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Reviews, Commentaries, Perspectives

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Critical Issues in Assessing Occupational Exposure to Diesel Dust Exhaust

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Summary

The Italian Interministerial Decree of February 11, 2021, introduces the diesel engine exhaust (DDE) among the carcinogenic occupational compounds, also establishing an occupational exposure limit. Elemental carbon (EC), improperly called black carbon, has been proposed as a tracer of DDE exposure; EC is the carbon that is quantified in the ambient matrixes after all the organic carbon has been removed; traditionally, EC is measured with a thermo-optical analytical technique. EC determination and relative interpretation are challenging for the following reasons: (i) the scarce availability of equipped laboratories hampers EC analysis, (ii) EC interpretation is not easy due to the lack of reference values. Finally, (iii) the limit value of 0.050 mg/m^3 of EC in the workplace appears too high compared to recently published exposure data. All these aspects stimulate a reflection on the significance of EC data in the context of both occupational hygiene and occupational medicine.

1. Introduction

Today, diesel engines are still widely used because they are efficient, durable, and with low maintenance, especially for heavy vehicles. They have been used on a large scale since the 1930s, first in mines and then in railway locomotives. For heavy vehicles, they appeared on the market in 1950 and became dominant between 1960 and 1970 [1]. Fire engines have been equipped with diesel engines since the 1960s, but the first measures taken to reduce exposure in car workshops date back to the 1980s, as reported in the IARC Monograph on "Occupational Exposure as a Firefighter" [2]. Since then, diesel engines have been widely used in various industries: transport, construction, agriculture, marine, manufacturing and mining, to power various vehicles, equipment and machinery. The most studied sectors for this type of exposure in scientific literature are mines and underground works [3]. Instead, the starting point for assessing occupational exposure to Diesel Dust Exhaust (DDE) is 2012, when IARC classified DDE as a Group 1 carcinogen [4]. Previously, it was considered a possible carcinogen. Data from the European Union's Roadmap on carcinogens [5] shows the scale of occupational DDE

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exposure: (i) more than 3.6 million workers in Europe are exposed to DDE; (ii) almost 4700 cases of lung cancer and over 4200 deaths are reported each year; (iii) workers who are frequently exposed to DDE in the course of their work have a 40% increased risk of developing lung cancer.

The assessment of exposure to DDE follows the International Labour Organization's (ILO) three-step process [6]: (i) hazard identification, (ii) workplace exposure assessment, (iii) identification of operating conditions and risk management measures (RMM) to control the risks.

Regarding the exposure assessment to DDE in Italy, a key milestone is the publication of the Interministerial Decree of February 11, 2021 [7], which implements EU Directive 130/2019 [8]. This decree adds "Oils previously used in internal combustion engines" and "exhaust emissions from diesel engines" to Legislative Decree 81/08, increasing the number of processes involving exposure to carcinogens from six to eight ("crystalline free silica" being the last included in 2020 by Legislative decree 44/2020) [9]. At the same time, the Interministerial Decree of February 11, 2021, introduces into the Legislative Decree 81/08 an occupational exposure level (OEL) for DDE, expressed as an airborne concentration of 0.05 mg/m^3 in elemental carbon (EC). This OEL value came into force on February 21, 2023, except for underground work, which will come into force in 2026. The choice of an OEL expressed as EC is not based on the toxicological properties of this element but rather on the fact that EC is the main diesel exhaust component [10]. The existence of an OEL for carcinogenic DDE means that this value should never be exceeded and, in this case, work activity must be stopped. Therefore, exceeding the limit value has important implications for the work activity, as well as for exposure control and health surveillance. The reference for discussing in detail the reasons behind the choice of the current occupational exposure limit must be sought in the official opinion of the SCOEL 2017 [11], reporting that it is not yet possible to establish "a critical threshold that could serve for the derivation of an OEL". Information provided by IARC also confirms that it is not possible to establish a critical health-based threshold for DEE but, in turn, this Agency suggests using EC, a significant percentage of DEE emissions, as an exposure indicator (as reported in art. 16 Directive 130/2019) [8].

Nevertheless, the choice of EC as a tracer involves several critical issues for its complex quantitative determination since EC is the carbon obtained by thermal volatilization under the flow of an inert gas, followed by oxidation to carbon dioxide (CO_2). Moreover, several critical issues are known for quantitatively assessing DDE exposure in different workplaces [12, 13]. Considering that diesel particulates contain carbon as EC and black carbon (BC), defining which particle size fraction best suits diesel exhaust sampling in workplaces is also a priority.

In light of the above considerations, this article analyzes these critical aspects, trying to explore the possible impact of the application of the Italian Interministerial Decree on February 11, 2021, on the practices of occupational hygiene and occupational medicine.

2. Occupational Exposure to DDE

Table 1 shows some work activities and/or macro-sectors with possible different types of exposures related to work environment and/or specific

Table 1. Some environmental and work occupational exposures to diesel dust exhaust.

Occupational sectors	Workshops	Industries	Constructions
Indoor	Mechanics	Compressor / Generator Operators	Miners
	Firefighters	Waste Collectors	Masons / Builders
	Administratives	Maritimes	Airport Workers
Outdoor	Firefighters	Carpenters	Masons / Builders
	Taxi Drivers	Waste Collectors	Forklift operators
	Bus Drivers	Maritimes	Airport Workers
	Truckers	Forklift operators	

tasks [14], highlighting that occupational exposure can vary for the same type of work indoors or outdoors. Short-term exposure to DDE can cause irritation of the eyes, nose, throat, and lungs. Prolonged exposure may increase the risk of developing chronic respiratory diseases and, in particular, lung cancer [14, 15]. DDE (as solid particulate matter and gaseous pollutants) can induce and develop cellular inflammation in the upper and lower airways. Moreover, DDEs are responsible for pro-inflammatory and pro-allergenic effects [16].

3. The Dust Diesel Exhaust

3.1. Diesel Fuel

Diesel fuel is a derivative of petroleum that contains hydrocarbons from nine to twenty carbon atoms. Aromatic hydrocarbons account for about 30% of the fuel, sulfur content is less than ten parts per million (ppm), and the percentage of polycyclic aromatic hydrocarbons (PAH) is less than 8% [17]. Diesel fuel, mixed with air (nitrogen and oxygen) at high pressure in the combustion chamber, ignites spontaneously due to the high temperature. The diesel engine uses heat to convert the chemical energy in the fuel into mechanical energy. The combustion process is imperfect; other pollutants are also produced in addition to carbon dioxide (CO_2) and H_2O. Several factors, including the air/fuel ratio, the ignition timing, the combustion chamber turbulence, the air and fuel concentration, and the temperature reached, cause incomplete combustion. Incomplete combustion products are modified and exposed to high temperatures, and "soot" is produced in greater quantities than in petrol engine exhaust. There are hundreds of chemical compounds in DDE, of which forty are known to cause cancer.

3.2. Chemical Composition of DDE

N_2 (67%) and O_2 (9%) are in the combustion chamber, and CO_2 (12%) and water (11%) are the combustion products in gas phases together with pollutant emissions (1%). Pollutant emissions are composed of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM). Diesel engines are lean burn. Indeed, CO and HC concentrations are low compared to NOx and SO_2 (CO is the product of combustion when hydrocarbons burn with oxygen deficiency, and HC contains many compounds: alkanes, alkenes, and aromatic hydrocarbons). NOx is a mixture of nitrogen monoxide (NO) and nitrogen dioxide NO_2 with a predominance of NO_2. N_2 does not react with O_2 in the combustion chamber, and it is expelled from the engine as N_2; but when the high temperature in the cylinders is reached (>1600 °C), a reaction occurs. The initial combustion product is NO, which is then oxidized in the atmosphere to NO_2. NO_2 is five times more toxic to the respiratory system than NO. Cars are the main source of NOx, with diesel engines accounting for 85%. After NOx, PM is in greater quantities compared to other pollutants, and it is made up of 31% to 41% of carbon [18] (Interministerial decree February 11, 2021, asserts that carbon must be quantified as EC). Engine diesel PM is six or ten times higher compared to gasoline. They are spherical particles with a diameter of 15-40 nm, and more than 90% of PM has a diameter of 1 micrometer. There are emission control systems for diesel engines (for cars, not aircraft). The Diesel Oxidation Catalyst (DOC) controls CO and HC emissions. At the same time, the Diesel Particulate Filter (DPF) is used to control PM emissions, and finally, the Selective Catalytic Reduction (SCR) control system is used to control NOx. Currently, there is no system for controlling SO_2, which is needed to reduce the sulfur content of diesel fuel. Despite these control systems, the emission of pollutants into the atmosphere has the percentages shown above. As shown in Figure 1, PM comprises a "solid carbon core" to which hydrocarbons are adsorbed, and liquid hydrocarbons appear near the adsorbed hydrocarbons. Adsorbed and liquid hydrocarbons are sometimes called the soluble organic fraction (SOF). Hydrated sulfate species, forming inorganic fraction (IF), are associated with liquid hydrocarbons. The solid carbon is sometimes called soot, but historically soot has been called BC [19].

Carcinogens such as benzene, formaldehyde, and PAH in DDE have been known for years [20]. We underscore the complexity of PAH mixtures being a complex mixture of compounds with different

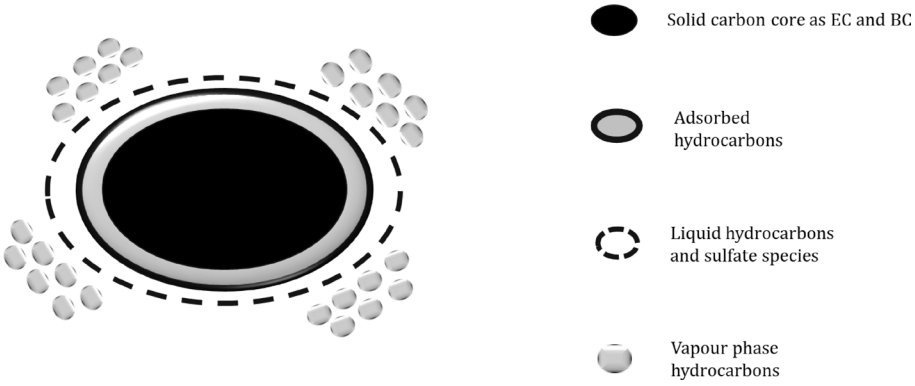

Figure 1. Schematic figure of particulate matter (PM) (amended by Martin V. Twigg and Paul R. Phillips, Platinum Metals Rev., 2009, 53, (1), 27-34).[19]

carcinogenicity, different concentrations, and possible formation of secondary toxic compounds. In addition, there are several non-carbon-based compounds, such as arsenic, cobalt, chromium, mercury, nickel, and phosphorus compounds, and organic compounds, such as acrolein, acetaldehyde, xylenes, etc. Because of the large number of chemical compounds present in DDE (including carcinogens), it would be useful to find more specific markers that do not have a background as EC (marker whose quantification is required by Interministerial Decree 2021). In addition, as reported in the Copenhagen Airport case study [21], caution must be exercised concerning the size of the engine particles. The study reports a dramatic scenario: "The result will be inhalation of 500 million particles per minute. This equates to 240 billion ultrafine particles per workday, a significant proportion of which are deposited in the most critical parts of the lungs (the alveoli)" [21]. This data shows that the number and the size of particles are important, and probably, they cannot be replaced by the measurement of EC alone. Moreover, the chemical composition of DDE has changed over time, from traditional diesel engines to those with new technology. Precisely in the new ones, EC decreases (from 75% to 13%) and organic carbon (OC) increases (from 19% to 30'%) [11]; also, NOx, CO, HC, and PM decrease in new engines diesel [22]. In particular, Piia Taxell reported that "for the new technology, diesel engine exhaust with significantly reduced particle mass and EC concentration, EC may not be an equally useful marker" [23].

3.3. Size Distribution and Mass Dust Content of Diesel Engine Exhaust. What Implications for Risk Assessment?

Exhaust emissions from diesel engines are a complex mixture of gas, vapors, and aerosols (all states of matter are present). PM or Diesel Particulate Matter (DPM) or Diesel Exhaust Particulate (DEP) are solid particles emitted by diesel engines as part of the DDE. In the IARC Press Release 213 of 12 June 2012 [24], some studies considered complete diesel emissions, which caused an increase in the incidence of lung cancer in rats. These studies showed that (i) the gas phase (with particles removed) did not increase the incidence of respiratory cancers in any of the species tested; (ii) the particulate phase caused malignant lung tumors in rats and sarcomas at the site of injection in mice.

The size distribution of particles emitted by diesel engines varies according to engine type, engine operating conditions, fuel formulations, lubricating oil, additives, and emission control systems. Substantial differences are also found depending on the age of the engines: the newest, compliant with Euro IV-VI, have a different emission composition from that of conventional diesel engines [11].

Diesel engine exhaust emissions are mixtures of hundreds of chemical compounds, which are

emitted partly in the gaseous phase and partly in the particulate phase [25]. Particle mass is reduced by more than 90% in the case of Euro IV-VI engines compared to Euro I and II engines [23]. Concerning the size distribution of the emitted particles, a recent study reports that the particles containing OC and EC peaks at 330–550 nm, with OC/EC ratio showing two peaks in the ultrafine (< 100 nm) and accumulation modes (170–330 nm) [26]. Moreover, in the study of Eric Garshick et al. [10], EC in PM1 was tested using the NIOSH 5040 method [27], concluding that diesel emissions contributed significantly to the EC in PM1 in the United States in urban areas before 2006. Fine and ultrafine organic particles, which can penetrate the respiratory system, are also reported as produced by diesel engines and aircraft engines following incomplete combustion [28] [21]. Aircraft engines emit 1000 times more particles per kg of fuel than modern diesel engines (EURO V/VI); this is an important critical point in these workplaces, and an example of such a case of occupational exposure can become a public health problem.

Therefore, without prejudice to SCOEL's opinion on differences in diesel exhaust, the IARC emphasizes the need not to make a distinction between age and diesel engine type for the exposure risk since the qualitative and quantitative composition of emissions depends on the type and age of the engine, the emission control system, the development, maintenance, and mode of use.

As a final consideration regarding the age of diesel engines, the Italian Interministerial Decree of February 11, 2021, adds "diesel engine exhaust emissions" as carcinogenic compounds without considering any differences in their characteristics or age. On the other hand, the particle size fraction to be selected in diesel exhaust sampling for EC determination remains an open question. If this is not specified as notation to the limit value, industrial hygiene practice requires sampling the inhalable fraction, even from a precautionary perspective. The NIOSH 5040 method would fully comply with this practice, requiring sampling of the inhalable fraction with a three-piece cassette [27].

4. Exposure Assessment by Comparison with OEL

4.1. Sampling of Elemental Carbon

The carbon components of PM (EC, OC and BC) take different names based on the availability of different measurement techniques. Also, different terms refer to the same type of exposure to carbon in PM, particularly in the fine fraction. In this regard, the Italian legislation does not indicate which dimensional fraction of the particles have to be sampled in assessing the exposure, but a technical document published by the Italian Association of Industrial Hygienists (AIDII) in March 2023 provides guidance, as far as the technical standards are concerned. The AIDII guide [12] refers to:

a. STANDARD UNI EN 14530/2005 [29] (Atmospheres in the workplace. Determination of diesel particulate matter. General Requirements). This standard defines EC as residual soot nuclei after removing OC from particulate matter. It provides for sampling the respirable fraction (according to the UNI EN 481:1994 standard) [30].
b. STANDARD UNI EN 16909/2017 [31] (Ambient Air – Determination of EC and OC deposited on filters). This refers to the UNI EN 12341:2014 [32] standard and indicates PM2.5 as the fraction to be sampled.

The UNI EN TECHNICAL STANDARDS suggest sampling respirable or fine fraction of PM, but certainly not the coarse one. The Italian Interministerial Decree of February 11, 2021, indicates EC as a marker for assessing DDE exposure. The most suitable method for occupational exposure to diesel exhaust seems to be the NIOSH 5040 (NIOSH Analytical Methods Manual, V Edition year 2016) [27]: in this method, soot is considered synonymous with EC.

