health profile in hairdressers.

2. Methods

The study population consisted of at least 18 years old individuals working as hairdressers in the city center of Isparta. Participants without any known neurological, orthopedic or cardiopulmonary disease, history of accident or injury requiring surgical operation in the last 2 years, and symptoms or signs of venous insufficiency (CEAP class C0 and C1) were included in the study. Pregnant women and those who did not meet the inclusion criteria were excluded from the study. After obtaining the information of the participants with the descriptive data form, the following assessment tools were applied to those who volunteered to participate in the research by experienced researchers in a face-to-face environment.

- Lower extremity fatigue: Participants' lower extremity fatigue was assessed with 2 questions containing a 5-point Likert scale. In the first question, lower extremity fatigue at the end of a typical working day was graded from "strongly agree" to "strongly disagree". In the second question, the effect of lower extremity fatigue on activities outside of work was graded between "strongly agree (5 points)" and "strongly disagree (1 point)" [12].
- Persons who declared that they "strongly agree (5 points)" or "agree (4 points)" that they experienced lower extremity fatigue were called "Fatigue Group" during the statistical analysis of the study.
- Numerical fatigue rating scale: The overall fatigue rating was graded in the range of 0 points: not fatigued at all to 10 points: extremely fatigued with the help of a visual analogue scale [19].

- Occupational satisfaction: Occupational satisfaction level was graded between 0 points: not satisfied at all and 10 points: very satisfied with the help of visual analogue scale [20].
- Nottingham Health Profile (NHP): Developed by Hunt et al., this tool provided a simple and quick way to assess people's health-related problems. The assessment tool consisted of a total of 38 "yes/no" questions and 6 different sub-dimensions. As sub-dimensions, Energy, Pain, Emotional Reactions, Sleep, Social Isolation and Physical Mobility were examined. In this tool, which can be scored between 0-100 in each sub-dimension, the increase in the score indicated the increase in the severity of health-related problems [21]. The Turkish adaptation of this tool was carried out by Küçükdeveci et al. [22]. Cronbach's alfa coefficients for the NHP ranged between 0.56 and 0.83 [22].
- Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): In the present study, lower extremity parameters of CMDQ were used to assess lower extremity pain. This assessment tool examined the discomfort's frequency, severity and its effect on work performance in 11 different body parts during the last 1 week. The weighted score of the complaint in the body regions was calculated. The higher the score was, the higher the discomfort in the musculoskeletal system became. The Turkish language adaptation of the scale was made by Erdinç et al. [23]. Test-retest reliability of the T-CMDQ was satisfactory; Kappa coefficients, which ranged between 0.56-0.97 across the three scales, indicated moderate to almost perfect agreement between test-retest responses across body parts [23].

2.1. Power Analysis and Ethical Aspects of Research

In the sample that was accepted as the universe of the study (population size n=374), when the type 1 error was considered to be 0.05 and the type 2 error was considered to be 95% (GPower v.3.1), the number of people to be reached was determined as at least n=194. The study was approved by Süleyman Demirel University, Faculty of Medicine, Clinical Research Ethics Committee (72867572-050.01.04-218131).

2.2. Statistical Analysis

Data were summarized by descriptive statistics, as appropriate depending on the Shapiro-Wilk test, used to assess the normality of data distribution. The Mann-Whitney U test and Chi-square test were used to assess the differences between the groups. Binary logistic regression analysis was used to determine the factors associated with lower extremity fatigue. The regression model was examined with the Hosmer-Lemeshow goodness of fit test. Data were presented as frequency (n), percentage (%), and mean ± standard deviation. The p value was considered significant at the 0.05 level. SPSS v.23 package program was used for the analysis.

3. Results

A total of 249 hairdressers, 69 (27.7%) women and 180 (72.3%) men, participated in the present study. While 108 participants (43.4%) stated that they did not exercise at all, 91 (36.5%) stated that they exercised sometimes, and 50 (20.1%) that they exercised at least once a week. As many as 26 hairdressers (10.4%) declared not to take a break during the day. One hundred and sixty participants (64.3%) were smokers (Table 1).

It was determined that 214 (85.9%) of 249 hairdressers in the present study experienced lower extremity fatigue (Table 1). It was determined that 48.6% (n=121) of the hairdressers that were deemed "strongly agreed" and 36.1% (n=90) of them "agreed" that they experienced lower extremity fatigue.

When the effect of lower extremity fatigue on life in general was questioned, 21.7% (n=54) stated that they "strongly agreed" and 29.3% (n=73) stated that they "agreed". While 23.3% (n=58) of the hairdressers reported that they had days where they could not go to work due to lower extremity fatigue, the rate of those who were applicated to the outpatient clinic due to this complaint was 30.9% (n=77) (Table 1).

Table 1. Descriptive results.

	All (n=249)	Fatigue (n=214)	Non-fatigue (n=35)	*p*
Gender	69 (27.7)	66 (30.8)	3 (8.6)	**0.004***
F, n (%)	180 (72.3)	148 (69.2)	32 (91.4)	
M, n (%)				
Age, y (mean+SD)	28.28±8.81	28.39±9.06	27.60±7.19	0.979
BMI, kg/m^2(mean+SD)	23.66±3.93	23.54±3.86	24.39±4.36	0.335
Job duration, y (mean+SD)	3.79±0.56	3.77±0.59	3.91±0.28	0.258
Working time, h/week (mean+SD)	68.32±11.83	68.95±11.49	64.45±13.26	0.063
Exercise				0.669
Not exercise, n (%)	108 (43.4)	95 (44.4)	13 (37.1)	
Sometimes, n (%)	91 (36.5)	76 (35.5)	15 (42.9)	
Least once a week, n (%)	50 (20.1)	43 (20.1)	7 (20.0)	
Smoking				0.625
None, n (%)	89 (35.7)	79 (36.9)	10 (28.6)	
Sometimes, n (%)	45 (18.1)	38 (17.8)	7 (20.0)	
Often, n (%)	115 (46.2)	97 (45.3)	18 (51.4)	
Took a break, n (%)	223 (89.6)	191 (89.3)	32 (91.4)	0.689
Fatigue rating scale (0-10)	5.08±2.45	5.27±2.39	3.88±2.46	**0.004***
Occupational satisfaction (0-10)	7.78±2.44	7.67±2.43	8.43±2.43	**0.030***
Absenteeism, n (%)	56 (22.5)	49 (22.9)	7 (20.0)	0.871
Day of absence from work, n	0.85±2.93	0.94±3.14	0.34±0.73	0.636
Outpatient clinic application, n (%)	77 (30.9)	74 (34.6)	3 (8.6)	**0.004***

*F, M: Female, Male. BMI: Body mass index * p< 0.05 in the Independent-sample Mann-Whitney U and Chi-Square test.*

When the participants were divided into groups according to their fatigue in the lower extremities, the groups showed difference in terms of gender, numerical fatigue rating scale, occupational satisfaction and the presence of outpatient clinic application (Table 1).

The status of associating the lower extremity fatigue felt by the hairdressers with their profession was at the level of "completely" in 31.3% (n=78) and "partially" in 36.1% (n=90) of the participants. The effect levels of the fatigue felt while doing their job were observed as follows: For 0.8% (n=2), it was "inhibiting the job", for 5.2% (n=13) "effective on daily life", for 14.5% (n=36) "effective on work performance", for 43.0% (n=107) "mild" and for 36.5% (n=91) "no effect". Due to this effect, 22.5% (n=56) of the hairdressers reported that they had absent days (mean 0.85±2.93) in the last 1 year, while 30.9% (n=77) reported that they were applicated to the outpatient clinic with complaints. While there was no difference between the groups in terms of not going to work (p=0.871) and number of days absent from work (p=0.636), there was a difference in terms of outpatient clinic application (p=0.004) (Table 1).

Gender and outpatient clinic application were found to be risk factors for lower extremity fatigue (Table 2).

In the assessment of lower extremity pain, all hairdressers participating in the study reported the most pain after lower back pain (53.0%, n=132) at right lower leg (36.9%, n=92), left lower leg (32.5%, n=81), right knee (24.5%, n=61) and left knee (22.1%, n=55). The regions reported as least painful were hip-pelvis (12.0%, n=30), left upper leg

Table 2. Variables associated with lower extremity fatigue.

	Odd Ratio	95% CI Lower	95% CI Upper	*p*
Female gender	8.550	0.020	0.673	**0.016***
Outpatient clinic application	1.670	1.011	27.912	**0.049***

**:The p value is less than 0.05 in the binary logistic regression analysis tests.*

Table 3. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): Frequency of lower extremity pain.

	All (n=249)	Fatigue (n=214)	Non-fatigue (n=35)	*p*
Lower back	53.0%, n=132	56.4%, n=120	34.2%, n=12	**0.011***
Pelvis	12.0%, n=30	12.8%, n=27	7.9%, n=3	0.370
Right upper leg	21.7%, n=54	23.2%, n=49	13.2%, n=5	0.146
Left upper leg	18.9%, n=47	20.4%, n=43	10.5%, n=4	0.130
Right knee	24.5%, n=61	26.5%, n=56	13.2%, n=5	0.062
Left knee	22.1%, n=55	24.6%, n=52	7.9%, n=3	**0.012***
Right lower leg	36.9%, n=92	40.3%, n=85	18.4%, n=7	**0.017***
Left lower leg	32.5%, n=81	35.5%, n=75	15.8%, n=6	**0.012***

**p-value < 0.05 in the Chi-Square tests. Note: The number of 'n' exceeds the sample size.*

(18.9%, n=47), and right upper leg (21.7%, n=54). Statistically significant difference was found between Fatigue and Non-fatigue groups in lower back (p=0.011), left knee (p=0.012), right (p=0.017) and left (p=0.012) lower leg parameters (Table 3).

In the lower extremity Weighted Scores, there was no significant difference between the fatigue and non-fatigue groups in pelvis (p=0.365), right upper leg (p=0.153), left upper leg (p=0.156), right knee (p=0.054) but there were significant differences in lower back (p=0.002), left knee (p=0.023), right lower leg (p=0.006) and left lower leg (p=0.017) (Table 4).

In assessing the general health profile, a difference was observed in the participants' results who were grouped according to their fatigue in the lower extremities. The difference in the Energy, Pain, and Physical Mobility sub-dimensions of the Nottingham Health Profile of the hairdressers in the "Fatigue Group" was significant (Table 5).

4. Discussion

To our knowledge, this is the first study on lower extremity fatigue in hairdressers. The rate of lower extremity fatigue was 85.9%: female gender and outpatient clinic application were found to be risk factors for lower extremity fatigue.

Static and prolonged standing causes fatigue, especially in the lower extremities and lower back. Circulation decreases due to decreased muscle contractions in static standing or inactive posture. While this situation negatively affects the nutrition and oxygenation of the muscles, it also causes a decrease in the removal of metabolic waste products from the system, resulting in fatigue [24]. In the study of Gell et al., in which they examined the risk factors that cause lower extremity fatigue in assembly workers, it was stated that high-risk factors included smoking, rheumatoid arthritis, unsuitable shoes, and prolonged standing, weekly working hours, and high BMI [12]. In their study, Heather et al. found that lower extremity fatigue decreased vastus lateralis activation in young, healthy women, and knee joint loads decreased simultaneously with this deterioration in quadriceps activation [25]. In the present study, the variables related to lower extremity fatigue included female gender and outpatient clinic application. The higher lower extremity

Table 4. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): Lower extremity weighted scores.

	All (n=249)	Fatigue (n=214)	Non-fatigue (n=35)	*p*
Lower back	6.60±13.88	7.47±14.81	1.73±4.03	**0.002***
Pelvis	1.07±6.55	1.23±7.10	0.21±0.76	0.365
Right upper leg	2.46±9.49	2.77±10.24	0.77±2.40	0.153
Left upper leg	2.46±9.80	2.77±10.57	0.72±2.30	0.156
Right knee	2.93±9.78	3.39±10.55	0.39±1.13	0.054
Left knee	3.18±11.30	3.70 ±12.20	0.31±1.11	**0.023***
Right lower leg	4.79±12.64	5.43±13.54	1.26±3.96	**0.006***
Left lower leg	4.46±12.28	5.03±13.15	1.31±4.02	**0.017***

**p-value < 0.05 in the Independent-sample Mann-Whitney U.*

Table 5. General health profile assessment results.

	All (n=249)	Fatigue (n=214)	Non-fatigue (n=35)	*p*
Nottingham Health Profile				
Energy	24.09±29.32	26.32±29.91	10.47±21.04	**0.002***
Pain	18.47±23.19	19.39±22.99	12.86±23.96	**0.009***
Emotional reactions	32.44±28.06	33.43±28.34	26.35±25.86	0.187
Sleep	28.11±24.23	28.69±24.23	24.57±24.29	0.270
Social isolation	15.50±23.74	16.07±24.04	12.00±21.80	0.378
Physical mobility	14.81±17.49	15.42±16.83	11.07±20.95	**0.008***

**p-value < 0.05 in the Independent-sample Mann-Whitney U.*

fatigue in females might stem from the fact that females are a disadvantaged group in terms of muscular strength and endurance due to the lower testosterone hormone and muscle volume compared to males [26, 27]. There was no significant difference between the "fatigue" and "non-fatigue" groups regarding BMI. This can be attributed to the fact that the BMI values of the hairdressers participating in the present study were between 18.5 and 24.9 in both groups. Long working hours are the most frequently mentioned variable in the literature for both lower extremity pain and lower extremity fatigue. In addition to circulatory causes, fatigue is thought to occur due to a decrease in the efficiency and force-generating capacity of the muscles after prolonged exposure to the activity.

Lower quadrant pains are complaints that cause many occupational groups such as teachers and health workers to go to the hospital frequently. They constitute an important source of medical expenditure. These medical conditions are usually recurrent and progressive and significantly decrease quality of life [28,29,30]. Studies assessing pain in hairdressers reported that neck, lower back, and upper extremity pain were the most frequent types [7, 17,18, 31-33]. In addition, in a study conducted in India, 49.5% of hairdressers reported knee and foot pain [4]. In another study conducted in Taiwan, it was reported that the presence of leg pain was as high as 71.1% [17]. In the study conducted by Hassan et al. to collect information about the prevalence of musculoskeletal pain in hairdressers in the last 12 months, lower extremity pain in hairdressers came after upper extremity and waist-neck pain. However, the assessment of chronic pain found that lower back and knee pain had the highest rate. In addition, in that study, it was stated that lower extremity pain was more common in hairdressers with a high BMI value, while it was stated that standing for a long time and inappropriate back posture was significantly associated with lower extremity pain. However, there was no significant difference in average weekly working hours between hairdressers who reported and did not report symptoms [1]. In the present study, regarding pain frequency in hairdressers, the most affected area after the lower back was the lower leg, then the knee and the least affected area was the upper leg and the pelvis. Pain reporting was higher in the "fatigue" group than in the "non-fatigue" group in all assessed regions. The difference was significant in the lower back, left knee, and right and left lower leg. According to the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) of the lower extremity Weighted Scores results, there was a significant difference between the "fatigue" and "non-fatigue" groups in the same regions.