The method involves personal samplers with 37 or 25-mm diameter quartz fiber filters. Filters should be heated for 1-2 h at ~800°C to ensure

any removing contaminants. The sampling flow is between 2 and 4 L/min with a minimum volume of 142 L. Lower flow rates are used in dusty environments to avoid filter overloading (cyclone or impactor is recommended to prevent interference). The sampling respiratory zone for the workers corresponds to a hemisphere (radius 30 cm) extending in front of the human face; technical normative EN 1540:2011, ISO 18158:2016 [33] are used to define this area, but it is not selective of any particle size fraction. Some authors show that the EC is a better marker than gravimetric methods (not suitable for low concentrations (< 200 μg/m^3) of PM in air) [34], being it a more selective indicator of diesel engine emissions and representing a considerable fraction of the mass of PM.

In addition, it is stated that EC is a specific marker of occupational exposure to diesel engine emissions regardless of the particle fractions (inhalable and respirable fraction). The sampling of particle size fractions according to the UNI EN 481:1994 [30] standard is not considered necessary except in mining activities (where the sampling of the respirable fraction is recommended).

Nevertheless, some papers have been reviewed [35], providing airborne concentrations of EC in the workplaces in both inhalable and respirable fractions. Diesel engines emit many fine and ultrafine particles, as organic particles produce incomplete combustion [28]. Ultrafine particles (UFPs) are expressed in particle number concentration (#/cm^3) rather than mass concentration (mg/m^3). UFPs (< 0.1 μm in aerodynamic diameter), together with the nanoparticles (< 0.03 μm), contribute the majority of the particle number. It is also reported that the NIOSH 5040 method does not interfere with cigarette smoke or other carbon-based aerosols because these are mainly composed of OC. Still, once again, attention must be paid to the new diesel technology, where the percentage of OC increases and EC decreases [11]. These aspects and critical issues are not mentioned in the February 11, 2021, Interministerial Decree. Finally, to obtain sufficiently low limits of quantification (LOD) (less than 2 mg/m^3), it should be noted that more than 1 m^3 of air needs to be sampled. Therefore, long sampling times are usually required.

4.2. Analysis of Elemental Carbon

Several analytical thermo-optical methods (such as NIOSH 5040, NIOSH-like, EUSAAR2, IMPROVE) exist for the EC quantification. Briefly, the thermo-optical measurement involves two heating ramps: the first one, in helium gas, is used to determine the OC, whilst the second, at a higher temperature, in an oxygen oxidative atmosphere, is necessary to measure the remaining oxidized carbon. CO_2 released after the two heating ramps is quantified directly by the IR detector or after methane reduction with an FID detector. During thermal analysis, the instrument measures the laser transmittance at 660 nm through the filter to determine the split point between OC and EC. The difference quantifies elemental carbon: total carbon (TC) minus OC (EC = TC – OC).

Thermo-optical methods EUSAAR2, IMPROVE, NIOSH 5040, and NIOSH-like are four different thermal protocols for heating the sample with differences in the maximum temperature value of the first phase: IMPROVE (used in the USA) and EUSAAR-2 (used in Europe) are medium-low temperature protocols, in which the first phase ends at 550 °C (IMPROVE) or 650 °C (EUSAAR-2). In comparison, the two NIOSH protocols end the first phase at 870 °C (QUARTZ or NIOSH-like) or 850 °C (NIOSH 5040). In general, low- to medium-temperature protocols result in higher EC concentrations than those from high-temperature protocols. This may be due to an incomplete evolution of OC in the first phase of medium-low temperature protocols (underestimation of OC, leading to an overestimation of EC), or to a pre-combustion effect of EC in high-temperature protocols (underestimation of EC and consequent overestimation of OC) [36].

5. Main Critical Issues

5.1. Elemental Carbon *vs* Black Carbon (EC *vs* BC)

The methods for EC quantification, based on comparative differences between OC and EC determinations in the same line measurement (IMPROVE,

Table 2. The pro and cons of EC and BC measurements.

	Elemental Carbon (EC)	Black Carbon (BC)
PRO	Good specificity High sensitivity	Immediate and continuous measurement
CONS	A long and laborious measure High measurement uncertainty	Possible interferents

EUSAAR2, NIOSH 5040, NIOSH-like), imply measurement uncertainty to be added to quantitation uncertainty. The quantification of EC is difficult because there are only a few laboratories that can perform this determination in industrial hygiene. Still, many are equipping themselves as environmental agencies did in the past. In addition, the term BC is often used as a synonym for EC, as reported in the NIOSH METHOD 5040 [27]. BC is unbound carbon as EC, but these commonly used terms are potentially ambiguous.

In 2011, the Global Atmospheric Watch-Scientific Advisory Group (GAW/WMO) suggested definitions, which can be summarized as:

a. EC is carbon measured with a thermo-optical analytical technique.
b. BC is carbon measured with an optical analytical technique.

BC and EC refer to materials with different optical and physical properties (quantification of carbon with two different analytical techniques) rather than compounds with well-defined properties [37]. The determination of BC consists of an optical absorption measurement at one or more predetermined wavelengths and not an actual measurement of chemically well-defined parameters. It is also evidenced that EC is used as a surrogate to assess exposure to diesel PM. The word "surrogate" is used in a paper by Birch and Cary [38]. Could we assume BC is less "surrogate" than EC for quantifying diesel exposure? However, neither the EU nor the Italian legislation mentions these aspects.

The choice of using EC as a tracer of DDE, which has been endorsed by all official methods and technical standards worldwide, is probably due to three factors: i) The carcinogenic mechanism of DDE is mainly due to the particulate fraction (rather than exhausted gases); ii) EC represents more than 80% of DDE released particles; iii) EC measurement is less biased by interfering factors (e.g. cigarette smoke/OC) in comparison with BC [27].

In addition, BC is a component of the PM, the reduction of which can lead to climate and pollution benefits. Knowledge of the quantities and emission sources involved is necessary for effective intervention. The International and national scientific community should focus on standardization and, in particular, on definitions regarding the carbonaceous fraction of particulate matter and of measurement standards. BC is a primary pollutant from diesel engine exhaust and its measurement is important, but this does not mean that measuring black carbon could be prematurely endorsed as a good indicator of occupational exposure to diesel engine emissions. Further studies are needed to compare EC and OC measurements in ambient matrixes from different workplaces.

Finally, on April 2024, the European Parliament adopted the text for the legislative resolution on the proposal for a directive of the European Parliament and of the Council on ambient air quality and cleaner air for Europe [39], in which new rules are set for several pollutants including particulate matter (PM2,5, PM10), NO_2 and SO_2. The air quality standards shall be reviewed by 31 December 2030, and they are also based on the revised World Health Organization (WHO) Air Quality Guidelines, in which black carbon/elemental carbon was also a concern [40].

The new EU Directive updates the last version of the Directive on air quality in Europe [41]. It suggests continuous monitoring of EC, BC, and OC in the air. It proposes air quality standards for different pollutants, but no standard for EC is set.

Therefore, a new question arises regarding occupational exposure to DDE: is measuring both EC and BC in workplaces better? BC measurement can indeed be considered complementary to determinations via the thermo-optical reference technique.

5.1.1 Health Effects of Black Carbon

BC influences climate and pollution and has adverse health effects [42]. In 2012, the World Health Organization (WHO) highlighted that BC and EC were strongly correlated and measured with different analytical techniques. Moreover, the WHO has evidenced that BC is a carrier of other toxic or carcinogenic compounds. After 2012, new articles [43-45] reported that BC was not only a carrier, but it had effects on cardiovascular events and premature deaths in humans. These BC health effects further confirm the need to quantify it, and the WHO, in the 2021 Air Quality Guidelines update, included statements of good practice to address concerns about the health and environmental effects of the BC/EC.

5.1.2 Analytical Quantification of Black Carbon

The quantitative measurement of BC is done with a multi-spectrum instrument that constantly measures the transmittance of light at ten different wavelengths (from "near UV" to "near IR"). The instrument calculates, in real-time, the concentration of BC through filter support on which particulate matter accumulates. The room sampling system has a heater, and a sample flow rate of 2 or 5 l/min can be set. The analyzer uses a very common and inexpensive filter and allows the choice of the filter belt feed mode according to the concentration of BC. The instrument has sampling heads that allow the alternative measurement of PM10, PM2.5, or PM1. Using aethalometers for BC monitoring, high temporal resolution exposure data can be collected, which is very useful for identifying potential high-exposure peaks linked to specific work activities and thus to set up an effective risk management strategy.

The BC measurement may have interfering substances. It is well known that, in situations where particles opaque to light radiation, such as crustal particulate matter and heavy metals, are present, significant interferences can potentially lead to a significant overestimation of actual exposure levels [46].

5.2. Workers Exposed and Unexposed

In Occupational Medicine, "Exposed Workers" means workers who have an exposure above the background levels of the general population. However, although the EC can be considered a ubiquitous contaminant, there are no standard or guideline values for the protection of the health of the general population and this gap does not help the assessment of occupational exposures to DDE. The recently published Guideline of the Emilia-Romagna Region [47] refers to updating the guideline to discriminate between "Exposed and Unexposed Workers" in the future.

5.3. Elemental Carbon Values in Different Workplaces

Several papers have been published using EC as a marker to quantify occupational exposure to diesel exhaust. Among them, the most recent paper of Plato [48] reports measurements carried out in 72 different workplaces that are assimilable to life environments such as buses and cars and for operators on non-road equipment over a long observation period, ranging from 1950 to 2005. In this study, only a few recent data come for direct measurements of EC, while for the most part, the exposure has been estimated by a model adjusted with indirect measures. Exposures for workers exposed in the above environments decreased over the years, resulting below the OEL of 50 $\mu g/m^3$ set by the 2021 Interministerial decree. However, it should be noted that this study was carried out in Sweden, where air pollution levels are different from those in Italy, thus making exposures in working environments similar to living environments not entirely comparable.

In Italy, we have some data of EC [49] and BC [50] for general population exposure, with values varying over the seasons [51]. As a general consideration, environmental exposure to the EC ranges between 0.01 $\mu g/m^3$ and 5.1 $\mu g/m^3$ for EC [52], a maximum value that is approximately 10 times lower than the corresponding OEL. This "background" value, together with the measured EC concentrations in different workplaces, published in the

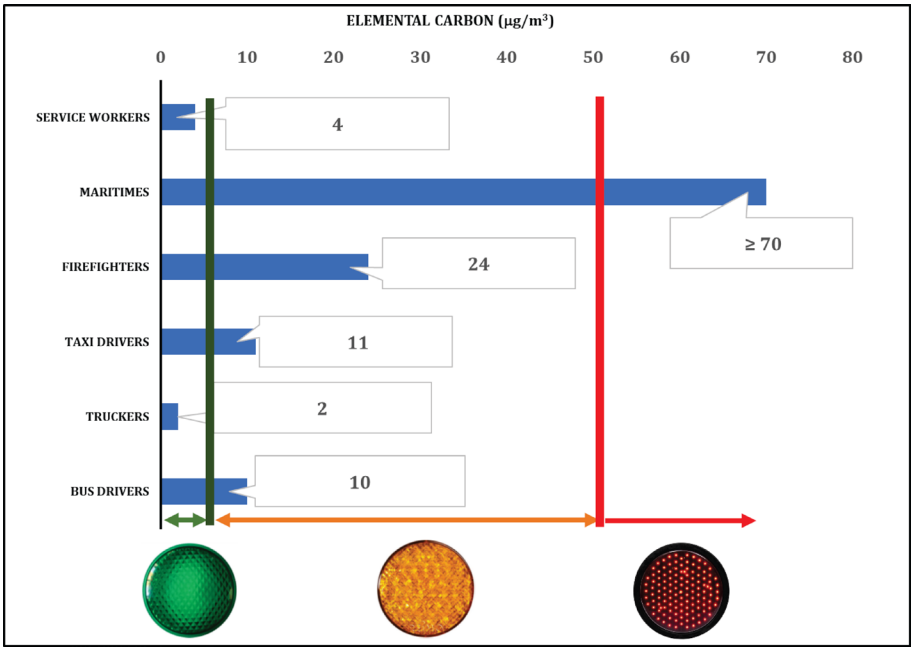

Figure 2. Mean air concentration for EC for exposed and unexposed workers (blue bars) **(Data from Pronk, 2009)** [35] and the general population (green line). The red line refers to the Italian OEL.

scientific literature for European and non-European workers [35], has been graphically compared with the OEL for EC in the graph shown in Figure 2.

Figure 2 shows that installers and truck drivers, so-called "unexposed workers," are exposed to EC values equal to or below the level for the general population; the exposed workers, instead, present exposure levels both below the OEL of 50 µg/m^3, taxi drivers, firefighters, bus drivers, and above 50 µg/m^3, maritimes. For these latter, a re-entry activity below the OEL is mandatory. This type of scheme may be useful in discriminating between exposed and not-exposed workers for the purpose of health surveillance for exposure to DDE.

5.4. Occupational Exposure Limit (OEL) for Elemental Carbon is not Health-Based

Another critical question is: "How precautionary are we in protecting workers from exposure to diesel engine exhaust fumes?" [53]. The 50 µg/m^3 limit value set by the 2021 Interministerial Decree is a regulatory, not health-based limit. It is a compromise between health and technically achievable values. The report by R. Vermeulen [53] shows the excess risk of lung cancer in Europe on the population of workers (229 million), setting different OEL values for exposure to DDE.

For an OEL value of 50 µg/m^3, an excess risk of 268 workers out of 10000 is obtained. For an OEL of 10 µg/m^3, the excess risk results in 166 workers out of 10000, which drops to 26 in the case of 1 µg/m^3. In the Netherlands, the Health Council, based on the exposure-response relationship by Vermeulen et al. [54], has set a health-based limit of 1 µg/m^3 for occupational exposure to DDE. To increase workers' health, the value of OEL should be reduced in the coming years, consistent with the technical possibility of measuring increasingly low concentrations.

6. Conclusion

This work highlights the critical issues in European legislation and, consequently, in the Italian one for assessing exposure to DDE. The 2021 Interministerial decree was issued by setting an OEL for EC about ten years after the publication of the 2014 IARC Monograph, where DDE was

classified carcinogenic for the first time. From a scientific point of view, the new legislation is already non-exhaustive because BC (and eventually OC) can be quantified as a carbon-based marker for this type of exposure in addition to EC. In Italy, the Environmental Agencies have quantified EC, BC, and OC for years, as also required by the proposal to amend the European Union Directive of October 2022, which invited all Member States to carry out a greater number of quantitative determinations of the three markers to control air quality in Europe. The amended Directive does not set a standard value for EC, referring to the general population's exposure, while from February 2023, the occupational exposure limit of 50 $\mu g/m^3$ as EC is operative for workers. The 2021 Interministerial Decree also does not indicate the particle size fraction to sample in the workplaces for quantifying EC, BC, and OC. Still, it is known that particle size is an important parameter to consider for the risk of exposure because the smaller the size, the greater the probability that particles deeply penetrate the respiratory system, up to the alveoli. The Environmental Agencies show that all BC in the atmosphere is present in the sub-micrometric fraction of particulate matter (PM1).

To date, there is a lack of data in Italy on the environmental monitoring of BC and EC both in the workplaces and in the living environments. Moreover, the 50 $\mu g/m^3$ limit for EC seems already high in a more concrete perspective of safeguarding workers' health. Finally, the thermo-optical quantification of EC is a laborious multi-step method (and probably not useful for new technology diesel engine exhaust) with the risk of a high measurement uncertainty that can influence the exposure results with consequent impact also the health surveillance.