There are few studies describing hairdressers' working conditions and occupational health problems. The most common work-related health problems in hairdressers are respiratory problems, skin and allergic diseases, and musculoskeletal disorders. According to the hairdressers' statements, the causes of musculoskeletal disorders are as follows: repetitive manual work, tiring upper extremity movements, inappropriate posture, and prolonged standing [1, 34]. A study conducted in Turkey revealed that female hairdressers experienced the most ergonomic health problems related to the load. These problems were followed by respiratory, eye, and skin complaints due to the chemicals they used. It was observed that people who work in hair salons are mainly exposed to chemical, ergonomic and psychosocial hazards and experience problems such as musculoskeletal system problems and stress [35]. Loughlin et al. stated that working as a hairdresser negatively affects one's health and found that especially young hairdressers were at risk of poor health in general. In addition, in the results of this study, while young hairdressers reported a higher prevalence of common health problems compared to the general population group, middle-aged and older hairdressers were generally as healthy as the general population. This result was attributed to the "healthy worker effect," in which individuals with poorer health caused by health problems retire from the profession [36]. Another study reported that hairdressers, especially older ones, were more likely to report symptoms due to longer working hours [1]. In assessing the general health profile in the present study, there was a difference in the Energy, Pain, and Physical Mobility sub-dimensions of the Nottingham Health Profile of the hairdressers in the "Fatigue Group". The Deschamps et al. study showed that female hairdressers were more likely to seek health services than men [37]. In the present study, the application rate to the outpatient clinic was significantly higher in the group with lower extremity fatigue, regardless of gender. In this case, it can be said that lower extremity fatigue negatively affects health by increasing outpatient clinic applications.

When Tsegay et al. examined the situations that cause lower back pain in hairdressers, they stated that occupational stress and satisfaction were among the core reasons. They suggested that ergonomic arrangements and psychosocial approaches should be emphasized in coping with lower back pain [31]. Similarly, Gell et al. stated that lack of occupational satisfaction was among the risk factors that cause lower extremity fatigue [12]. Page et al., in their study on hairdressers in Australia in 2021, reported that they felt insignificant and emotionally exhausted and needed support. However, they had a high rate of job satisfaction [38]. It was observed that the hairdressers who participated in the present study had a high rate of associating lower extremity fatigue with their profession. In contrast, the rate of preventing them from doing their jobs was low. When their occupational satisfaction was questioned, it was found that they generally had high occupational satisfaction. However, there was a significant difference between the "fatigue" and "non-fatigue" groups regarding lower extremity fatigue.

5. Conclusions

In conclusion, the rate of lower extremity fatigue found in hairdressers in the present study was relatively high, and fatigue prevention is an important issue that needs to be studied. Protective approaches such as making ergonomic arrangements, training hairdressers on correct working procedures, and reducing working hours are recommended in studies performed with hairdressers [39, 40]. In addition, lower extremity fatigue is associated with lower extremity pain, health, and occupational satisfaction. Therefore, future studies need to identify the factors that cause lower extremity fatigue and design effective treatment and preventive strategies to prevent fatigue so that hairdressers can improve their work efficiency and well-being.

Several limitations must be considered when interpreting these findings. First, the sample was self-selected and based only upon data collected in one country and may not apply to other countries with different regulatory regimes, levels of training, or cultural differences. Thus, these findings can be strengthened by further qualitative, quantitative, and mixed-methods research across various participants and contexts. On the other hand, reaching the targeted sample size as a result of power analysis makes the obtained data reliable.

Declaration of Interest: The authors declare that they have no conflict of interest.

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Effectiveness of Cardiopulmonary Resuscitation at the Workplace

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Abstract

Background: *Out-of-Hospital Cardiac Arrest (OHCA) is a medical emergency whose chances of survival can be increased by rapid Cardiopulmonary Resuscitation (CPR) and early use of Public Access Defibrillators (PAD). Basic Life Support (BLS) training became mandatory in Italy to spread knowledge of resuscitation maneuvers in the workplace. Basic Life Support (BLS) training became mandatory according to the DL 81/2008 law. To improve the level of cardioprotection in the workplace, the national law DL 116/2021 increased the number of places required to be provided with PADs. The study highlights the possibility of a Return to spontaneous circulation in OHCA in the workplace.* **Methods:** *A multivariate logistic regression model was fitted to the data to extrapolate associations between ROSC and the dependent variables. The associations' robustness was evaluated through sensitivity analysis.* **Results:** *The chance to receive CPR (OR 2.3; 95% CI:1.8-2.9), PAD (OR 7.2; 95% CI:4.9-10.7), and achieve Return to spontaneous circulation (ROSC) (crude OR 2.2; 95% CI:1.7-3.0, adjusted OR 1.6; 95% CI:1.2-2.2) is higher in the workplace compared to all other places.* **Conclusion:** *The workplace could be considered cardioprotective, although further research is necessary to understand the causes of missed CPRs and identify the best places to increase BLS and defibrillation training to help policymakers implement correct programming on the activation of PAD projects.*

1. Introduction

Out-of-Hospital Cardiac Arrest (OHCA) is the cessation of cardiac mechanical activity, confirmed by the absence of circulation signs in an out-of-hospital setting. The survival rate is less than 10%. Therefore, it is globally considered a health emergency and affects 40 to 170 people per 100,000 per year, or just over 350,000 per year in Europe and the United States [1, 2]. Emergency Medical System (EMS) resuscitation is attempted in approximately 50-60% of EMS-assisted cases. However, a substantial underestimation of the phenomenon is likely [3-9]. Furthermore, 1% of OHCAs occurred in the workplace, with differences in occupation, work environment, and health surveillance levels [10]. In Italy, OHCA is responsible for 60-70% of all causes of cardiovascular death [11, 12], and 5% of cardiac arrests occur during work, 70 workers a week [13]. The first act to improve OHCA workplace safety was introduced in 2008 with Legislative Decree 81. The law obligates the employers to identify the first

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aid responder, a worker who is supposed to undergo mandatory training [14]. With the 116/2021 standard of August 4, the automatic external defibrillator (AED) is also recommended in the workplace [15]. Regarding cardiopulmonary resuscitation, timeliness and efficacy is recognized as a crucial link in the chain of survival from cardiac arrest [16, 17]. Both the time of arrival and the level of training offered by the rescuer affect the outcome of Cardiopulmonary Resuscitation (CPR) [18-21]. A 50% survival rate can be achieved when bystanders intervene to provide CPR with automated external defibrillators (AEDs). To increase bystander intervention, laypeople should undergo CPR training, and Public Access Defibrillators (PAD) should be widely disseminated [23-26].

This is especially important when considering that the recent COVID-19 [27] pandemic had a meaningful impact on CPR training practice [15] and profoundly changed the EMS system [28-30], even changing the work policy [31]. In addition, it has been shown that early defibrillation, when made available in the workplace, is a primary need and desirable standard for improving workers' and citizens' survival rates after cardiac arrest [32-37].