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Two Decades of Fatal Workplace Accidents in Milan and Monza, Italy: Trends, Work Sectors, and Causes from Autoptic Data

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Keywords: Work-Related Fatalities; Occupational Injuries; Workplace Safety; Occupational Safety and Health; Autopsy; Forensic Pathology

Abstract

Background: *Work-related fatalities represent an important global public health threat, accounting for over 300,000 deaths annually. Despite preventive strategies, fatalities persist, necessitating extensive investigations. Autoptic investigations, when ordered, offer comprehensive data on fatal accidents, in particular with detailed information about the type of accident, lesions, and type of work, enabling a thorough analysis of various factors contributing to workplace deaths. This study investigates work-related fatalities in Milan and Monza Brianza, Lombardy, analyzing patterns, industries, and factors leading to death among workers.* **Methods:** *This retrospective study analyzed all fatal work accident data from the Autopsy Database of the Legal Medicine Institute of Milan from January 2000 to December 2022. We also estimated the risk of fatal accidents per 1.00.000 workers using ISTAT data for the different work sectors.* **Results:** *Of the 17,841 violent deaths in Milan and Monza Brianza, 308 resulted from work-related accidents. The majority were male (95.1%). The secondary sector showed the higher estimated risk (27 /10^6 vs. 19/10^6 in primary and 2.3/10^6 in tertiary sector) accounted for 78.5% of fatalities, with specialized workers (35.1%) and construction workers (25%) being the most affected. Falls from above were the leading cause of death (36.7%). A decreasing trend in fatal accidents over the study period was observed, with July having the greatest frequency. The most common causes of death were polytrauma (36.4%) and head injuries (19.2%). Non-Italian workers constitute a noteworthy percentage of fatal cases (24%).* **Conclusions:** *The secondary sector has the most fatal accidents at work despite a decrease in accidents over the observed time period. There is a need for rigorous analysis and interventions, using forensic autopsy case data to help understand causes, and collaboration between institutions is encouraged to develop effective preventive policies.*

1. Introduction

Work-related fatalities represent a critical public health and safety concern since they are accidents that could have been avoided with proper measures. Whether due to occupational hazards, safety breaches, or communication breakdowns, occupational injuries account for more than 300,000 of the 2.3 million work-related deaths globally each year [1, 2]. These numbers show that work-related

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fatalities are a serious issue that affects many countries and industries around the world. For example, over 6,200 people in the US die from work-related injuries each year [3]. Meanwhile, in Italy, the Italian Compensatory Authority (INAIL) estimates that roughly 1,300 fatal accidents occur each year during working hours [4].

Despite the development of newer and improved preventive strategies and tools, the issue of work-related fatalities is still very topical [5, 6]. The volume of work-related fatalities and occupational diseases varies significantly between occupational sectors. The primary and secondary sectors, defined by intrinsic dangers, usually have a greater incidence of deaths and occupational diseases than sectors with largely office-based work [7–12]. This persistence of fatalities at work has many probable causes, such as the diversity of work environments, the role of human error, economic pressures, globalization, technological changes, inconsistent enforcement of safety regulations, emerging risks, and evolving workforce demographics [11, 13–15].

In the Italian legal system, the communication of an accident at work that led to absence from work of at least one day, excluding one of the events, is an obligation for all employers. If the accident at work involves an absence from work for more than three days, an injury notification report is mandatory [16]. The Legislative Decree 9 April 2008 n.81 (D. Lgs. 81/08) is an Italian law that sets the rules relating to health and safety at work. According to the decree, the employer is responsible for the safety of their employees and must take all the necessary measures to guarantee it. Article 589 of the Italian penal code establishes that the punishment for whoever causes the death of a person through negligence is imprisonment from six months to five years. If there is suspicion of a death caused by a crime, the public prosecutor can order a judicial autopsy to establish the cause of death. Therefore, in the presence of a work-related fatal accident, the public prosecutor's office usually requests the execution of a judicial autopsy to ascertain the causes of death, together with an investigation aimed at understanding whether the death was caused by the employer's negligence or not. The judicial autopsy is then carried out by the Legal Medicine Institute of the province in which the fatal accident occurred.

Lombardy is Italy's most populous region, with approximately ten million residents, and it is home to almost one million production activities, both small and large enterprises. The provinces of Milan and Monza Brianza alone have more than 364,000 active businesses, and they are two of the wealthiest provinces in Italy. With more than 4 million workers, the region has the greatest labor force in Italy [17]. Therefore, there is a high risk of injuries at work; in fact, in recent years, the region has recorded a great number of fatal accidents [18].

INAIL publishes a national and regional report of all the notified accidents at work every six months. These are well-collected and processed data, but they are presented according primarily to its insurance agenda and not a prevention logic. The public data on fatal accidents is mainly aggregated and doesn't report details about what led to the death of the person and the type of job that the victim performed [4]. This lack of information makes it difficult to analyze the causes and patterns of work-related fatalities and design and implement effective prevention strategies. The autopsy act is necessary to identify the type of lesion that caused the worker's death. The added value of the autopsy data is highlighted by the need to differentiate the information sources to increase the data flow. Autopsies provide comprehensive data on the circumstances and events leading to fatal accidents, and crucial insights into the individuals involved, allowing for a thorough investigation of the numerous elements that contribute to workplace deaths.

This study aims to examine work-related fatalities in two of the biggest and wealthiest provinces of Lombardy, Milan and Monza Brianza, over 23 years, from January 2000 to December 2022. The study also intends to identify the industries and occupations that have the highest occurrence of fatal accidents and to evaluate the major factors that lead to death among workers.

2. Methods

The data for this retrospective study was obtained in March 2023 from the Autopsy Database of the Legal Medicine Institute of Milan. The Autopsy Database systematically collects the relevant information

available on all the violent deaths that occurred in the provinces of Milan and Monza Brianza since 1986, for a total of 36,618 autopsies. The Autopsy Database contains personal data (gender, weight, height, Body Mass Index (BMI), ethnicity, date and place of birth, city of residence, current job, smoking and drinking habits, history of drug abuse), medical history (pathological history, medications, previous surgical interventions, disabilities), and autopsy details (date and place of death, age at the time of death, details from the site inspection, long and accurate description of the circumstances of the fatality, cause of death, toxicology, site of lesions) of the deceased. All the autopsies are recorded using an anonymous ID, such as the report number. The inclusion criteria were: i) autopsies performed from 2000 to 2022, ii) all the fatalities labeled as work-related accidents, including commuting injuries. The exclusion criteria were: i) missing or questionable data about the type of fatal accident and occupation, ii) natural deaths or suicides that occurred during working hours.

We transferred the selected cases in a new database for further analysis. The long and accurate descriptions of the circumstances of the fatality and cause of death were then read and coded in six entries named type of fatal accident: fall from above, falling objects, stuck in machinery, commuting accident, electrocution, other (drowning, explosion, burned, chemical toxicity, animal attack, combination of two types of injury). The same was performed with the job of the deceased, classifying them according to the ATECO job sector categorization: primary sector (A-B such as farmers and breeders), secondary sector (C-F such as construction workers, maintenance/technicians such as electricians and plumbers, specialized workers such as carpenters and foremen, metalworkers, unskilled workers), tertiary sector (G-U such as couriers, white-collars, law enforcement, healthcare workers).

The statistical analysis was performed using the program SPSS PC version 29. Statistical significance was set for a P-value ≤ 0.05. We used the chi-square and ANOVA tests to compare categorical and quantitative variables between the different types of fatal accidents, respectively.

3. Results

From January 2000 to December 2022, there were 17,841 violent deaths in the province of Milan and Monza Brianza, with 308 (0.017%) caused by workplace accidents. Out of our sample of 308 casualties, 293 (95.1%) were men, and 15 (4.9%) were women, with an average age of 44.2 years at the time of death (±13.7 sd) ranging from 17 to 77 years. The mean BMI of the sample was 27.9 (±5.2 sd), with a minimum of 15.2 and a maximum of 45.5, with overweight being the most represented BMI class (26.6%). Two hundred thirty-three (75.6%) of the deceased were Italian, while 36 (11.7%) were European, 20 (6.5%) African, 12 (3.9%) Asian, and 7 (2.3%) South American. The pathological history of 258 (83.8%) of the sample was known, and it was positive for 81 (26.3%) of them. Out of the 81 deceased with a positive pathological history, 27 (33.3%) had hypertension, 11 (13.6%) from metabolic diseases, 6 (7.4%) were suffering from cardiovascular diseases, 5 (6.2%) from pluri-pathological diseases, 3 (3.7%) from neurological diseases, 2 (2.5%) from psychiatric diseases, and 27 (33.3%) from other diseases. Nonsmokers accounted for 33.8% of the sample, 40.6% weren't consuming alcoholic beverages regularly, 15.3% consumed coffee daily and 29.9% never consumed drugs. The demographic characteristics of the sample are described in detail in Table 1.

In the 23 years studied, there were an average of 13.3 fatal accidents each year, with a high of 27 in 2007 and a low of four in 2020. Figure 1 depicts a decreasing trend in the number of fatal accidents over time. Overall, the month with the most fatal accidents was July, with 34 (11%) fatal workplace accidents, followed by June with 32 (10.4%) fatal accidents.

The secondary sector was the one with the most fatal accidents at work with 242 (78.5%) events, 108 (35.1%) involved specialized workers, 77 (25%) involved construction workers, 35 (11.4%) involved maintenance/technician workers, 12 (3.9%) involved metalworkers, and 10 (3.2%) involved unskilled workers. The tertiary sector registered 59 (19.2%) fatal workplace accidents, 30 (9.7%) involved white-collar workers, 23 (7.5%) involved couriers, 3 (1%)

Table 1. Demographic characteristics of the sample (BMI, nationality, pathological history, smoking habit, alcohol consumption, coffee consumption, drug abuse).

Tot = 308	N (%)
BMI	
Unknown	90 (29.2%)
Underweight	4 (1.3%)
Normal weight	62 (20.1%)
Overweight	82 (26.6%)
Obese class 1	47 (15.3%)
Obese class 2	20 (6.5%)
Obese class 3	3 (1%)
Nationality	
Italian	233 (75.6%)
European	36 (11.7%)
African	20 (6.5%)
Asian	12 (3.9%)
South American	7 (2.3%)
Pathological history	
Unknown	50 (16.2%)
Negative	177 (57.5%)
Positive	81 (26.3%)
Cardiovascular	33 (10.7%)
Metabolic	11 (3.6%)
Pluripathological	5 (1.6%)
Neurological	3 (1%)
Psychiatric	2 (0.6%)
Other	27 (8.8%)
Smoking habit	
Unknown	83 (26.9%)
Nonsmoker	104 (33.8%)
Smoker	101 (32.8%)
<20 cig/die	62 (61%)
>20 cig/die	40 (39%)
Ex-smoker	20 (6.5%)
Alcohol consumption	
Unknown	88 (28.6%)
No	125 (40.6%)
Yes	95 (30.8)
Coffee consumption	
Unknown	228 (74%)
Yes	47 (15.3%)
No	33 (10.7%)
Drug abuse	
Unknown	211 (68.5%)
No	92 (29.9%)
Yes	3 (1%)
Past use	2 (0.6%)

involved law enforcement workers, and 3 (1%) involved healthcare workers. The primary sector had 7 (2.3%) fatal accidents at work involving farmers and breeders. In the primary sector, the most common accident at work was represented by other causes such as attacks from animals or drowning with 4 (57.1%) events, while a fall from above was the most common in the secondary sector with 99 (32.3%) events, in the tertiary sector the most common accident was represented by commuting accidents with 23 (7.4%) events. With 113 (36.7%) events, the most common type of fatal workplace accident was a fall from above. Commuting accidents accounted for 40 (13%) events, falling objects for 38 (12.3%), stuck in machinery accounted for 30 (9.7%), and electrocution for 5 (1.6%) events. Other fatal accidents were responsible for 82 (26.6%) events. Among genders, the predominant occupation for men was a specialized worker (36.2%), while women were mostly white-collar (53.3%). The most common fatal workplace accident for men was a fall from above, accounting for 110 (37.5%) fatalities, while for women it was commuting accidents with 6 (40%) events (Table 2).

With 112 (36.4%) occurrences, the most common injury was polytrauma, followed by 59 (19.2%) injuries on the head, 15 (4.9%) injuries on the thorax, 3 (1%) injuries on the abdomen, and 119 (38.6%) in other areas of the body.

No statistically significant differences were observed among accident types concerning age, nationality, history of drug abuse, BMI, alcohol consumption, or pathological history (Supplementary materials 1).

4. Discussion

A novelty of this study is the use of autopsy data to describe workplace fatal accidents, allowing for

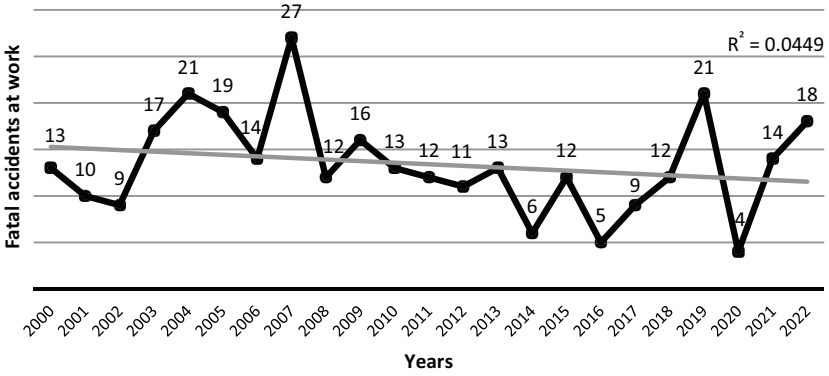

Figure 1. Fatal accidents at work from Jan 2000 to Dec 2022 in the provinces of Milan and Monza Brianza.

some comparability with traditional databases. This approach also helps to enrich our epidemiological understanding and provides insights into the affected individuals, fostering a holistic exploration of the multifaceted dynamics behind fatal accidents. Three hundred and eight fatal accidents at work were reported to the Forensic Institute of Milan in the study period. In the same years, INAIL's reports in the Lombardy region registered 4,408 fatal accidents at work for the whole region [18], with no province details for the whole period. Considering the proportion between the inhabitants of Lombardy and the inhabitants of the provinces of Milan and Monza Brianza, we estimated the number of expected fatal accidents in the provinces of Milan and Monza Brianza in the same period as 1,928. Thus, the data collected from the Forensic Institute of Milan would represent 16% of the expected fatal accidents in the Milan and Monza Brianza provinces.

The Lombardy's Regional Registry for Accidents at Work reports 17 and 24 accidents for 2021 and 2022 respectively, in the Health Protection Agencies' (ATS) territory of Milan and Monza Brianza [19]. The territory of Monza Brianza's ATS also comprehends the province of Lecco. The autoptic data reports 14 fatal accidents in 2021 and 18 in 2022. Based on the ATS's reports, the Forensic Institute of Milan data accounts for 82.3% and 75% of fatal work accidents in 2021 and 2022 respectively.

This partial coverage of the fatal accidents was expected and is part of the study's limitations. The Milan Forensic Institute's database underestimates the number of deaths caused by accidents at work because a judicial autopsy may not be ordered for all fatal occupational accidents, and their reporting can vary between institutions and their agendas. Divergent definitions of what constitutes a fatal accident at work, reporting timelines, and data collection methodologies may also lead to these differences. For example, in the INAIL's reports, all the deaths caused by work-related COVID-19 are considered fatal accidents at work [20]. At the same time, no judicial autopsies were ordered for this kind of death, and they aren't taken into consideration in Lombardy's Regional Registry for Accidents at Work. INAIL and ATS's databases have various recording techniques and timings that are not always easy to access and do not allow extensive or comparative examination. However, the incomplete coverage of fatal cases by the Forensic Institute of Milan may reduce the generalizability of our results. Another limitation is determined by a possible misclassification in the Institute's database. Anamnestic data are reported by third parties. Therefore, some are missing, and some may be unreliable. To explore potential preventive measures, it's vital to update and improve accessibility to the data collected.

Despite the above-mentioned limitations, the data obtained is valuable in bringing substantial insights to the larger context of our research. In our sample, most recorded accidents involved male workers, accounting for 95.1% of the cases. This gender imbalance reflects a prevailing trend observed in the literature on

Table 2. Analysis of fatal workplace accidents by ATECO job sector categorization (primary (A-B), secondary (C-F), and tertiary (G-U)), occupation (farmers and breeders, couriers, construction workers, maintenance/technicians, metalworkers, unskilled workers, white collars, law enforcement, healthcare workers), accident type (fall from above, falling objects, stuck in machinery, commuting accident, electrocution, other), and gender.

	Fall from above	Falling objects	Stuck in machinery	Commuting accident	Electrocution	Other	Total
Primary sector (A-B)	**0**	**0**	**1 (0.3%)**	**1 (0.3%)**	**1 (0.3%)**	**4 (1.4%)**	**7 (2.3%)**
Farmers and breeders	0	0	1 (0.3%)	1 (0.3%)	1 (0.3%)	4 (1.4%)	7 (2.3%)
Men	*0*	*0*	*1 (0.3%)*	*1 (0.3%)*	*1 (0.3%)*	*4 (1.4%)*	*7 (2.3%)*
Women	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Secondary sector (C-F)	**99 (32.3%)**	**32 (10.3%)**	**24 (7.9%)**	**16 (5.1%)**	**4 (1.4%)**	**67 (21.6%)**	**242 (78.5%)**
Construction workers	44 (14.4%)	9 (2.9%)	1 (0.3%)	5 (1.6%)	2 (0.6%)	16 (5.2%)	77 (25%)
Men	*44 (14.4%)*	*8 (2.6%)*	*1 (0.3%)*	*4 (1.4%)*	*2 (0.6%)*	*16 (5.2%)*	*75 (24.4%)*
Women	*0*	*1 (0.3%)*	*0*	*1 (0.3%)*	*0*	*0*	*2 (0.6%)*
Maintenance/ technicians	10 (3.3%)	1 (0.3%)	4 (1.4%)	3 (1%)	2 (0.6%)	15 (4.8%)	35 (11.4%)
Men	*10 (3.3%)*	*1 (0.3%)*	*4 (1.4%)*	*2 (0.6%)*	*2 (0.6%)*	*15 (4.8%)*	*34 (11.1%)*
Women	*0*	*0*	*0*	*1 (0.3%)*	*0*	*0*	*1 (0.3%)*
Specialized workers	41 (13.4%)	18 (5.8%)	15 (4.8%)	5 (1.6%)	0	29 (9.5%)	108 (35.1%)
Men	*41 (13.4%)*	*18 (5.8%)*	*13 (4.4%)*	*5 (1.6%)*	*0*	*29 (9.5%)*	*106 (34.5%)*
Women	*0*	*0*	*2 (0.6%)*	*0*	*0*	*0*	*2 (0.6%)*
Metalworkers	2 (0.6%)	2 (0.6%)	1 (0.3%)	2 (0.6%)	0	5 (1.6%)	12 (3.9%)
Men	*2 (0.6%)*	*2 (0.6%)*	*1 (0.3%)*	*2 (0.6%)*	*0*	*5 (1.6%)*	*12 (3.9%)*
Women	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Unskilled workers	2 (0.6%)	2 (0.6%)	3 (1%)	1 (0.3%)	0	2 (0.6%)	10 (3.2%)
Men	*2 (0.6%)*	*1 (0.3%)*	*2 (0.6%)*	*1 (0.3%)*	*0*	*2 (0.6%)*	*8 (2.6%)*
Women	*0*	*1 (0.3%)*	*1 (0.3%)*	*0*	*0*	*0*	*2 (0.6%)*
Tertiary sector (G-U)	**14 (4.6%)**	**6 (1.9%)**	**5 (1.6%)**	**23 (7.4%)**	**0 (0%)**	**11 (3.6%)**	**59 (19.2%)**
White collars	10 (3.3%)	1 (0.3%)	0	14 (4.5%)	0	5 (1.6%)	30 (9.7%)
Men	*7 (2.4%)*	*1 (0.3%)*	*0*	*10 (3.4%)*	*0*	*4 (1.4%)*	*22 (7.5%)*
Women	*3 (1%)*	*0*	*0*	*4 (1.4%)*	*0*	*1 (0.3%)*	*8 (2.2%)*
Couriers	3 (1%)	3 (1%)	4 (1.4%)	8 (2.6%)	0	5 (1.6%)	23 (7.5%)
Men	*3 (1%)*	*3 (1%)*	*4 (1.4%)*	*8 (2.6%)*	*0*	*5 (1.6%)*	*23 (7.5%)*
Women	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Law enforcement	0	2 (0.6%)	0 (0%)	0 (0%)	0 (0%)	1 (0.3%)	3 (1%)
Men	*0*	*2 (0.6%)*	*0*	*0*	*0*	*1 (0.3%)*	*3 (1%)*
Women	*0*	*0*	*0*	*0*	*0*	*0*	*0*

	Fall from above	Falling objects	Stuck in machinery	Commuting accident	Electrocution	Other	Total
Healthcare workers	1 (0.3%)	0	1 (0.3%)	1 (0.3%)	0	0	3 (1%)
Men	*1 (0.3%)*	*0*	*1 (0.3%)*	*1 (0.3%)*	*0*	*0*	*3 (1%)*
Women	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total	**113 (36.9%)**	**38 (12.2%)**	**30 (9.8%)**	**40 (12.8%)**	**5 (1.7%)**	**82 (26.6%)**	**308 (100%)**
Men	*110 (35.9%)*	*36 (11.6%)*	*27 (8.8%)*	*34 (11%)*	*5 (1.7%)*	*81 (26.3%)*	*293 (95.1%)*
Women	*3 (1%)*	*2 (0.6%)*	*3 (1%)*	*6 (1.8%)*	*0*	*1 (0.3%)*	*15 (4.9%)*

Occupational Health, where different studies highlight a disproportionate representation of men in work-related accidents. In a 2012 study on occupational accidents in Mexico, Gonzalez-Delgado et al. reported a frequency of 96.23% of male workers [11], while Perotti and Russo, in a 30-year study on fatal injuries in the Brescia province of Italy, reported a 99% majority of male workers [21]. Similar numbers can be found in many other studies with similar percentages such as 98% found by Errico et al. [22] and 98.95% by Yamaguchi et al. [23]. This phenomenon can be explained by the fact that men are still employed at a somewhat larger rate than women (80% males and 69.3% women in the EU in 2022) [24]. Our data isn't equally distributed between genders, and this can be also attributed to occupational segregation, with men traditionally being overrepresented in high-risk and physically demanding professions, except for healthcare occupations [25–27]. This is consistent with our study analysis, in which the predominant occupation for men was specialized worker (36.2%), while for women was white-collar (53.3%). The most common fatal workplace accident for men was a fall from above (37.5%) while commuting accidents accounted for 40% of the events for women. The percentage of commuting accidents for women is similar to the 56% found by Gilberti and Salerno in a 5-year analysis based on INAIL's data [26]. More studies, that possibly include more women, are needed in order to understand the reason behind this difference in terms of the type of fatal accidents.

With an average age of 44.2 years at the time of death, our sample is similar to the mean age of 44.5 found by Perotti and Russo [21] and by Errico et al. [22] in other provinces of Italy. As the working population ages, it's important to consider this factor for future studies.

A large percentage of accidents at work in foreign workers is expected and confirmed by both our data (24.5%) and in literature (13% in the province of Brescia [21], 11% in the province of Genoa [22], and 10% in the prefectures of Tokyo and Chiba [23]), as foreign workers are often employed in particularly demanding activities, which expose them to greater health and safety risks [28]. INAIL, in its reports, distinguishes between Italians and non-Italians for the last years only, and for the whole Region. Therefore, it isn't easy to make this comparison for the entire period (2000-2022) and Milan and Monza provinces. However, we compared our 2022 results (27% of fatal cases occurring in non-Italian workers – i.e. 5 on a total of 18) and the whole period (24% - i.e. 75 over a total of 308 of cases among non-Italians workers) obtaining comparable results with INAIL data for non-Italian workers from 2022: 11% of total workers, 22% of total injuries, 29% of fatal cases. This observation highlights the high risk of injuries and severe injuries in non-Italian workers. In interpreting our relatively low proportion is important to consider that our data covers a longer period, reflecting the increased share of foreign workers over time. In the contemporary world marked by increased migration, it becomes

imperative to acknowledge the differences in working cultures. One should not assume that all workers universally comprehend and share safety procedures, underscoring the importance of vigilant attention to these factors.

In the 23 years studied, we found a decreasing trend in fatal workplace accidents. This confirms what was shared by national and regional INAIL reports that states that the decline was probably caused by an efficient increase in risk control and that it was also partially caused by the reduction of COVID-19-related deaths [29]. Despite this decreasing trend in Italy, China, and Taiwan [21, 30, 31], overall occupational deadly accidents are on the rise worldwide [27]. According to our data, July and June had the highest percentage of fatal accidents (11% and 10.4% respectively), supporting the notion that workplace deaths typically occur during the summer [14, 21, 22] even though there isn't a consensus on the specific month [23]. More studies are needed to better understand the reasons behind this occurrence, but these findings underline the need for increased vigilance during the summer months. In the autopsy database, some data were not available, such as information on the employment relationship, shift duration and place of residence. We believe that this information, if added to the autoptic records could be very useful in terms of preventive medicine.

In our study, the sector with the most fatal work accidents was the secondary one with 78.5% of events, followed by the tertiary sector (19.2%) and the primary sector (2.3%). According to the Italian National Institute of Statistics (ISTAT), the approximate number of employees in the primary sector in the provinces of Milano and Monza Brianza is 18,359, while in the secondary sector is 444,111 and in the tertiary sector is 1,258,222. Therefore, we could approximate an estimated average risk (as the number of fatal cases per year in each sector) of 19/1,000,000 fatal accidents in the primary sector, $27/10^6$ fatal accidents in the secondary sector, and $2.3/10^6$ fatal accidents in the tertiary sector. The increased incidence of fatal accidents occurring in the secondary sector is a common finding in literature in Italy [21, 22], and worldwide [11, 14, 23, 27]. This, once again, underscores the inherent dangers associated with industrial and construction activities. We observed a noteworthy incidence of fatal accidents in the primary sector, but given the low percentage of workers in the agricultural sector in our mostly urbanized area, we observed a lower percentage of total cases if compared to INAIL national data (2.3% versus 10.7%), and in a previous epidemiological study conducted in Lombardy [21, 32]. Regional and province variations, the types of industries, and risk profiles included in our sample may differ from those studied in the existing literature, leading to a lower proportion of fatal accidents in the primary sector than anticipated. Understanding these sector-specific patterns is critical for formulating targeted Occupational Health and safety strategies.

Our research provided unique insights and information not included in public reports from other organizations that could considerably improve our understanding of the subject. The occupations with the most fatalities were specialized workers (35.1%), followed by construction workers (25%) and maintenance/technician workers (11.4%). These results differ from the ones by Errico et al. [22], Perotti and Russo [21], Al-Abdallat et al. [14], and Yamaguchi et al. [23] that found construction workers to be the most impacted by fatal work accidents (40.5%, 36.6%, 44% and 39% respectively). This difference may be due to regional differences in industries and different categorizations of workers' jobs in literature, which may include specialized workers in the large category of "construction workers". Therefore, a limitation of our study was the difficulty in attributing a clear ATECO code to the specific occupation, which would have improved the aggregation and comparability of our results to other databases. Understanding occupation-specific patterns is crucial for developing effective Occupational Health and safety strategies.

The most common type of fatal workplace accident was a fall from above (36.7%). This is also the main type of fatal workplace accident in the studies by Al-Abdallat et al. (44%) [14], Errico et al. (42.5%) [22], and Yamaguchi et al. (25%) [23]. It is noteworthy that some studies, such as the one by Perotti and Russo, while not distinguishing between various types of mechanical trauma, still highlight

its importance as the leading cause of fatal accidents (77.69%) [21]. The consistency in reporting falls from above as a primary cause of fatal accidents across different studies underscores the pervasive nature of this occupational hazard. Taking occupational sectors into consideration, is important to underline that, in our study, fall from above is the main accident in the secondary sector, but not in the primary and the secondary. The predominance of falls from above in the secondary sector might be attributed to the nature of work, involving activities at heights, construction, and other tasks that inherently expose workers to elevated fall risks, deadly or not [33, 34]. These findings across multiple studies emphasize the importance of targeted preventive measures specific to the occupational contexts.

Commuting accidents were the second leading type of fatal injury (13%). This percentage is larger than the 6.4% found by Errico et al. [22], but smaller than the average of 26.5% from 2018 to 2022 reported by INAIL in Lombardy [18]. This may be because different institutions may have different procedures and standards for determining if there is an autopsy to order for a commuting accident. Commuting accidents are the most represented in the tertiary sector (41.7% of the events). Workers in the tertiary sector, often involved in administrative and service-oriented roles, may frequently commute for work-related purposes, exposing them to increased vulnerability on the roads especially if they work long hours [35]. More studies are needed to understand the specific reasons behind these accidents and formulate effective preventive measures.

The most common injury was polytrauma with 112 (36.4%) events, followed by 59 (19.2%) injuries on the head. Fatal head traumas are a common finding in work-related accidents literature, in a 10-year study in Genoa they accounted for 63.4% of the events [22], and 33.56% of the events in a study in the Brescia province [21]. An injury on the head, a site with the most vulnerability, can lead to death, especially in falls from above accidents [36]. More studies are needed to understand the efficacy of implementing targeted preventive measures to avoid head injuries.

Concerning alcohol consumption and history of drug abuse, we didn't find any differences among fatal accident types. There is some evidence that alcohol and drug consumption impact the occurrence of fatal accidents, especially commuting ones, but the literature is not unanimous on this matter [37]. A study by Blandino et al. reports that over 40% of workers who died due to commuting accidents were positive for ethanol [38]. In the study by Al-Abdallat, 9.1% of the workers who died on the job tested positive for alcohol [14]. A study on car accidents in West Virginia by Rudisill et al. found that the chance of dying with a positive alcohol test was 85% less likely in those who were commuting from and to work compared to individuals who were driving for other reasons [39]. This lack of difference among types of fatal accidents and alcohol consumption in our data can be because toxicology reports aren't ordered for all the fatal accidents during work. They must be done as soon as possible after the death of the worker, and in some cases, they cannot be performed (i.e. a death that occurred after days of hospitalization). A limitation of our study consists in the impossibility of going into detail on this kind of information as a family member of the deceased reports them during the interview before the autopsy act. Some organizations have already implemented preventive strategies, such as a ban on alcohol consumption at work or alcohol and drug testing [40]. More studies are needed to investigate the impact of alcohol and drug intake on the workplace in terms of types of fatal accidents to implement specific preventive strategies.

We didn't find any statistically significant difference between individual characteristics (age, nationality, BMI, pathological history) and the type of fatal accident. The impact of individual characteristics should be investigated further as age <30 years old and higher BMI were described as a risk factor for occupational accidents in research by Chau et al. and Darus et al. [34, 41].

5. Conclusion

In conclusion, our investigation into work-related fatal accidents in the provinces of Milan and Monza Brianza over 23 years sheds light on some critical aspects of Occupational Health and safety. This study underlines that, despite an overall decrease in

accidents, the secondary sector is the occupational area with the highest number of fatal accidents, especially for specialized construction workers. These preventable deaths underscore the need for rigorous analysis and interventions. Our understanding of what causes fatal occupational accidents can be improved using forensic autopsy case data, including epidemiological information on individual cases. Collaboration between different institutions should be encouraged to improve the knowledge of these topics. By understanding the patterns, trends, and causes of work-related fatalities, policymakers, employers, and safety professionals can establish targeted preventive policies and legislation to decrease risks and preserve workers' lives. Further research should aim to reduce the human toll, which has also significant economic implications, and improve collaboration between different institutions.