The present study highlights the difference in OHCA management by laypeople in the workplace and other settings in the Lombardy Region. All rescues of OHCAs in the Lombardy region are managed by AREU (Agenzia Regionale Emergenza Urgenza), which coordinates all medical emergencies in out-of-hospital settings [31]. All data are cataloged in EM-MA (emergency medical system), the regional emergency mission registers.

2. Methods

This is a retrospective observational cohort study. The study was conducted following the principles of the Helsinki declaration and was approved by the AREU Data Protection Officer in November 2021 (reference number: 5.2021).

2.1. Data Registry

The Lombardy AREU headquarters register provided data. The data was analyzed using the SAS-AREU portal and R (version 4.1.2). The portal contains all data regarding emergency calls, and the scenarios involving OHCA were selected. The ambulance crew is trained to recognize cardiac arrest as the absence of consciousness to verbal and tactile stimulus and the absence of breathing. This is enough to start Basic Life Support manoeuvres by rescuers while bystanders begin external chest compression under the guidance of healthcare personnel through 112. The medical team evaluates possible causes of cardiac arrest if an advanced vehicle with a doctor on board is sent to the event.

We analyzed all OHCAs in the Lombardy region register from the 1st of January 2019 to the 31st of December 2019. The selection criteria were age (from 18 to 67 years), non-cancer in medical history, no signs of death (i.e., rigor mortis), and no traumatic events (details in Figure 1).

2.2. Statistical Analysis

The categorical variables are presented as number and percentage, the continuous variables are presented as averages and standard deviation (SD). The categorical variables were analysed by means of χ^2 test, and the relative odds ratios (OR) and 95% Confidence Intervals (95% CI) were provided. Continuous variables were tested for normality by means of the Kolmogorov-Smirnov test, and the analysis was performed by Z-test for two population means.

Differences were considered significant when $p<0.05$. A logistic regression analysis was conducted in R to investigate the roles of different variables which may influence the chance of achieving a Return to Spontaneous Circulation (ROSC) in OHCAs. The robustness of the associations between the independent variables "CPR practice" and "Place" and the dependent variable "ROSC" was tested by means of a sensitivity analysis. The relative E-Values were calculated [38].

3. Results

Figure 1 shows a diagram of the OHCAs included in the analysis. Of 12140 OHCAs, only 3308 (27.2%) occurred in subjects of working age

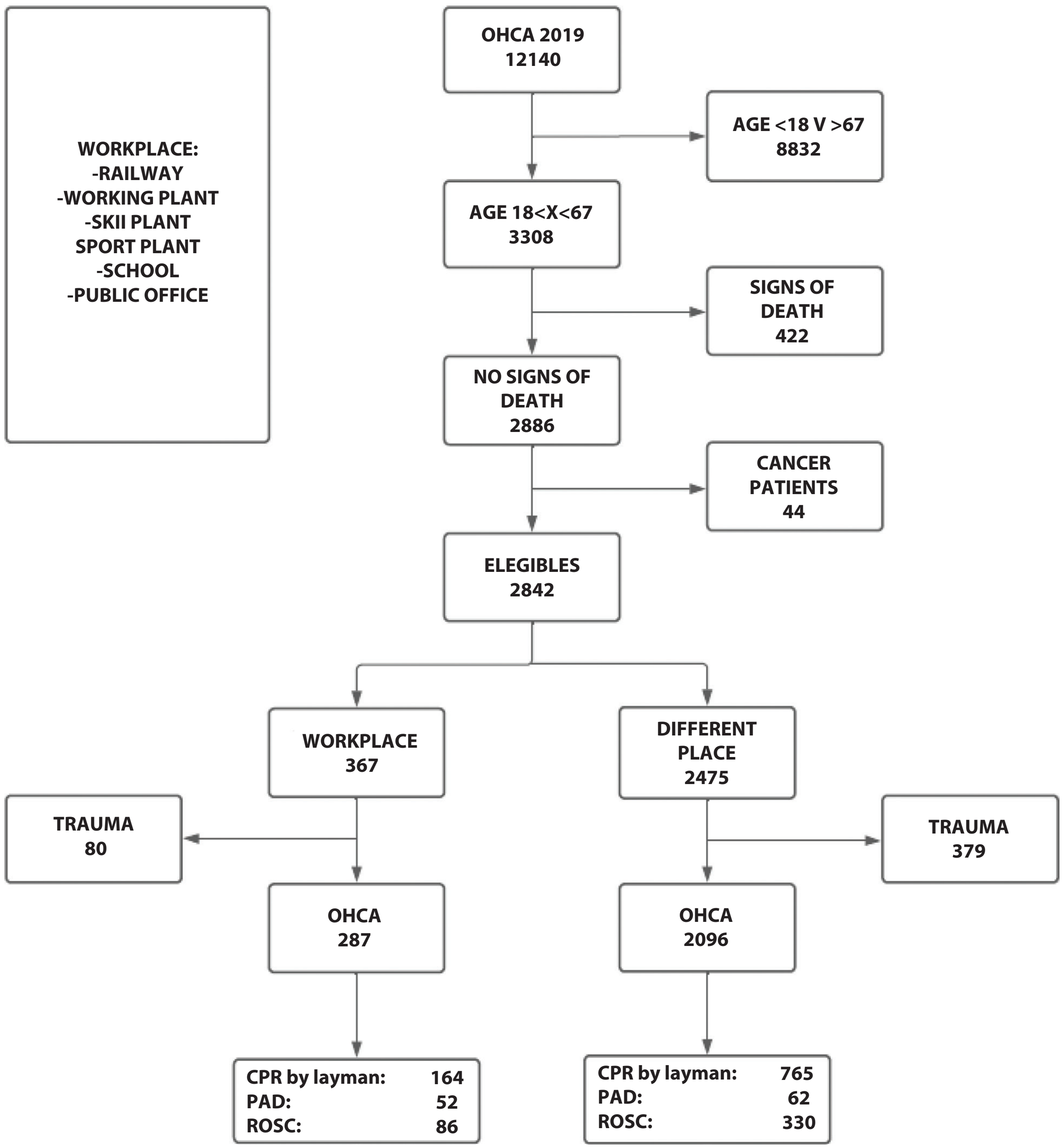

Figure 1. OHCA diagram.

(18-67); 422 cadaveric subjects were excluded as they presented evident signs of death (rigor mortis, decapitation, etc.). Of the remaining 2,886 eligible subjects, 44 subjects diagnosed with cancer in medical history were excluded.

Out of the total, 2,842 (23.0%) subjects were defined as eligible for the analysis, 367 (12.9%) OHCAs took place in the workplace, and 2,475 in a different place (87.1%). According to national law, the following locations were identified as workplaces

Table 1. Main characteristics of the subjects with Out of Hospital Cardiac Arrest (OHCA) stratified by place of occurrence.

	Workplace (287 subjects)	No workplace (2,096 subjects)	p
Females*	44 (15.33%)	597 (28.48%)	p<0.00001
Average years (SD)§	52±10.2	55.2±9.9	p<0.00001
Hospitalized by EMS	60 (21%)	356 (17%)	p>0.05
CPR	164 (57.14%)	765 (36.49%)	p<0.0001
PAD	52 (18.11%)	62 (2.95%)	p<0.0001
ROSC	86 (29.96%)	330 (15.74%)	p<0.0001

**Chi-square significant at p<0.05.*
§ Z-test for two population means significant at p<0.05.
CPR: Cardiopulmonary Resuscitation).
PAD: Public Accee Defibrillators.
ROSC: Return to Spontaneous Circulation.

requiring employees to be trained in BLS practice: railway facilities, working plants, ski plants, sports plants, schools, and public offices [14]. Eighty OHCAs in the workplace and 379 in other places were excluded because they occurred due to trauma. Trauma-related OHCAs are more frequent in the workplace than other places, OR 2.8 (C.I. 95% 1.8-4.3) p<0.0001.

The total of acute cardiological OHCAs (excluding traumatic ones) is 2,383, of which 287 (12.04%) happened in the workplace and 2,096 (87.96%) took place elsewhere.

In Table 1, the main characteristics of the OHCAs occurred in the workplace and other settings are compared. The proportion of females and the average age were significantly lower at the workplace, whereas a higher percentage of subjects received CPR, used PAD and achieved ROSC. (Crude ORs 2.3, 95%CI 1.8-2.9, 7.2, 95%CI 4.9-10.7 2.2, 95% CI:1.7-3.0 respectively). Furthermore, we observed an increase in the chance of having ROSC in the working place (30% vs. 16%). The proportion of subjects hospitalized by EMS did not differ between the settings (21% in the workplace vs. 17% in other settings).

To verify if there is a relationship between Sex, Age, and Minutes to the first vehicle on the scene, CPR practice, PAD use, ACLS practice, Place, and ROSC, we conducted a logistic regression analysis. The independent variables included in the model were Sex (0=Female), Age (years), Minutes to the first vehicle (continuous), CPR practice (0=no practice), ACLS practice (0=no practice), and Place (0=not a workplace).

Table 2. Effects of predictor variables on ROSC chance (multivariate logistic regression).

Predictor variable	Estimated Odds Ratio	95%CI
Sex	0.73	(0.58-0.93)
Age	0.97	(0.96-0.98)
Minutes to the first Vehicle	0.92	(0.90-0.95)
CPR practice	1.69	(1.34-2.13)
PAD use	1.26	(0.99-1.59)
ACLS practice	2.56	(1.97-3.34)
Workplace	1.66	(1.23-2.24)

Adjusted Odds ratios for all predictor variables are reported in Table 2. The chance of Return to Spontaneous Circulation (ROSC) was lower in males and decreased with age, increasing minutes to the first vehicle. CPR and ACLS practices were positively associated with ROSC and having OHCA in the workplace compared to other settings.

We also investigated the relationship between the predictor variable PAD use and the predictor variable CPR practice in order to evaluate independence, owing to the fact that PAD is rarely used without CPR. A chi-square test of independence was performed to examine the relation between CPR practice and PAD use. The relation between these variables was significant, $\chi 2$ (1, N= 2383)=149.1571 (with Yates correction), p<0.00001. People who were rescued with PAD use almost always underwent CPR practice. The results may account for the lack of significance of OR for the predictor variable PAD use in our logistic model.

The strength of the associations between CPR practice and Place and the dependant variable ROSC was investigated by means of sensitivity analysis. The calculated E-Values are reported in Supplementary Figure 1.

The observed odds ratios of 1.69 and 1.66 (CPR practice and Place) could be explained by an unmeasured confounder that was associated with both the treatment and the outcome by a risk ratio of 2.77 and 2.71-fold each, respectively, above and beyond the measured confounders, but weaker confounding could not do so; the confidence interval could be moved to include the null by an unmeasured confounder that was associated with both the treatment and the outcome by a risk ratio of 2.01 and 1.76-fold each, respectively, above and beyond the measured confounders, but weaker confounding could not do so.

4. Discussion

Our findings showed a higher chance (+66%, adjusted OR 1.6, 95%CI 1.2-2.2) of achieving ROSC and a higher probability of receiving CPR (57.14% vs. 36.49%) in the workplace compared with other settings. Similar findings emerged from the studies of Baldi et al. [39] and Marino et al. [5], who detected a 90% increase in ROSC chance in the workplace (computed on all OHCAs in the Pavia province and Canton Ticino from 2015 to 2017) and a 56.25% probability of receiving CPR on the workplace (on 32 OHCAs occurring in the workplace), respectively.

The higher probability of receiving ROSC proves that the workplace could be considered a cardioprotective place. On the other hand, although the probability of receiving PCR is higher than in other settings, we cannot consider it entirely satisfactory considering the mandatory training of lay people in the workplace established by Legislative Decree 81 2008. This finding underlines the need for further research to investigate the causes of missed CPR execution in the workplace.

Through a logistic regression model, we also examined the roles of different predictive variables associated with the chance of achieving ROSC. Male sex reduced the chance of achieving ROSC by about 26%. This percentage is somewhat in line with the findings of Bakran et al. [23], who report a 34% increase in OHCA mortality in a retrospective study of 1,440 male patients resuscitated between 2011 and 2017 in Istra, Croatia.

Increasing age was associated with a decreased probability of achieving ROSC of 2.7% every year, highlighting that the efficacy of rescue manoeuvres decrease in older people. ACLS was found to have the most decisive impact on ROSC, increasing the probability of achieving it by 156%. This can be linked to the role of the ACLS crew's medical and nurse personnel, underlining the EMS's importance. CPR was found to be effective, too, increasing the chance of achieving ROSC by 69%. Interestingly, the associations were reasonably robust to potential confounding, according to the interpretations suggested by Tyler and Peng [38].

These results are also relevant for emergency training. They confirm the impact of Legislative Decree 81 2008 and support Law No. 116, passed on August 4, 2021. Having trained operators in the workplace increases the chance of achieving ROSC in agreement with strategies suggested by K. Bakran et al. [23]. Furthermore, the trained operator for emergency shows high satisfaction during the course and for the emergency skill learned, as shown in previous research [40]. However, our research has several limitations, i) the central operator of the AREU collected all data, and some data could have gone missing during the emergency. ii) we did not know if the layman who performed CPR was the first responder. Therefore, we can only suppose the impact of mandatory training.

5. Conclusion

The workplace is safer regarding OHCA outcomes than other places. We highlighted a higher chance to receive CPR, PAD use, and achieve ROSC, which could partly be explained by the mandatory BLS training introduced in companies. Future regulations regarding OHCA could consider including training programs in other settings, with a greater commitment towards placing PADs in other places, always with public access. In fact, from our analysis, it emerges that workplaces are just a small percentage of places where OHCA occurs. However, further analyses are necessary to identify the best place to increase basic life support and defibrillation training to help policymakers implement correct programming to activate PAD projects.

Conflict of Interest: all authors declare no conflicts of interest.

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Supplementary Material: Figure S1: Sensitivity Analysis of the associations between specific predictive variables and the dependent variable.