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Malignant Mesothelioma Patterns in Emilia-Romagna: A Retrospective Asbestos Exposure Assessment (1996-2023)

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ABSTRACT

Background: *Malignant mesothelioma (MM) is a rare but lethal cancer strongly associated with asbestos exposure. This retrospective study examines mesothelioma trends and past asbestos exposure assessment in Emilia-Romagna, Northern Italy.* **Methods:** *Between 1996 and 2023, 3,513 cases of MM were recorded by the Regional Operating Center, predominantly in males (72%) and older than 65 years (79%). MM diagnosis was defined as certain, probable, and possible. Information concerning asbestos exposure was collected through an analytical questionnaire administered to patients or proxies and classified as occupational and non-occupational.* **Results:** *Occupational exposure accounted for 82% of cases, significantly increasing from 71% to 88% in the most recent period. A more accurate definition of occupational exposure indicates that specific exposure has gone from 49% in the first period to 62% and 58% in the last two periods; probable exposure decreased from 21% to 16%, while possible exposure decreased from 16% to 13%. Familiar exposure remained relatively constant at around 8%, environmental exposure slightly decreased from 4% to 2%, while non-occupational exposure remained stable at 2%. Among patients with exclusively occupational exposure (1,826 cases), 87% were male and aged between 65 and 75 years (36%) and 75+ (41%). Exposure rates for the province of residence see the province of Reggio Emilia with the highest occupational exposure rate (2.5 x 100,000 residents), followed by Ravenna (2.3 x 100,000 residents) and Parma and Piacenza, which have similar exposure rates with 2.2 x 100,000 residents. Occupational sectors such as construction, railway maintenance, and metalworking are identified as high-risk industries. Despite efforts to mitigate exposure, non-occupational and environmental exposures persist. The study highlights the importance of continuous surveillance and exposure monitoring to guide effective interventions and legal recognition of MM.*

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1. Introduction

Malignant mesothelioma (MM) represents a rare tumor, nevertheless significant in terms of public health, primarily due to its well-documented association with asbestos exposure in both occupational and environmental settings [1, 2]. This association has led to a concerning escalation in MM incidence rates across Italy and numerous other industrialized countries [3-8]. In our country, asbestos was definitively banned in April 1994 (Law 257/92); nevertheless, the long latency between exposure and onset of the disease, the extension of life, and the improvement of diagnostic techniques have recorded an increase in the incidence of MM in recent years, currently still ongoing, even if the incidence trends of population, according to the latest reports, do not seem to grow further [9-12].MM is a disease that mainly affects the pleura (80-90%) and peritoneum (10-15%) [13-15], although, in recent years, there has been growing interest in the forms that affect the pericardium and testicle [16, 17]. The main histological subtype of mesothelioma is represented by the epithelioid form, which has a better prognosis than biphasic and sarcomatoid tumors. The surgical approach involves a complete macroscopic resection in combination with chemotherapy or radiotherapy. In cases deemed unresectable, the therapeutic approach involves chemotherapy with the regimen of cisplatin plus pemetrexed [18]. The prognosis is poor, with a median survival between 10 and 13 months [19, 20].

Most cases of mesothelioma are attributed to occupational or environmental exposure to asbestos. The association of mesothelioma and exposure to asbestos fibers had been well documented by Wagner for the first time in 1960 [21]. The risk of mesothelioma onset after exposure to asbestos increases continuously with the time elapsed since exposure. It appears to peak approximately 45 years after exposure for pleural mesothelioma, while for peritoneal mesothelioma, it continues to increase even after exposure period [22]. In general, the incidence of mesothelioma has decreased over the years in the United States in conjunction with the decrease in occupational exposure to asbestos and has remained stable since 2003 [23]. There is approximately 20% of mesothelioma cases in which significant asbestos exposure is not documented, including radiations [24], mineral fibers other than asbestos [25], viruses [26], and genetic factors are other putative causes [27].

The onset of mesothelioma typically occurs in older patients: the average age at presentation is 74 years for pleural mesothelioma and 68 years for peritoneal mesothelioma [28]. For cases that arise at a younger age, considering the long latency period [29], one could hypothesize a genetic predisposition or environmental exposure to carcinogenic mineral fibers rather than asbestos exposure alone. MM shows a dose-responsive asbestos exposure in reaction to cumulative asbestos exposure [30, 31]; however, MM can also arise following modest and time-limited exposures [32], as well as among family members responsible for washing work clothes contaminated by asbestos [2, 33]. Furthermore, cases of MM resulting from environmental asbestos exposure have been well documented among residents living near industrial sites [34–36], underscoring the presence and pervasive use of asbestos. In the Emilia-Romagna Region, an MM registration activity started in 1996 to monitor the incidence of mesothelioma and evaluate exposure to asbestos with the possibility of creating a network of professionals sensitized on the topic. The National Mesothelioma Registry (ReNaM) was established by Prime Ministerial Decree 308/02; the regional registry was identified as leveraging a network of Regional Operations Centers (CORs).

The Emilia-Romagna COR collects all cases of mesothelioma of the pleura, pericardium, peritoneum, and tunica vaginalis testis from patients residing in the Emilia-Romagna Region at the time of diagnosis. Data collection was initiated in 1996, following the guidelines of the National Registry [36]. This study aims to describe, based on the malignant mesotheliomas registered in Emilia-Romagna, northern Italy (January 1996-June 2023), the mesothelioma trend and asbestos exposure concerning the type of exposure and residence of the exposed individuals.

2. Methods

The study includes all malignant mesotheliomas of the pleura, peritoneum, pericardium, and

tunica vaginalis of the testicle occurring in the resident population of Emilia-Romagna from 1 January 1996 to 30 June 2023. For each registered case, detailed anatomical-pathological reports and the medical records from relevant hospitalizations conducted at public and private healthcare facilities, within or outside the region, are acquired and reviewed by COR staff. The diagnostic classification of each case is determined according to the guidelines established by the National Registry [36] (Table S1-A) and includes only MM defined as certain, probable, and possible. Information concerning asbestos exposure, both occupational and non-occupational, is collected through an analytical questionnaire administered to patients or their closest family members by the sanitary personnel of the Public Health Departments, constituting the regional survey network. A panel of experts subsequently evaluates the questionnaire responses, and exposure classification is conducted again according to the national guidelines [36] (Table S1-B). This study includes exposures classified as categories 1-7 only.

Descriptive analyses of patient characteristics by sex, age of diagnosis, tumor site, and the province of residence were reported. The standardized incidence rate for the provinces was calculated. Population estimates, used to derive rates, are represented by the general population of the Emilia Romagna region registered on 1 January of each year. Incidence rates were adjusted to the 2013 European standard population and calculated per 100,000 person-years. Exposure levels were categorized by distinct periods (1996-2000, 2001-2005, 2006-2020, 2011-2015 and 2016-2019). 2020-2023 was excluded from the analysis due to ongoing data collection activities. Analyses were performed using STATA 16.1 software.

3. Results

Between 1 January 1996 and 30 June 2023, 3,513 cases of MM were registered (Table 1).

Predominantly, 72% of cases were diagnosed in males, with 79% occurring in individuals aged 65 and older, representing a median age of 72.5 years, and 22% are residents in Bologna.

Table 1. Emilia-Romagna Mesothelioma Registry 1996-2023. Cases by sex, age, province, and site.

	n	%
Overall	**3,513**	
Sex		
Female	977	27.8
Male	2,536	72.2
Age group		
0-44	50	1.4
45-54	159	4.5
55-64	526	15.0
65-74	1,111	31.6
75+	1,667	47.5
Province		
Bologna	774	22.0
Forlì-Cesena	250	7.1
Ferrara	342	9.7
Modena	391	11.1
Piacenza	298	8.5
Parma	408	11.6
Ravenna	364	10.4
Reggio Emilia	528	15.0
Rimini	158	4.5
Site		
Pleura	3,225	91.8
Peritoneum	256	7.3
Pericardium	10	0.3
Testicular	22	0.6
	mean	**sd**
Age at diagnosis	72.5	10.7

Concerning site distribution, 3,225 cases (91.8%) involved the pleura, while 256 cases (7.3%) affected the peritoneum. Smaller proportions were registered for pericardial (10 cases, 0.3%) and testicular (22 cases, 0.6%) mesotheliomas.

A detailed investigation through 2,226 questionnaires administered from 1996 to 2019 revealed evolving trends in asbestos exposure (Table 2). Occupational exposure was predominant across all periods, increasing from 70.7% in the initial period (1996-2000) to 87.9% in the most recent

Table 2. Emilia-Romagna Mesothelioma Registry. Years 1996-2019. Definition of the 2,226 questionnaires by year and type of exposure.

	Occupational exposure		Non-occupational exposure		Unexposed		
	N	%	N	%	N	%	Total
1996-2000	210	70.7	34	11.4	53	17.8	297
2001-2005	329	79.5	44	10.6	41	9.9	414
2006-2010	367	78.4	56	12.0	45	9.6	468
2011-2015	505	87.8	62	10.8	8	1.4	575
2016-2019	415	87.9	55	11.7	2	0.4	472

Table 3. Emilia-Romagna Mesothelioma Registry. Years 1996-2019. Definition of the 2,077 questionnaires (only exposed to asbestos) by year and subtypes of exposure.

	1		2		3		4		5		6		Total
	n	%	n	%	n	%	n	%	n	%	n	%	
1996-2000	120	49.2	52	21.3	38	15.6	21	8.6	9	3.7	4	1.6	**244**
2001-2005	224	60.1	52	13.9	53	14.2	27	7.2	12	3.2	5	1.3	**373**
2006-2010	267	63.1	58	13.7	42	9.9	36	8.5	9	2.1	11	2.6	**423**
2011-2015	353	62.3	89	15.7	63	11.1	41	7.2	16	2.8	5	0.9	**567**
2016-2019	275	58.5	77	16.4	63	13.4	36	7.7	9	1.9	10	2.1	**470**

1 occupational certain; 2 occupational probable; 3 occupational possible; 4 familial; 5 environmental; 6 non-occupational.

period (2016-2019). This upward trajectory persisted despite the progressive increase in questionnaires administered over time (Table 2). Conversely, non-occupational exposure exhibited a consistent pattern of stability throughout the study period, around 11%. Finally, cases with sufficient documentation but without a defined exposure to asbestos decreased substantially from 17.8% during the initial period to only 0.4% in the final period.

Excluding the 149 not exposed, Table 3 shows the trend over time based on an analysis focusing solely on exposed individuals divided by exposure levels. *Specific occupational exposure* has demonstrated an upward trend, increasing from 49.2% in the first period to 62.3% and 58.5% in the last two periods. Conversely, *probable occupational exposure* decreased from 21.3% to 16.4%, while possible *exposure* decreased from 15.6% to 13.4%. *Family exposure* remained relatively constant at around 8%. *Environmental exposure* decreased slightly from 3.7% to 1.9%, whereas *non-occupational exposure* remained stable at approximately 2%.

Among patients with only occupational exposure (1,826 cases) (Table 4), a substantial majority were male (87.4%) and belonged to older age groups, specifically 35.6% aged 65-74 years and 41.1% aged 75 or older.

When examining the province of residence among patients with occupational exposure, we observed that 21.9% resided in Bologna, 16.7% in Reggio Emilia, and 11.7% in both provinces of Parma and Ravenna. However, when assessing exposure rates for the province of residence, Reggio Emilia emerged with the highest rate of occupational exposure (2.5 x 100,000 residents), followed closely by Ravenna (2.3 x 100,000 residents) and Parma and Piacenza, which exhibit similar exposure rates at 2.2 x 100,000 residents. Considering the differences between sexes, the provinces with the greatest male exposure are confirmed as Reggio Emilia, Ravenna,

Table 4. Emilia-Romagna Mesothelioma Registry. Years 1996-2019. Definition of the 1826 questionnaires (only occupational exposures to asbestos) by sex, age, province of residence, and tumor site.

	Total			Males			Females		
	n	%	TSD	n	%	TSD	n	%	TSD
Overall	1,826								
Sex									
Females	230	12.6							
Males	1,596	87.4							
Age group									
0-44	24	1.3		23	1.4		1	0.4	
45-54	93	5.1		72	4.5		21	9.1	
55-64	309	16.9		276	17.3		33	14.4	
65-74	650	35.6		563	35.3		87	37.8	
75+	750	41.1		662	41.5		88	38.3	
Province									
Bologna	400	21.9	1.7	353	22.1	2.5	47	20.5	0.3
Forlì-Cesena	124	6.8	1.4	115	7.2	2.2	9	3.9	0.1
Ferrara	177	9.7	2.0	162	10.1	2.8	15	6.5	0.2
Modena	165	9.0	1.0	145	9.1	1.6	20	8.7	0.2
Piacenza	148	8.1	2.2	127	8.0	3.0	21	9.1	0.3
Parma	214	11.7	2.2	174	10.9	2.9	40	17.4	0.6
Ravenna	213	11.7	2.3	201	12.6	3.3	12	5.2	0.2
Reggio Emilia	307	16.8	2.5	247	15.5	3.7	60	26.1	0.7
Rimini	78	4.3	1.1	72	4.5	1.8	6	2.6	0.1
Site									
Pleura	1711	93.7		1,504	94.2		207	90.0	
Peritoneum	101	5.5		78	4.9		23	10.0	
Pericardium	4	0.2		4	0.3		0	0.0	
Testicular	10	0.6		10	0.6		0	0.0	

and Piacenza. The provinces with the highest exposure for females are Reggio Emilia and Parma, followed by Piacenza and Bologna.

4. Discussion

This study aimed to describe the trends of malignant mesothelioma and asbestos exposure in northern Italy. The work included 3,513 cases of malignant mesothelioma occurring in Emilia-Romagna from January 1996 to 30 June, 2023. The analysis of 2,226 questionnaires from 1996-2019 documented occupational exposure in 82% of cases, non-occupational exposure in 11%, and 7% of cases were declared unexposed.

These findings highlight the persistent public health challenges associated with asbestos exposure, prompting a series of considerations.

First, the increase in occupational exposure, particularly within specific sectors like construction and metalworking, underscores the persistent risk despite regulatory measures. Our analysis revealed an increasing trend in occupational exposure over time, rising from 71% in the first period to 88% in the

last period. Conversely, non-occupational exposure remained stable, with a decline in the proportion of unexposed subjects, dropping from 18% to 0.4% in the most recent period. However, it is crucial to note that this escalation in exposed cases may be attributed more to improved exposure definition than an actual increase in occupationally exposed incidents. This interpretation is supported by the diminishing number of unexposed subjects over time, from 53 cases in the first period to merely 2 cases in the last period. Additionally, the most significant increase was observed in the category of *specific occupational exposure*, reflecting a rate of 10% over time. This category requires robust documentation to validate exposure, including morphological certainty, immunohistochemical confirmation, and a compatible clinical picture.

The second consideration delves into gender disparities observed in asbestos-related MM, where a clear predominance of cases in males emerged, consistent with global trends [37]. Nonetheless, the lower proportion of female cases in occupations historically linked to asbestos exposure quite clearly explains the difference in the exposure rates. When focusing solely on occupational exposure, our findings confirmed a predominance of male individuals, typically older, and predominantly manifesting pleural mesothelioma.

The geographic distribution of exposed individuals is noteworthy, with the majority residing in the province of Reggio Emilia. This province harbored the highest concentration of asbestos-cement-producing industries across the region, a significant factor in explaining the elevated exposure rates. Furthermore, a substantial portion of these industries' labor force comprises females.

An additional concern deals with the specific asbestos-related industries and occupations associated with an increased risk of malignant mesothelioma, already described in the literature [11,38]. In Emilia-Romagna, specific industries, such as building construction (uniformly distributed throughout the Region), railway rolling stock construction/repair (predominantly in Bologna and Reggio Emilia provinces), metalworking, sugar factories/other food industries, and asbestos-cement product manufacturing (with nearly 80% based in Reggio Emilia province), as well as in the petrochemical hubs located in the provinces of Ravenna and Ferrara were prominently associated with mesothelioma onset.

According to WHO, about 125 million individuals worldwide are highly exposed to asbestos at work, resulting in over 255,000 deaths annually from asbestos-related diseases [39]. Considering E.U. statistics on occupational diseases collected by Eurostat, 78% of recognized cases of occupational cancer in the E.U. are linked to asbestos [40], and 85% affect males [41].

In Italy, asbestos was extensively used from 1945 to 1992. For instance, in Lombardy during the period from 2000 to 2012, 4,442 cases of MM were recorded with occupational asbestos exposure more prevalent in men (73.6%) than in women (38.2%) [42], figures comparable to those reported in our study (76% and 14%, respectively). Despite the ban on asbestos in 1992, its exposure among construction workers in Italy remains a significant concern. Among over 31,000 cases of MM reported between 1993 and 2018, asbestos exposure was documented in 78.2% of cases, with occupational exposure noted in 69.1% of subjects. In the construction sector, there has been a concerning trend of increasing exposure from 15.8% in 1993-1998 to 23.9% in 2014-2018 [43].

Our study indicates 11% non-occupational exposure, with literature reporting an excess risk for familial (HR 5.4; 95% CI 2.6-11.2) and environmental (HR 6.9; 95% CI 4.2-11.4) exposures, with no significant variation concerning the type of fiber (chrysotile, mixed and amphibolic) [44]. Although environmental exposure appears to be slightly decreasing, it remains a risk for the general population through contact with commercial products containing asbestos (e.g., housing materials) [34]. Notably, data on environmental exposures typically exhibit a male-female ratio of 1, albeit less robust compared to occupational exposures [45]. Presently, approximately 8,200 asbestos-related cancer deaths occur annually, with projections suggesting a rise to approximately 9,700 cancer deaths per year by 2000. [46]. Globally, the burden of mesothelioma continues to increase, with an estimated 34,511 incident cases and 29,251 deaths recorded in 2019. Also, while the burden rate decreased among individuals

under 70, it increased within the population over 80, especially in regions with a high socio-demographic index [47]. Projections based on SEER data for 2008 estimate approximately 2,400 mesothelioma cases, with asbestos identified as the probable cause in 58% of instances. Encouragingly, these data predict that asbestos will no longer be a significant factor in mesothelioma cases after 2042. However, for the period spanning from 2008 to 2042, estimates suggest over 68,000 cases of mesothelioma, with asbestos implicated as the probable cause in 34% of cases [48]. These projections emphasize the enduring impact of past asbestos exposure and the imperative for sustained efforts in prevention, early detection, and comprehensive management strategies to mitigate the future burden of asbestos-related diseases.

Among the strong points of this work, it is highlighted that these are cases with a high percentage of microscopic confirmations (95%), which reflects the attitude of the registry to build a real detection network at the regional level which includes pathologists, pulmonologists, thoracic surgeons, gynecologists and internal medicine doctors, as well as occupational doctors. Such collaboration contributes to the high percentage of extra-pleural tumors observed, surpassing the Italian average, and facilitates the thorough collection of detailed questionnaires. Furthermore, our effort to directly gather patient information, rather than relying on family members, ensures the accuracy and reliability of documentation regarding previous exposures. Given the high mortality rate associated with MM, this approach requires considerable organizational efforts to conduct patient interviews, often managed at home or in hospital settings. This meticulous process underscores the importance of comprehensive data collection in informing effective prevention and management strategies for MM.

The study faces several significant limitations. Its retrospective design introduces biases that may skew findings. Accurately assessing asbestos exposure proves challenging; relying on occupational histories or geographic data may overlook environmental or distant exposures. Mesothelioma's long latency requires prolonged follow-up to detect cases reliably. Small sample sizes outside specific occupational groups limit generalizability. Addressing these challenges demands meticulous study design, rigorous data collection, and interdisciplinary collaboration to provide accurate evidence for informing public health policies and preventive measures.

5. Conclusion

Our study highlights ongoing concerns regarding asbestos exposure in northern Italy, revealing persistent occupational risks, gender disparities, and a global rise in asbestos-related diseases. Moving forward, continued research and comprehensive data collection are crucial for informing effective prevention strategies and improving outcomes for individuals affected by MM and other asbestos-related conditions. Furthermore, such efforts could facilitate improved diagnostic and therapeutic approaches for the patient, rationalize the eligibility for the public insurance entity's privileged protection against work-related injury, and reduce legal disputes over the identification of disease-related effects.

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Supplementary material

Table S1. Diagnostic definition of the level of certainty of malignant mesothelioma (A) and exposure to asbestos (B) according to the guidelines of the National Mesothelioma Registry (ReNaM).

A. Definition of the level of certainty of malignant mesothelioma	
MM certain	Histology presents with characteristic morphological picture, characteristic/suggestive/absent immunohistochemistry + diagnostic confirmation by imaging/clinical discharge diagnosis
MM probable	Histology presents with doubtful morphological picture or cytology with characteristic picture + diagnostic confirmation by imaging/clinical discharge diagnosis
MM possible	Absent histology/cytology, indicative clinical and radiological data + hospital discharge diagnosis of MM
MM to define	"Temporary container" for cases that do not fall into any of the previous levels
Non mesothelioma	Cases deceased for at least two months who do not meet the requirements to be included in the first three levels
B. Definition of the level of exposure to asbestos	
1	reliable professional
2	probable professional
3	professional as possible
4	familiar
5	environmental
6	extra-professional (no 4 and 5)
7	unlikely (not exposed)
8	unknown (no one knows)
9	to be defined (questionnaire to be completed)
10	not classifiable (no interview due to refusal or otherwise)

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Levels of Nursing Students' Exposure to Colleague Violence and Affecting Factors: A Multicenter Cross-Sectional Study

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Keywords: Colleague Violence; Nursing; Nursing Education; Students

ABSTRACT

Background: *Colleague violence experiences of students negatively affect their vocational education in the short term and their desire to stay in the profession in the long term. This study aims to determine the levels of colleague violence experienced by nursing students and the affecting factors in Türkiye.* **Methods:** *This study was conducted with second-, third-, and fourth-year nursing students (N = 703) from three state universities in three different provinces in Turkey. The data were collected using the "Student Information Form" and "The Scale of Exposure to Colleague Violence" with an online questionnaire. Descriptive statistics, the Independent Samples t-test, and the ANOVA test were employed for data analysis.* **Results:** *Students' total mean score on the scale was 46.72 ± 21.30. The "exposure to verbal/psychological violence" and "effect of violence on physical and mental health" subscales were 21.62 ± 10.09 and 25.10 ± 12.02, respectively. The most common reaction to the violence they were exposed to was "remain silent" (34.7%).* **Conclusions:** *Nursing students were exposed to moderate levels of verbal/psychological colleague violence, and students' physical and mental health were moderately affected by this violence. Most students remained silent as a response to colleague violence. This study contributed to the emergence of factors that affect and are related to colleagues' violence. The results highlighted the need for programs that educate people about colleague violence and what should be done.*

1. Introduction

Violence is defined as "the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either result in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation" [1]. The phenomenon of violence, which continues to exist increasingly today, negatively affects millions of people physically and mentally [2].

Workplace violence (WPV) is defined as "incidents where staff is abused, threatened, or assaulted in the circumstances related to their work, including commuting to and from work, involving an explicit or implicit challenge to their safety, well-being, or health" [3]. Working in areas where security measures are low and crime rates are high and working with people with a history of violence and drug and alcohol addiction are stated as risk factors for workplace violence [4]. WPV in the health field is more than in other workplaces. Aggression and

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violence against healthcare professionals is a global problem [5, 6]. Violence in health institutions is defined as "verbal or behavioral threat, physical assault or sexual assault from the patient, patient relatives or another individual that poses a risk to the health worker" [5]. WPV can be classified as physical violence, verbal violence, psychological violence, and sexual harassment. Physical violence and sexual harassment have reportedly been less common than verbal and psychological abuse [7, 8].

WPV can be classified as vertical and horizontal violence according to its structure. Vertical violence involves both healthcare workers and patients, while horizontal violence occurs only between healthcare workers or patients themselves [4]. Horizontal violence is called co-worker or peer violence and is quite common in the healthcare industry [9]. Horizontal violence includes disrespectful and humiliating behavior that damages a person's reputation and value through negative behavior such as intimidation, belittlement, bullying, and hostility, usually carried out by peers or colleagues and often by people who have relative power over the victim [9,10] Horizontal violence is nurse-to-nurse common in clinical practice [11].

Colleague violence among nurses is an act of aggression perpetrated by a colleague against another colleague. While colleague violence is usually verbal or emotional abuse, it can also include physical abuse [12]. Colleague violence in nursing usually manifests itself in situations such as constantly criticizing, engaging in insulting interpretations, humiliating, applying pressure, speaking loudly and shouting, making groundless accusations, ignoring, acting in a sarcastic and ridiculous style, making a scapegoat, and overburdening [13, 14]. WPV is a major threat to nurses' physical and mental health [7]. Furthermore, workplace violence can cause nurses to leave their profession, decrease nurse manpower, and disruption in the delivery of care [15].

Nursing students are more likely to encounter colleague violence in healthcare settings due to inexperience [16–18]. Nursing students participate in clinical placements to undertake nursing care under the guidance and support of experienced nurses [19]. Nurses need to have a supportive attitude towards nursing students during clinical placement. Because it will enable students to feel safe in the healthcare team and provide professional satisfaction by having a positive clinical practice experience [9]. Nursing students experience problems such as anxiety, psychological distress, lack of self-confidence, and loss of self-esteem due to colleague violence they are exposed to during their clinical practice [18, 20]. Colleague violence negatively affects nursing students' learning desires, professional perceptions, professional development, professional commitment, quality of clinical training, and interpersonal communication with team members, patients, and their relatives [13, 21].

In the systematic review and meta-analysis study conducted by Mohammed et al., 55.1% of nursing students were exposed to workplace violence, and 24.2% of these were committed by nurses [22]. The issue of colleague violence needs to be addressed as it is on the rise [8]. Colleague violence experiences of students negatively affect their vocational education in the short term and their desire to stay in the profession in the long term [23]. Determining the exposure of nursing students to colleague violence and its effects will contribute to the determination of necessary strategies for the prevention of violence and its effects in both clinical and academic fields. This study aims to determine the levels of colleague violence experience of nursing students in clinical practice and the factors affecting colleague violence in Türkiye.

2. METHODS

2.1. Design

To meet the study's aims, a descriptive and cross-sectional study was designed using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.

2.2. Participants and Sample

The study population was nursing students enrolled in nursing departments of three different state universities in three different provinces in Türkiye. Nursing students at the universities included in the research: first-year nursing fundamentals; internal

diseases nursing, surgical diseases nursing in the second year (2nd); women's health and obstetrics nursing, pediatrics nursing in the third year (3rd); in the fourth year (4th), they receive education and training in the form of theoretical education and clinical practice for mental health nursing, community health nursing, nursing management, and nursing education courses. The inclusion criteria were undergraduate students in nursing programs at the selected universities, enrolled in the 2nd, 3rd, and 4th years, with internet access, and willing to participate. Since first-year students did not have sufficient clinical experience, they were not included in the sample due to their inability to be with their colleagues. First-year students were excluded from the study.

The study's sample size was calculated with the G*Power 3.1.9.7 software program. It was determined as 210 students based on 95% power, medium effect size (d=0.50), and 0.05 significance level using the Independent Samples t-test on this software. Considering a 20% loss in the study, the sample size was planned to consist of 252 students. 737 nursing students participated in the study. 34 of 737 students were excluded because they were first-year students. As a result of the post hoc power analysis performed considering the sample size of 703 students, based on the Independent Samples t-test used in this study, the power of the study was calculated as 0.99% with an effect size of 0.47 (a medium effect) and a margin of error of 0.05 [24, 25].

2.3. Instrument

The "Student Information Form" and the "The Scale of Exposure to Colleague Violence (SECV)" were used to collect the study's data.

The Student Information Form: As a result of the literature review by the researchers, 14 items consist of expressions such as the student's age, gender, alcohol and cigarette use, psychiatric diagnosis, income perception, family type, choice of department voluntarily, academic success status, reactions to colleague violence, and of committing violence against others [11, 21, 26].

The Scale of Exposure to Colleague Violence (SECV) was developed by Bahadır-Yılmaz et al. (2020), to determine the severity of colleague violence experiences of nursing students in clinical practice and the effect of colleague violence on them. The scale consists of 22 items with five-point Likert-type questions, and Each item has scores on a Likert scale ranging from "1=Strongly Disagree," "2=Disagree," "3=Moderately Agree," "4=Agree," and "5=Completely Agree."The scale has two subscales defined as "The exposure to verbal/psychological violence" ve "The effect of violence on physical and mental health". The minimum and maximum scores that can be obtained from the total of the scale are between 22 and 110. The "Exposure to verbal/psychological violence" sub-dimension has a minimum and maximum of 11-55 points, and the "Effect of violence on physical and mental health" sub-dimension is between 11-55 points. The higher scores obtained from the scale indicate a higher level of exposure to violence and the higher negative effects of violence on physical and mental health. The items in the scale "The Scale of Exposure to Colleague Violence (SECV)" are given in Table 3. Cronbach's alpha value for the scale was 0.94, and they were found to be 0.93 for "The exposure to verbal/psychological violence" and 0.89 for "The effect of violence on physical and mental health" [20]. In this study, the Cronbach alpha value was found to be 0.93 for the total scale, 0.90 for the "exposure to verbal/psychological violence" subscale, and 0.89 for the "effect of violence on physical and mental health" subscale.

2.4. Data Collection

In 2022, the study was carried out in two academic periods between April and November. Considering the students' clinical experience and exposure to their colleagues, the sample was collected during the academic year. Participating students completed data collection forms through a secure online survey platform. The online survey link of the study was delivered to the nursing students through the faculty members working in the nursing departments of the universities and the nursing student representatives in these universities. The goal of the study, the fact that participation in the study is optional, and the fact that they can leave at any moment were

all explained to the students in an explanation paragraph before they were led to the online data collection forms. After reading the informative material, the students who accepted to participate in the study were given access to the online questionnaires. Personal information like the names and numbers of the students was excluded from the data collection forms to protect the participants' confidentiality. The nursing students answered the research questions without any time limitations.

2.5. Ethical Considerations

The relevant Social and Humanities Ethics Committee also approved (07.04.2022, Number of meeting: 05, Decision no: 06). The study followed the Helsinki Declaration.

2.6. Analysis of Data

SPSS 22.0 was used to analyze the data. The data were assessed using descriptive statistics. Skewness (.766) and kurtosis (-.246) values were used to determine whether the data were normally distributed. Data found homogenous by Tabachnick and Fidell (2013) values between +1.5 and -1.5 [27]. Since the data were normally distributed, parametric tests were used. The independent variables were descriptive characteristics of students. The dependent variable is the SECV mean scores. The "Independent Samples t-test" was used to compare the means of two separate groups, while the "ANOVA test" was used to compare three or more independent group samples. For post hoc analysis, Tukey's and Scheffe's tests were applied. For all analyses, the level of statistical significance was specified at $p < .05$ (two-tailed).

3. RESULTS

This study was completed with 703 nursing students. The mean age of the students was 21.5 ± 1.87, and 68.1% were female. The majority of the students did not smoke, drink alcohol, or have any psychiatric diagnosis. 51.8% of the students had a medium income level, and 71% had a nuclear family structure. 67% of the students perceived their academic achievement at a moderate level, 58.6% chose nursing voluntarily, and 46.5% were satisfied with being in the nursing department (Table 1).

The mean scores of the total and subscales of the 4th-grade students, the students who had a psychiatric diagnosis, perceived their academic success as bad, were not satisfied with the department, were exposed to violence other than colleague violence, and inflicted violence on others were statistically significantly higher ($p < .05$). The mean score of the "exposure to verbal/psychological violence" subscale of the students who use alcohol was statistically significantly higher. The "effect of violence on physical and mental health" subscale mean scores of students who willingly chose the department were lower ($p < .05$). Of the students, 48.9% were not exposed to any violence, and 85.9% did not inflict violence on others (Table 1).