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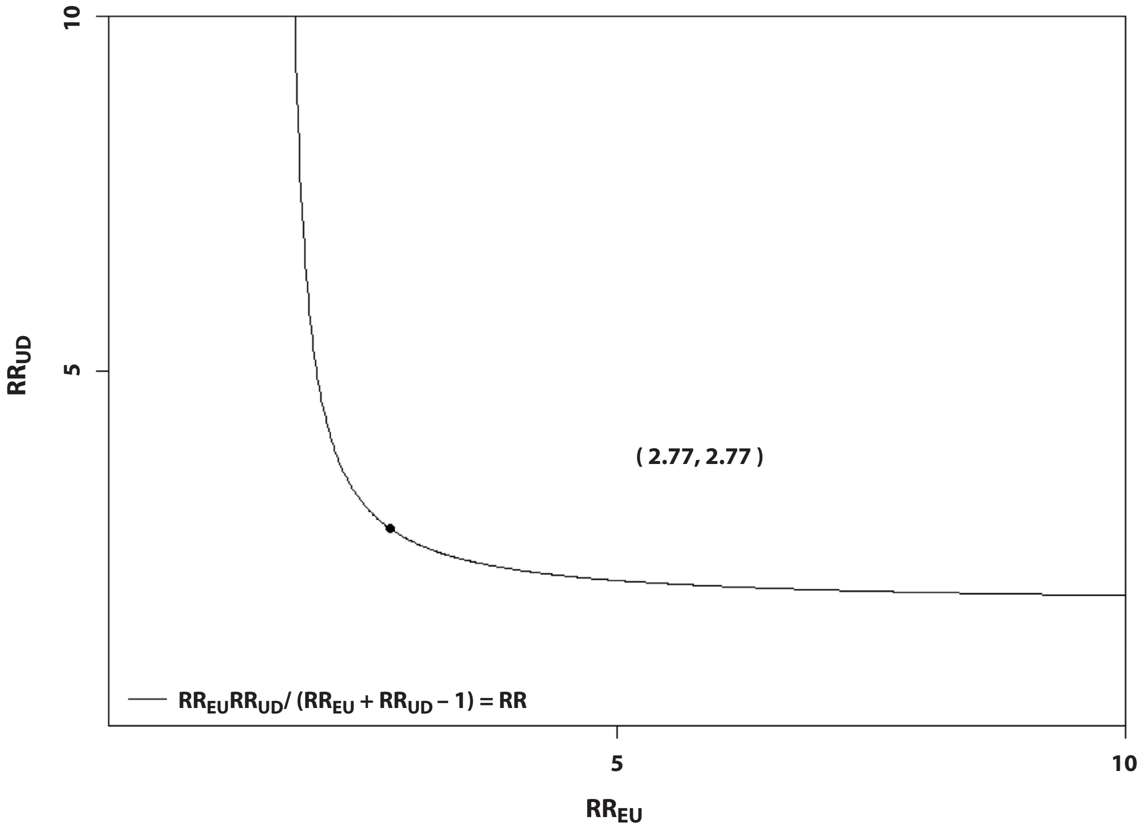
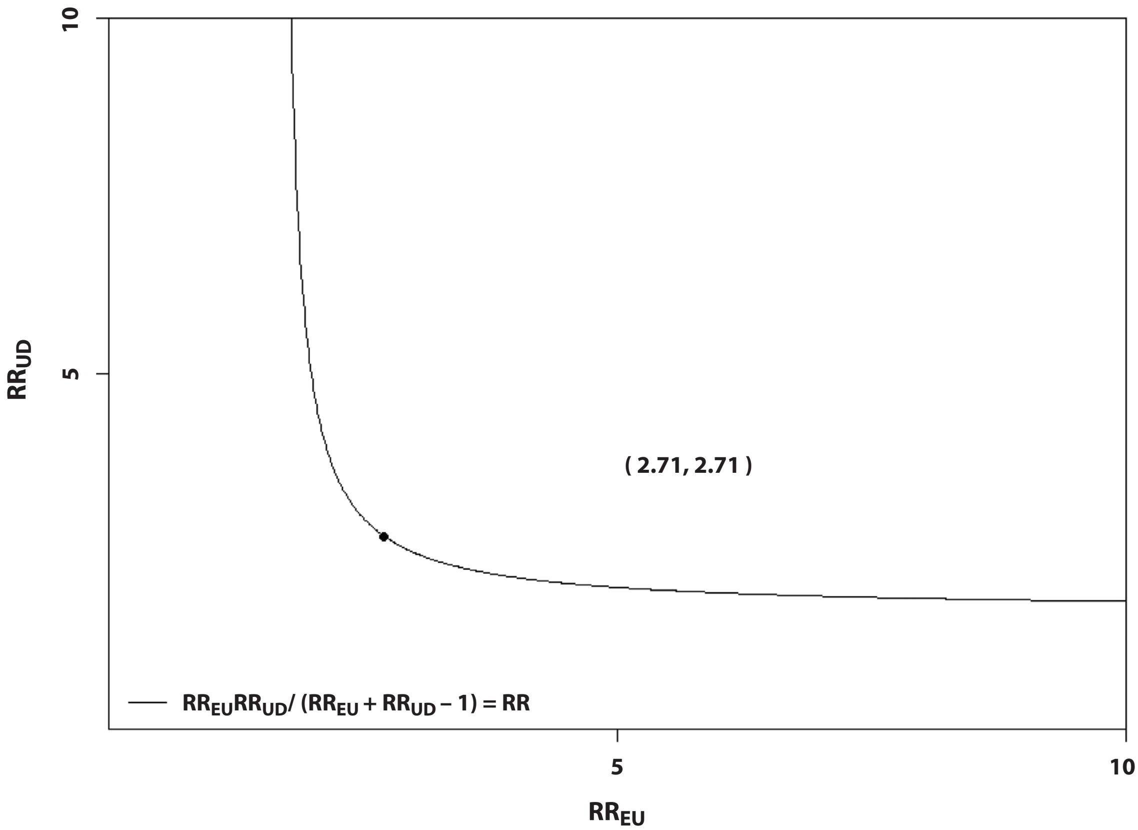
Appendix

Supplementary Figure 1: Sensitivity Analysis of the associations between specific predictive variables and the dependent variable.



"CPR" Odds-Ratio Sensitivity Analysis.



"Place" Odds-Ratio Sensitivity Analysis.

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Excess Total Mortality in Italy: An Update to February 2023 with Focus on Working Ages

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Keywords: COVID-19; SARS-CoV-2; Pandemic; Excess Deaths; Working Age

Abstract

Background: *Italy had a persistent excess of total mortality until July 2022. This study provides updated estimates of excess mortality in Italy until February 2023.* **Methods:** *Mortality and population data from 2011 to 2019 were used to estimate the number of expected deaths during the pandemic. Expected deaths were obtained using over-dispersed Poisson regression models, fitted separately for men and women, including calendar year, age group, and a smoothed function of the day of the year as predictors. The excess deaths were then obtained by calculating the difference between observed and expected deaths and were computed at all ages and working ages (25-64 years).* **Results:** *We estimated 26,647 excess deaths for all ages and 1248 for working ages from August to December 2022, resulting in a percent excess mortality of 10.2% and 4.7%, respectively. No excess mortality was detected in January and February 2023.* **Conclusions:** *Our study indicates substantial excess mortality beyond those directly attributed to COVID-19 during the BA.4 and BA.5 Omicron waves in the latter half of 2022. This excess could be attributed to additional factors, such as the heatwave during the summer of 2022 and the early onset of the influenza season.*

1. Introduction

Excess total mortality is a major indicator of the impact of the COVID-19 pandemic [1]. It refers to the difference between the observed deaths during the pandemic period and the expected number of deaths based on historical data. Unlike COVID-19 deaths – i.e. deaths registered as COVID-19 –, total excess mortality provides a comprehensive picture of the pandemic as it is not affected by uncertainties in the definition of the underlying cause of death and underreporting. In addition, it accounts for the indirect effects of the pandemic on the management of other conditions. Thus, variations in total mortality may be influenced by causes other than COVID-19.

We previously estimated a total excess of approximately 100,000 deaths in Italy in March-December 2020 and around 60,000 deaths in 2021, with persistent excess up to July 2022 [2-4]. In this update, we have extended our analyses until February 2023 [2-4].