The three most common reactions to colleague violence were "remain silent" (34.7%), "ignore" (33.6%), and "share with friends and family members" (29.1%) (Figure 1).

The total mean score of SECV of students was 46.72 ± 21.30. The mean score of the "exposure to verbal/psychological violence" subscale was 21.62 ± 10.09, and the mean score of the "effect of violence on physical and mental health" subscale was 25.10 ± 12.02 (Table 2).

Table 3 displays the mean scores of the SECV items. The statement "I am afraid of not meeting their expectations" was in the highest position with an average of 2.53 ± 1.37. The statement with the lowest mean is "They frighten us with threats." with 1.61 ± 0.98 (Table 3).

4. DISCUSSION

Nursing students are mostly exposed to violence and encounter rude behavior in clinical practices [28, 29]. Studies show that nursing students frequently experience colleague violence [3, 14, 21, 30]. In a study conducted with Turkish nursing students, students were exposed to moderate levels of colleague violence in clinical practice [20]. In a study of Australian nursing students, half of the students had been bullied and harassed in the previous 12 months, and nurses were among those who were bullied and

Table 1. Students' characteristics and the relationship between characteristics and SECV scores (n = 703).

Characteristics	N	%	Exposure to verbal/ psychological violence Mean ± SD	Effect on physical and mental health Mean ± SD	Total Mean ± SD
Study year					
2nd year[a]	283	40.3	20.05 ± 8.83	23.36 ± 10.98	43.41 ± 18.97
3rd year[b]	294	41.8	22.01 ± 10.51	25.54 ± 12.25	47.55 ± 21.91
4th year[c]	126	17.9	24.25 ± 11.13	27.97 ± 25.10	52.23 ± 23.54
Test[**]; *p*			*t*= 8.079; **< 0.001 (a,c)**	*t*= 6.865; **0.001 (a,c)**	F= 7.996; **< 0.001 (a,c)**
Gender					
Female	479	68.1	21.74 ± 10.18	25.67 ± 12.26	47.41 ± 21.55
Male	224	31.9	21.36 ± 9.91	23.88 ± 11.42	45.25 ± 20.73
Test; *p*			*t*= .472; 0.637	*t*= 1.833; 0.067	*t*= 1.257; 0.209
Alcohol					
Yes	84	11.9	23.90 ± 11.15	26.61 ± 12.44	50.52 ± 22.93
No	619	88.1	21.31 ± 9.91	24.89 ± 11.96	46.21 ± 21.04
Test; *p*			*t*= 2.213**; 0.027**	*t*= 1.232; 0.218	*t*= 1.743; 0.082
Smoking					
Yes	134	19.1	22.96 ± 11.37	26.44 ± 12.75	49.41 ± 23.32
No	569	80.9	21.30 ± 9.75	24.78 ± 11.83	46.09 ± 20.77
Test; *p*			*t*= 1.708; 0.088	*t*= 1.440; 0.150	*t*= 1.623; 0.105
Psychiatric diagnosis					
Yes	20	2.8	27.05 ± 12.57	31.70 ± 13.87	58.75 ± 25.61
No	683	97.2	21.46 ± 9.97	24.90 ± 11.92	46.37 ± 21.08
Test; *p*			t= 2.447**; 0.015**	t= 2.498**; 0.013**	t= 2.571**; 0.010**
Income perception					
Low	293	41.7	21.92 ± 10.22	25.99 ± 12.29	47.92 ± 21.61
Average	364	51.8	21.62 ± 9.68	24.78 ± 11.65	46.40 ± 20.56
High	46	6.5	19.73 ± 12.26	21.89 ± 12.78	41.63 ± 24.52
Test; *p*			F= .932; 0.394	F=2.585; 0.076	F= 1.821; 0.163
Family type					
Nuclear family	499	71.0	21.12 ± 9.77	24.86 ± 11.95	45.99 ± 20.90
Extended family	184	26.2	22.57 ± 10.37	25.40 ± 11.97	47.97 ± 21.57
Broken family	20	2.8	25.25 ± 13.89	28.35 ± 14.33	53.60 ± 27.52
Test; *p*			F= 2.724; 0.066	F= .886; 0.413	F= 1.660; 0.191
Perceived academic success					
Good[a]	179	25.5	19.96 ± 9.05	22.96 ± 11.16	42.92 ± 19.53
Medium[b]	471	67.0	21.84 ± 9.89	25.44 ± 11.85	47.29 ± 20.91
Bad[c]	53	7.5	25.24 ± 13.62	29.28 ± 14.89	54.52 ± 27.46
Test; *p*			F= 6.043**; 0.003 (a,c)**	F= 6.326**; 0.002 (a,c)**	F= 6.682**; 0.001 (a,c)**

Table 1 continues

Table 1. Students' characteristics and the relationship between characteristics and SECV scores (n = 703). *(continued)*

Characteristics	N	%	Exposure to verbal/ psychological violence Mean ± SD	Effect on physical and mental health Mean ± SD	Total Mean ± SD
Choosing the department willingly					
Yes	412	58.6	21.41 ± 10.15	24.16 ± 11.69	45.58 ± 21.18
No	291	41.4	21.91 ± 10.02	26.43 ± 12.37	48.35 ± 21.40
Test; *p*			t= -.647; 0.518	t= -2.474**; 0.014**	t=-1.700; 0.089
Being satisfied with the department					
Yes[a]	327	46.5	19.79 ± 9.18	21.97 ± 10.85	41.76 ± 19.38
No[b]	116	16.5	24.97 ± 12.31	29.49 ± 13.05	54.46 ± 24.40
Not sure[c]	260	37.0	22.43 ± 9.62	27.08 ± 11.96	49.51 ± 20.67
Test; *p*			F= 13.017; < **0.001 (a-b)**	F= 23.762; < **0.001 (a-b,c)**	F= 19.731;< **0.001 (a-b,c)**
Exposure to violence other than colleague violence					
Yes	344	48.9	23.09 ± 10.78	27.25 ± 12.63	50.34 ± 22.42
No	359	51.1	20.21 ± 9.18	23.04 ± 11.04	43.25 ±19.58
Test; *p*			t= -3.820; < **0.001**	t= -4.710; < **0.001**	t= -4.472; < **0.001**
Violence against another					
Yes	99	14.1	25.34 ± 11.51	29.96 ± 12.49	55.31 ± 22.74
No	604	85.9	21.01 ± 9.71	24.30 ± 11.76	45.31 ± 20.74
Test; *p*			t= 3.997; < **0.001**	t= 4.401; < **0.001**	t= 4.382; < **0.001**

** SECV: The Scale of Exposure to Colleague Violence; **t: Independent Sample t-Test. F: One-way ANOVA.*

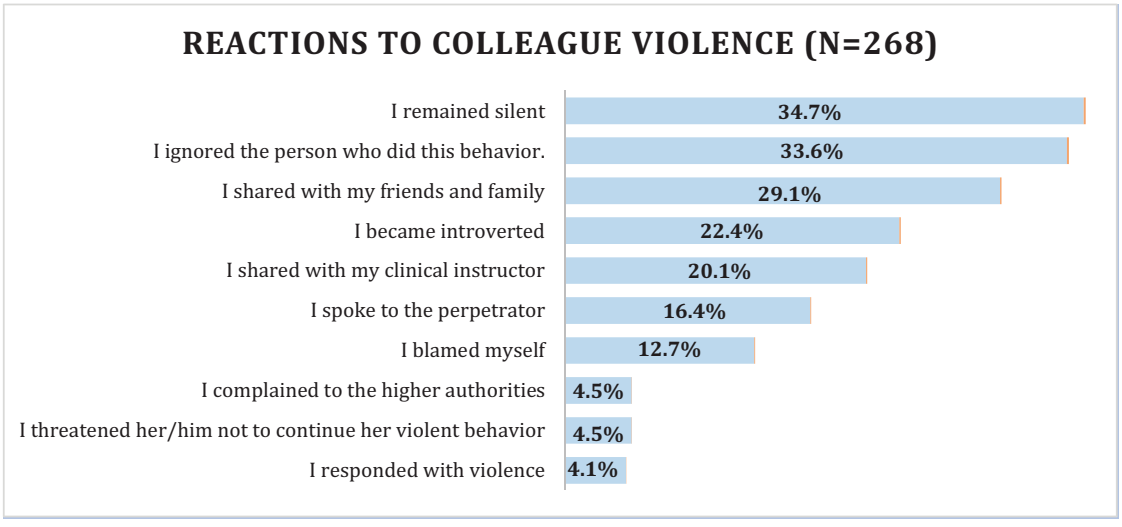

Figure 1. Reactions to colleague violence.

harassed [31]. In this study, according to the total scale (min=22- max=110), the mean score was also found to be moderate (46.72 ± 21.30), the "exposure to verbal/psychological violence" subscale score (min=11- max=55) was also found to be low-moderate (21.62 ± 10.09). Since violence cannot be accepted at any rate and level in any setting, these results should not be ignored and should draw attention to

the issue. It was stated that students mostly did not report colleague violence because they were afraid of being treated negatively [31]. Therefore, in this study, the possibility of students being reluctant to indicate colleague violence should not be ignored. This may have affected the level of exposure to colleague violence reported by students in this study. In this study, our finding on the most frequent response to violence by remaining silent shows that we should not ignore it.

In this study, the "effect of violence on physical and mental health" subscale score (min=11-max=55) was also found to be moderate (25.10 ± 12.02). According to the scale score similar to the literature, the impact of violence on students' physical and mental health was modest in the current study [20]. In a qualitative study, students reported feeling less excited and motivated about their careers as a result of colleague violence [14]. The majority of participants in a study looking into the clinical experiences of bullying and/or harassment among Australian nursing students said that the event left

Table 2. Range and mean scores of the Exposure to Colleague Violence Scale and subscales.

Scales and subscales	Min.-Max.	Mean ± SD
The exposure to verbal/ psychological violence	11-55	21.62 ± 10.09
The effect of violence on physical and mental health	11-55	25.10 ± 12.02
Total	22-110	46.72 ± 21.30

Table 3. The mean scores of the items of the SECV (n=703).

Items	Min.	Max.	Mean	SD
1. They act like I am not there	1.00	5.00	2.39	1.25
2. They talk to me loudly.	1.00	5.00	2.16	1.15
3. I am exposed to humiliating words.	1.00	5.00	1.85	1.09
4. They do not allow me to apply the treatment to the patient.	1.00	5.00	2.27	1.26
5. They give me more work than I can handle.	1.00	5.00	2.25	1.22
6. When I make a mistake, they scold me repeatedly.	1.00	5.00	1.98	1.15
7. They make fun of the things we do	1.00	5.00	1.97	1.20
8. They gossip among themselves about us.	1.00	5.00	2.21	1.30
9. They frighten us with threats.	1.00	5.00	1.61	.98
10. They vent their anger on us when they get angry about something else.	1.00	5.00	2.18	1.30
11. They insist that I do something that I know is wrong	1.00	5.00	1.77	1.10
12. They say humiliating words in front of others.	1.00	5.00	1.79	1.09
13. They exhibit insulting behaviors in front of others.	1.00	5.00	1.79	1.13
14. When I am with them, I feel useless.	1.00	5.00	2.07	1.27
15. After working with them, I feel physically exhausted.	1.00	5.00	2.28	1.31
16. They cause me to be reluctant to practice	1.00	5.00	2.36	1.43
17. I am afraid of not meeting their expectations	1.00	5.00	2.53	1.37
18. They disincline me from my profession.	1.00	5.00	2.35	1.40
19. They negatively affect my clinical success.	1.00	5.00	2.27	1.37
20. I do not want to go to internship because of their behavior toward me.	1.00	5.00	2.20	1.36
21. I constantly have a headache after the internship due to the tension they make me experience.	1.00	5.00	2.20	1.32
22. I cannot pay attention to the things I do.	1.00	5.00	2.13	1.28

SECV: The Scale of Exposure to Colleague Violence, Min: Minimum, Max: Maximum, SD: Standard Deviation.

them feeling anxious and depressed [31]. Colleague violence shouldn't be discounted because it might have adverse psychological impact on students and long-term effects.

Nursing students' exposure to colleague violence is affected by many factors including some sociodemographic characteristics. This study has indicated a higher likelihood of senior students experiencing colleague violence, a finding consistent with the existing literature [13, 21, 31]. Due to the increased time spent in clinical settings, interactions with colleagues, expectations from students, and students' tasks, the rise in students' grade level may have contributed to increased exposure to colleague violence in clinical practice [28]. The students who consume alcohol had higher levels of exposure to verbal/psychological violence. Students may consume alcohol as an ineffective way of coping with stress [32]. Students who use alcohol may have difficulties coping with stress effectively and performing the desired performance in clinical settings. This situation could have an impact on students' exposure to colleague violence in this study. According to this study, students diagnosed with psychiatric conditions are at a higher likelihood of being at risk for colleague violence. The rate of exposure to violence may have increased as a result of the mentally ill students' less successful academic achievement than anticipated [33].

In the current study, students who perceived their academic success as bad did not choose the nursing department voluntarily, and were not satisfied with the department were more exposed to colleague violence and were affected by it. Professional success is closely related to knowing the profession's requirements and choosing the profession willingly [34, 35]. The profession perceptions of students who chose the profession willingly and are satisfied with the profession had higher positive perceptions of nursing [35]. For nursing students to be productive, they should perceive their profession as important and valuable and have good communication skills [36]. According to a study, students who believe they succeed academically have better communication skills [37]. In our study, the positive perceptions of the students who had high academic success chose nursing voluntarily. They were satisfied that the department enabled students to cope more effectively with the problems they encountered in their clinical practice, to communicate more positively with their colleagues, and to fulfill the professional practices expected from them more successfully. This may have reduced students' exposure to colleague violence. Colleague violence can be avoided by developing students' professional attitudes and successes.

In this study, the level of being exposed to colleague violence was higher for students who were exposed to violence other than colleague violence and perpetrated violence against others. The fact that students who were exposed to violence did not feel safe and could not reach academic qualifications [38] may have affected their exposure to violence in their clinical education.

The students reacted to colleague violence by being silent most frequently in the current study. Ignoring and sharing with friends and family were the other most common reactions. In Koç and Batkın's study, nursing students struggled with colleague violence by sharing with their friends and lecturers and staying away [21]. A qualitative study conducted with nursing students determined that students generally preferred to remain silent and communicate with academics about the problems they encountered during their clinical practices [14]. In another study, students who were exposed to colleague violence responded by avoiding communication [28]. Moreover, in this study, it was determined that the rate of students responding to colleague violence with violence, warning the perpetrator of violence, and complaining was low. Students are vulnerable and often feel powerless to question their colleagues about their violent behavior [31]. Clinical educators should closely monitor the communication and interaction of the students with their colleagues in the practice areas and support the students in reporting violent behaviors. It will help to define violent behaviors, prevent colleague violence, and make it easier for students to identify and report colleague violence.

The study's strength is its use of a valid and reliable scale. Its limitations are that the results cannot be generalized to all nursing students and that the data is collected online.

5. Conclusion

The level of exposure of nursing students to colleague violence and the effect of the violence on their physical and mental health were moderate. The level of exposure to verbal/psychological violence of the students was low. Students were most frequently exposed to psychological violence and reacted to violence by remaining silent. Colleague violence should not be normalized. This study showed that there is colleague violence. The results of this study may help identify the essential tactics for reducing colleague violence, as well as for reviewing and maybe correcting the elements that contribute to it.