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2. Methods

The study analyzed national daily mortality data from January 1, 2011, to February 28, 2023, and population data for the same period [5]. Data were provided by the National Institute of Statistics (ISTAT).

To estimate the number of excess deaths, we compared the number of observed deaths during the pandemic period to the expected number of deaths had the pandemic not occurred. Daily expected deaths were estimated separately for men and women using an over-dispersed Poisson regression model. The model included a linear term for the calendar year to account for temporal trends in mortality, age groups (<1, 1-4, 5-9,..., ≥100 years) to consider the effect of age on mortality rate, and a natural spline function of the day of the year to capture seasonal variations. To account for the population's demographic changes in size and age structure, the model included the natural logarithm of the population as an offset term. The number of knots of the spline function was selected based on the quasi-Akaike Information Criterion (QAIC), testing up to 10 equally spaced knots. The model's coefficients were estimated using daily mortality data between January 1, 2011, and December 31, 2019.

We presented the results on excess deaths in both absolute terms (i.e., the difference between observed and expected deaths) and relative terms (i.e., percent relative differences) for all ages and working ages (25-64 years). The working-age population was defined as individuals aged 25-64, excluding those still in education or retired.

We run a Monte Carlo simulation to calculate the 95% Confidence Intervals (CI) for excess deaths. We sampled 10,000 sets of model parameters from a multivariate normal distribution, using the parameter's estimates and the variance-covariance matrix. Then, we computed the difference between the number of observed deaths and the expected deaths obtained from each iteration to obtain the estimate's variance. Then the 95% CI was computed using the quantiles of the standard normal distribution.

3. Results

Table 1 displays the monthly number of observed and expected deaths for all ages and working ages between August 2022 and February 2023. From August to December 2022, we estimated 26,647 excess deaths for all ages and 1,248 for working ages, resulting in percent excess mortality of 10.2% and 4.7%, respectively. The highest excess mortality for all ages was observed in August 2022 (+13.3%) and December 2022 (15.8%), while at working ages, observed deaths were higher than expected in August 2022 (+9.8%), September 2022 (+9.5%) and October 2022 (+5.7%). Since November 2022 for working ages and January 2023 for all ages, the number of observed deaths has been lower than expected.

Figure 1 provides estimates of excess deaths (in absolute and relative terms) for all ages and working ages in March-December 2020, the whole of 2021, and 2022. In March-December 2020, 99,335 excess deaths (+18.8%) were estimated for all ages, and this number decreased to 60,353 deaths (9.3%) in 2021 and 66,304 deaths (+10.2%) in 2022. For individuals of working age, excess mortality accounted for 5057 deaths (+7.5%) in March-December 2020, 6760 deaths (+10.2%) in 2021, and 2848 deaths (+4.3%) in 2022.

Figure 2 shows the estimated monthly number of excess and COVID-19 deaths during the pandemic period [6]. Excess deaths were considerably higher than COVID-19 deaths in March-April 2020 (47,740 excess deaths *vs.* 27,938 COVID-19 deaths), November 2020 (25,489 excess deaths *vs.* 16,958 COVID-19 deaths), August 2021 (5812 excess deaths *vs.* 1158 COVID-19 deaths), July-August 2022 (20,340 excess deaths *vs.* 7242 COVID-19 deaths) and December 2022 (9257 excess deaths *vs.* 3288 COVID-19 deaths).

4. Discussion

The persistent excess mortality observed from August to December 2022 can be attributed to multiple factors. One of the major factors is the emergence of new sub-lineages of the Omicron variant (BA.4 and BA.5) in June-October 2022 in Italy,

Table 1. Observed, expected deaths and excess total mortality between August 2022 and February 2023 in Italy among the working-age population and the whole Italian population.

Period	Observed deaths	Expected deaths[1]	Absolute Difference (95 % CI)	Percent difference (95% CI)
Working ages				
August 2022	5661	5158	503 (470 to 535)	9.8 (9.1 to 10.4)
September 2022	5379	4912	467 (436 to 497)	9.5 (8.9 to 10.1)
October 2022	5477	5181	296 (264 to 327)	5.7 (5.1 to 6.3)
November 2022	5326	5329	-3 (-36 to 30)	-0.1 (-0.7 to 0.6)
December 2022	5955	5970	-15 (-53 to 23)	-0.3 (-0.9 to 0.4)
August – December 2022	27,798	26,550	1248 (1100 to 1389)	4.7 (4.1 to 5.2)
January 2023	6064	6761	-697 (-751 to – 652)	-10.3 (-11.0 to -9.6)
February 2023	5318	5875	-557 (-595 to -518)	-9.5 (-10.1 to -8.8)
All ages				
August 2022	57,423	50,665	6758 (6493 to 7022)	13.3 (12.8 to 13.9)
September 2022	50,334	48,255	2079 (1842 to 2315)	4.3 (3.8 to 4.8)
October 2022	54,965	50,905	4060 (3809 to 4310)	8.0 (7.5 to 8.5)
November 2022	56,848	52,355	4493 (4224 to 4761)	8.6 (8.1 to 9.1)
December 2022	67,870	58,613	9257 (8946 to 9567)	15.8 (15.3 to 16.3)
August – December 2022	287,440	260,793	26,647 (25,594 to 37,693)	10.2 (9.8 to 10.6)
January 2023	65,779	66,637	-858 (-1222 to -493)	-1.3 (-1.8 to -0.7)
February 2023	57,416	57,909	-493 (-799 to -186)	-0.9 (-1.4 to -0.3)

CI: Confidence Interval.
[1]*Estimated from 2011-2019 mortality and population data, separately by sex, through over-dispersed Poisson regression models including a linear term for the calendar year, age groups as a categorical variable, a smooth function of the day of the year with seven equally spaced knots, and the natural logarithm of the population as an offset. Values were rounded up to the smallest integer.*

which resulted in approximately 4 million registered COVID-19 cases. This number represents only a fraction of the actual cases [7]. Another possible contributing factor is the deferral of medical care, particularly during the first phase of the pandemic, which may have led to poorer outcomes for patients affected by chronic conditions [8-10]. The heat wave of June to August 2022 may also account for part of the excess during summer. Furthermore, the excess mortality could be partially attributed to the increased cardiovascular events among COVID-19 patients [11, 12], which may account for the nearly 10% excess mortality within the working-age population during the summer of 2022.

The excess mortality observed in November and December 2022 among all age groups, but not within the working age population, is likely due to the early onset of influenza in Italy last winter. The influenza epidemic in Italy for 2022-2023 peaked in December 2022 and then levelled off. This may also explain the higher number of excess deaths compared to COVID-19 deaths in December 2022, as well as the lower-than-expected number of deaths in January and February 2023 [13]. The difference between COVID-19 deaths and total excess deaths in 2022, particularly at working age, suggestrs that it is partly due to causes other than COVID-19.

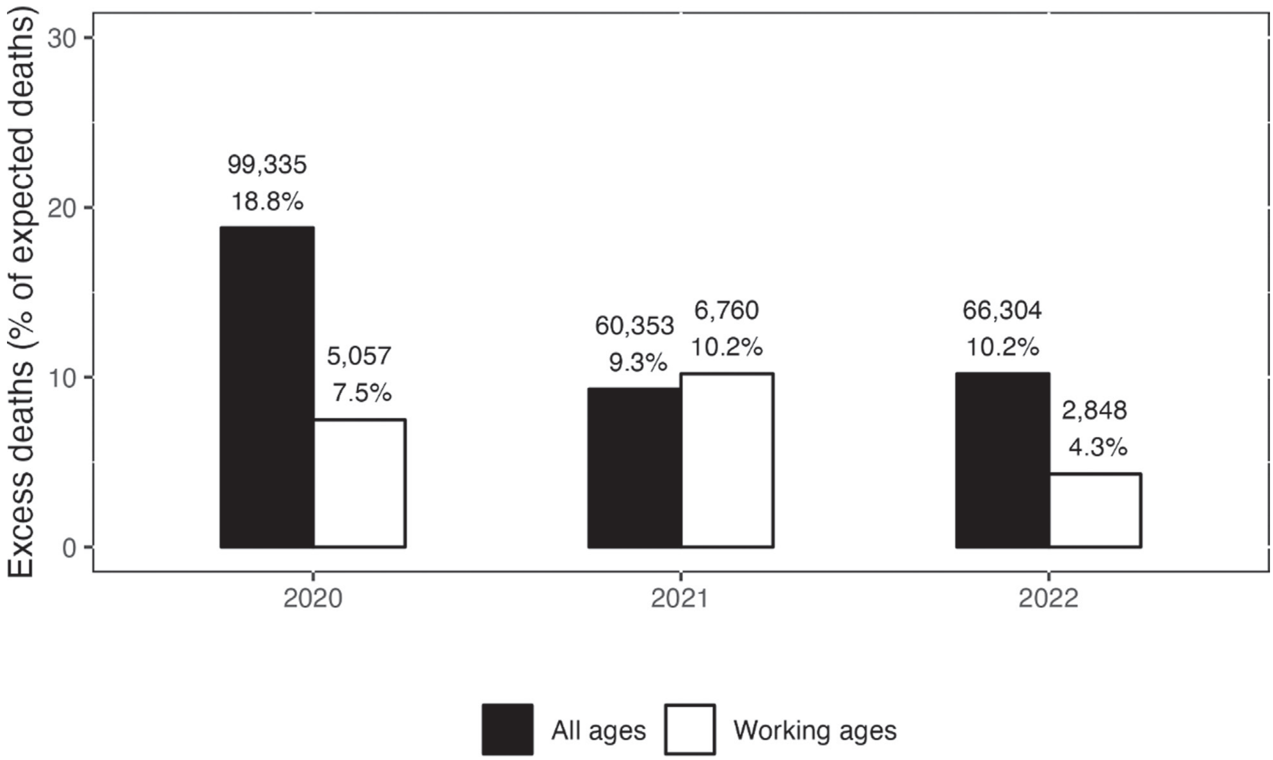

Figure 1. Excess total mortality in Italy at all ages and working ages (25-64 years) in 2020-2022.

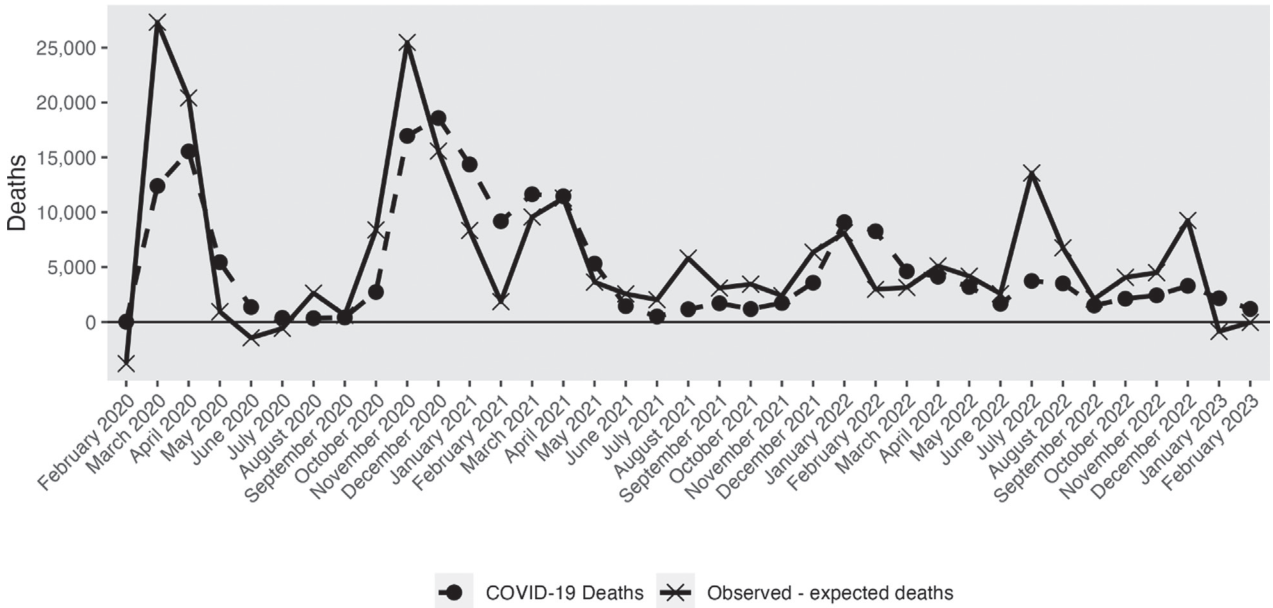

Figure 2. Excess and COVID-19 deaths at all ages from March 2020 to February 2023 in Italy.

Eurostat estimated excess mortality for European countries, including Italy, using the average deaths registered from 2016 to 2019 as a historical baseline not impacted by the COVID-19 pandemic [14]. Although their methodology differs from the current study, their estimates also demonstrate persistent excess mortality in the second half of 2022 in Italy and other European countries, with values ranging between +6.4% in October 2022 and +13.7% in December 2022 but no excess in January and February 2023.

Our study also shows important differences between total excess deaths and COVID-19 deaths. At the beginning of the pandemic (March-April 2020) total excess deaths were substantially larger than the COVID-19 registered deaths, due to under-diagnosis [15]. This was evident in October-November 2020, too. In July-August 2022, total excess deaths were higher than COVID-19 deaths, likely due to the heatwave, which was associated to over 10,000 excess deaths [3]. In November-December 2022 the main likely reason for the higher total excess deaths was the early arrival of the influenza in winter 2022-23, later reflected in the reduced mortality in January-February 2023.

The findings of our study have important implications for public health. First, they highlight the importance of monitoring excess mortality as a complementary indicator to other COVID-19-related data, such as confirmed cases and hospitalizations. Excess mortality provides a comprehensive understanding of the pandemic's impact, as it captures the potential consequences of deferred medical care for non-COVID-19-related conditions. However, using a different baseline period to estimate the expected number of deaths may yield different results [16]. Additionally, while our model for expected deaths accounted for the seasonality of mortality and temporal trends, it did not remove the effect of occasional peaks in mortality related to severe influenza seasons and heatwaves from the estimate of excess deaths. Finally, current estimates may differ somewhat from those previously published, as they were based on provisional mortality data that will be subject to revisions in future releases.

Conclusion

Our study has shown significant excess mortality during the COVID-19 pandemic in Italy, with approximately 27,000 excess deaths between August and December 2022. A smaller excess (around 1200 deaths) was also observed within the working-age population, and no excess was observed in January and February 2023. In this period, the excess mortality at all ages exceeded the 12,800 COVID-19 deaths. This difference is likely due to other factors, such as the heatwave of June-August 2022 and the early onset of influenza in November 2022. The early start of the influenza season may also be responsible for the absence of excess mortality in January and February 2023.

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