Exposure to a low level of violence does not change the fact that violence exists, it can be argued that violence is a problem that should never be tolerated. Academic nurses, clinical nurses, and nursing supervisors all play a significant part in decreasing colleague violence. For this, mutual expectations should be shared and cooperation should be ensured in the triangle of nursing student, educator, and manager. Additionally, it's critical to increase their understanding of colleague violence. Nurse educators should support students to share and report violence with positive and constructive behaviors. For students to voice their feelings and defend their rights when they are the targets of colleague violence, it is crucial to support them in developing their advocacy and communication skills. Nurses should approach students favorably, be good role models for pupils, and be aware of their violent conduct. It is advised for educators to incorporate the topic into the curriculum and teach pupils about what violence is and how to respond to it. Techniques such as case studies and role-playing can be used to teach effective methods of combating colleague violence. The negative effects of colleague violence on students' psychological health should be considered. Counseling and psychological support should be provided to all students who have been subjected to colleague violence, but especially to students with a diagnosis of psychological illness.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Hatay Mustafa Kemal Universtiy Social and Humanities Ethics Committee (07.04.2022, Number of meeting: 05, Decision no: 06). The aim of the study and filling procedures of the form were given on the top of the form that was delivered online.

Informed Consent Statement: There was an option at the beginning of the data collection form that the participants had to fill out to agree that they understood and volunteered to participate.

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Examining the Effect of Sleep Hygiene Education Given to Nursing Students on Sleep Quality

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Keywords: Nursing Students; Sleep; Quality; Sleep Hygiene Education

ABSTRACT

Background: *The study aimed to ascertain the effect of sleep hygiene training on nursing students' sleep quality.* **Methods:** *The research study group consisted of 80 nursing students studying in the nursing department. A quasi-experimental model with a pretest-posttest control group was used. Sleep hygiene training was given to nursing students in the experimental group. The sociodemographic data form for nurse students and the Pittsburg Sleep Quality Index (PSQI) were used to collect data. The t-test for independent groups was used to compare the PSQI pre-test and post-test scores of the experimental and control groups, and the dependent group t-test was used to compare the PSQI pre-test and post-test scores within groups.* **Results:** *There was a difference in the sleep-related data of the nursing students in the experimental and control groups and between the PSQI pretest and posttest score averages according to the groups. No significant difference between the pre-test and post-test mean scores was observed in the control group for subjective sleep quality, sleep duration, sleep disturbance, and daytime dysfunction.* **Conclusions:** *Sleep hygiene education helps nursing students develop regular sleep behaviors.*

1. Introduction

Human beings are whole with their physical, social, intellectual, and spiritual needs. A balanced approach to meeting these requirements is necessary for an individual to be healthy. "Sleep" is one of the fundamental human needs that must be satisfied [1, 2]. Sleep is a significant health variable affecting the individual quality of life and well-being [3, 4]. Some factors affecting sleep quality are drugs, diseases, habits, and psychological and social aspects. Today, sleep quality is a concept that is emphasized in clinical practices and sleep-related research. The reasons for this are that sleep-related complaints are pretty common, poor sleep quality can be a symptom of many medical diseases, and a strong relationship exists between sleep health and physical and psychological well-being [5]. It is seen that studies on sleep disorders are increasing rapidly all over the world [6]. Although it varies according to societies and age groups, the rate of sleep disorders varies between 5% and 71%. A study conducted in Turkey reported that 21.8% of the Turkish population had a deterioration in sleep quality, 34% had difficulty falling asleep and had early waking problems [7]. When looking at the issue of sleep in university students, there is a general belief that university students sleep inadequately [8]. The amount and quality of college

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student sleep have changed significantly in the last few decades; from 1969 to 2001, the average sleep time reported by college students decreased from 7.75 hours to 6.65 hours, and sleep disturbances increased from 24% to 71% between 1978 and 2001 [9]. In the study of Liu, Zhao, Jia, and Buysse (2008) [10], it was found that there was a relationship between sleep quality and psychological health, and university students with poor sleep quality had more psychological health problems. Likewise, the study of Keshavarz Akhlaghi and Ghalebandi (2009) [5] reported a relationship between sleep quality and the general health status of university students.

In our country, hardly much research has been done on the sleeping habits of college students. In the study of Altıntaş et al. (2006) [6], sleepiness was examined in medical faculty students, and it was found that 54.4% of the students thought they had sleep-related problems. Since the training programs in health professions such as medicine, nursing, and pharmacy are intense and tiring, students can sacrifice their sleep time (Mayda et al., 2012) [11]. Therefore, students who do not get enough sleep are negatively affected physically, cognitively, and emotionally. Insomnia is also reported to negatively impact students' academic success (Curcio, Ferrara, & Gennaro, 2004) [12]. It is crucial for professional members who provide health services to the public to be in complete physical and mental well-being and to maintain this state of well-being. For this purpose, it will be helpful to determine the current situation and examine the factors that affect it positively or negatively to ensure adequate and quality sleep, among the parameters of a healthy lifestyle. The ability of students to develop a healthy lifestyle, each of whom will be a member of a profession that provides health services to society and even cares for sick/healthy individuals during their student life, will also be reflected in the individuals and society they serve and serve as role models.

One of the critical factors in maintaining sleep health is sleep hygiene. Sleep hygiene is defined as performing activities that facilitate sleep (maintaining regular sleep routines) and avoiding behaviors that hurt sleep (watching movies, encouraging talking, taking caffeine-containing foods, etc.) (Odabaşıoğlu et al., 2017) [13]. Sleep hygiene training is a practice that increases the nature and quality of sleep (Geiger et al., 2015) [14]. It is essential in preventing problems arising from sleep problems and disorders (Güneş, 2018) [15].

Examining the sleep quality of nursing students will contribute to determining the adequate and quality sleep status of the students in this department and the affecting factors. It will also create a database for studies on improving students' sleep quality. The aim of this study was to find out how sleep hygiene instruction affected nursing students' sleep quality.

2. Methods

It was collected from Cyprus Science University, Faculty of Health Sciences, Department of Nursing students. It was completed with 80 people between 17.06.2023 and 05.11.2023, including 40 people in the experimental group who received training and 40 in the control group who did not. Criteria for sample inclusion and exclusion are presented below.

2.1. Sampling Inclusion Criteria

2.1.1. Inclusion Criteria

- Students who agree to participate in the research voluntarily.
- Students studying in the nursing department.
- Having completed the informed consent form.

2.1.2. Exclusion Criteria

- Students who do not agree to participate in the research voluntarily.
- Students outside the nursing department
- Not having completed the informed consent form.

2.2. Research Hypotheses

2.2.1. Hypothesis 1- H_1

The pre-test-post-test PSQI score averages of the nursing students in the experimental group who

received sleep hygiene training before and after the training differed.

2.2.2. Hypothesis 2- H_2

There is no difference between the PSQI score averages of Nursing Students in the Control Group before and after training.

2.3. Collection of Data

- The forms below were used to collect research data.
- Sociodemographic Data Collection Form.
- Pittsburg Sleep Quality Index (PSQI).

2.3.1 Socio-Demographic Data Collection Form

This form consists of 3 questions about the nursing students' gender, age, and class status.

2.3.2 Pittsburg Sleep Quality Index (PSQI)

PSQI was developed by Buysse et al. in 1989 and has been shown to have adequate internal consistency, Cronbach's alpha=0.80), test reliability and validity (Buysse et al., 1989) [16]. The validity and reliability study of PSQI in our country was conducted by Ağargün et al. (1996) [17]. In this study, the Cronbach alpha value of the scale was found to be 0.79 (Cronbach alpha=0.79). PSQI is a self-report scale that assesses sleep quality and disturbance over one month. On a scale of 24, 19 questions are answered by the person, while the last five questions are filled in by the person's roommate or bed partner. With 19 questions answered by the person, seven sub-dimensions are evaluated: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disorder, use of sleeping pills, and daytime dysfunction. These seven subscales are subjective sleep quality (component 1), sleep latency (component 2), sleep duration (component 3), habitual sleep efficiency (component 4), sleep disturbance (component 5), sleeping pill use (component 6), and daytime dysfunction (component 7). The sum of the seven component scores gives the total PSQI score. Each response is scored between 0-3 according to symptom frequency. The total score has a value between 0-21. High values indicate poor sleep quality and a high level of sleep disturbance. A score above five clinically indicates poor sleep quality (Ağargün et al., 1996) [17].

2.4. Application of Pretest

The "Sociodemographic Data Form" and Pittsburg Sleep Quality Index (PSQI) were collected during the pre-test through face-to-face interviews.

2.5. Interference

2.5.1. Preparation of Objectives and Training Content

In the first stage of the research, sleep hygiene education content/module was prepared for nursing students, considering the data obtained from focus group interviews.

2.5.2. Conducting Training

Nursing students (40 Experimental groups) were given training. The researcher conducted the training for two hours, two days a week, for eight weeks. Each session lasted approximately 30 minutes. In the research, training was given in groups of 5 people. The training started with introducing and determining meeting rules (10 minutes). A presentation on sleep hygiene education to nursing students included (20 minutes) of distribution and explanation of written educational material (10 minutes).

2.6. Application of Post-test

In the post-tests, the Pittsburg Sleep Quality Index (PSQI) was re-applied to the nursing students in the experimental and control groups.

2.7. Evaluation of Data

Before analyzing the data, the distribution of PSQI scores of the experimental and control groups was examined by applying the Kolmogorov□Smirnov normality test. The results showed that the scores had a normal distribution according to groups. In

line with this result, inter- and intra-group PSQI scores were compared using parametric analysis techniques. Within the scope of the research, an independent groups t-test was applied to compare the PSQI pre-test and post-test scores of the experimental and control groups. Dependent groups t-test was used to compare PSQI pretest and post-test scores within the groups. Cohen's d coefficients were calculated to determine the effect value. Approximately 0.20; Effect values of 0.50 and 0.80 were considered small, medium, and large effects, respectively (Cohen, 1988) [18]. Data were analyzed using the SPSS 25.0 statistical package program.

3. RESULTS

When Table 1 is analyzed, it is understood that 50% of the participants in the experimental group and 57.5% of the participants in the control group were male. A large proportion of the participants in the experimental group (52.5%) were in the 24-26 age group. In the control group, a large proportion of the participants (45%) were in the 21-23 age group. Results showed that the groups were homogenous regarding gender, age, and grade level variables.

When Table 2 was analyzed, it was determined that there was no statistically significant difference between the pre-training PSQI score averages of nursing students in the experimental and control groups ($p>0.05$).

When Table 3 is examined, it is understood that there is no significant difference between the experimental group's pre-test and post-test mean scores of sleep duration and habitual sleep activity. However, a significant difference was found between the mean pre-test scores of sleep latency, subjective sleep quality, sleep disturbance, sleep medication use, daytime dysfunction, and PSQI total. This result showed that the sleep quality of the experimental group participants generally increased after the experimental procedure.

When Table 4 is analyzed, it is understood that there is no significant difference between the control group's pre-test and post-test mean scores of subjective sleep quality, sleep duration, sleep disturbance, and daytime dysfunction. However, a

Table 1. Distribution of participants by descriptive characteristics.

		Experiment	Control		
		N (%)	N (%)	Chi square	p
Gender	Male	20 (%50)	23 (%57.5)	0.45	0.51
	Female	20 (%50)	17 (%42.5)		
Age	18-21	3 (%7.5)	6 (%15)	3.69	0.29
	21-23	13 (%32.5)	18 (%45)		
	24-26	21 (%52.5)	13 (%32.5)		
	27 and over	3 (%7.5)	3 (%7.5)		
Class Status	1	10 (%25)	11 (%27.5)	0.09	0.99
	2	7 (%17.5)	7 (%17.5)		
	3	10 (%25)	10 (%25)		
	4	13 (%32.5)	12 (%30)		

Table 2. Pre-Training PSQI Nursing Students' Scores.

	Pre-test					
Group	**Min**	**Max**	$\bar{X}$	**SS**	***t***	**p**
Experiment	5.00	17.00	11.70	2.43	1.000	0.321
Control	7.00	16.00	11.17	2.26		

Table 3. Pre-Test and Post-Test PSQI scores in the group receiving sleep hygiene training.

Group	Variable	Test	N	Mean	SD	t(39)	p	*Cohen d*
Experiment	Subjective sleep quality	Pre-test	40	0.93	1.07	4.78	<0.001	0.76
		Post-test	40	0.15	0.58			
	Sleep latency	Pre-test	40	1.70	0.69	6.98	<0.001	1.10
		Post-test	40	0.88	0.40			
	Sleep duration	Pre-test	40	0.95	1.06	0.00	1.00	0.00
		Post-test	40	0.95	1.06			
	Habitual sleep activity	Pre-test	40	1.40	1.24	-1.43	0.16	0.23
		Post-test	40	1.50	1.32			
	Sleep disturbance	Pre-test	40	1.40	0.50	7.06	<0.001	1.12
		Post-test	40	0.48	0.55			
	Use of sleeping pills	Pre-test	40	1.23	0.77	5.37	<0.001	0.85
		Post-test	40	0.38	0.49			
	Daytime dysfunction	Pre-test	40	1.15	0.62	4.42	<0.001	0.70
		Post-test	40	0.65	0.74			
	PSQI Total	Pre-test	40	8.75	3.12	7.27	<0.001	1.15
		Post-test	40	4.98	3.34			

Table 4. Pre-test and post-test PSQI scores in the control group.

Group	Variable	Test	N	Mean	SD	t(39)	p	*Cohen d*
Control	Subjective sleep quality	Pre-test	40	1.63	0.93	0.54	0.59	0.08
		Post-test	40	1.50	0.93			
	Sleep latency	Pre-test	40	1.78	0.92	-562	<0.001	0.89
		Post-test	40	2.50	0.68			
	Sleep duration	Pre-test	40	1.00	1.04	-1.78	0.08	0.28
		Post-test	40	1.08	1.07			
	Habitual sleep activity	Pre-test	40	1.88	1.20	-2.36	0.02	0.37
		Post-test	40	2.00	1.26			
	Sleep disturbance	Pre-test	40	2.55	0.50	-1.43	0.16	0.23
		Post-test	40	2.60	0.50			
	Use of sleeping pills	Pre-test	40	2.73	0.45	-2.62	0.01	0.41
		Post-test	40	2.88	0.33			
	Daytime dysfunction	Pre-test	40	2.83	0.38	-1.43	0.16	0.23
		Post-test	40	2.88	0.33			
	PSQI Total	Pre-test	40	14.38	2.32	-3.56	<0.001	0.56
		Post-test	40	15.43	2.60			

significant difference was found between the control group's mean scores on sleep latency, habitual sleep efficiency, sleep medication use, and PSQI total pre-test scores.

Mean scores of sleep duration and habitual sleep activity post-pre-test scores did not differ between the groups (Table 5). In contrast, differences were found for sleep latency, subjective sleep quality,

sleep disturbance, sleep medication use, daytime dysfunction, and PSQI pre-test mean scores. After the experimental procedure, the PSQI scores of the experimental group decreased more in general, suggesting that the experimental method effectively improved sleep quality, with a moderate and significant effect on sleep quality.

4. Discussion

Nursing students who met the inclusion criteria were included in the study, and their characteristics were analyzed. The data of nurses and students excluded from the inclusion criteria were not analyzed. It was concluded that the sociodemographic characteristics (age, gender, and class status) of the nursing students in the experimental and control groups were homogeneous. This finding is similar to the sociodemographic findings of Huang et al. (2018) [19] study titled Factors associated with teaching sleep hygiene to nursing students. The study results on factors affecting sleep quality in nursing and non-nursing students conducted by Kim and Yoon (2013) [20] are similar to our findings. The findings of Brown et al. (2002) [21] study titled are similar between the groups.

A significant difference was found between the score averages of the nursing students in the experimental group who received sleep hygiene training before and after the training. **(H_1)**. Silva et al.'s (2016) [22] study determined that their sleep quality increased due to the sleep training provided. Likewise, Revathi et al. (2016) [23] study of sleep quality positively affected sleep education and quality. In İsmailoğlu and Özdemir (2020) [24], their study, sleep education and factors affecting sleep hygiene education were determined as positive and negative determining criteria for sleep quality. The results of Yazdi et al. (2016) [25] study parallel our findings.

There was no difference between the pre-test and post-test PSQI score averages of the nursing students in the control group before and after the training **(H_2).** This finding supported the hypothesis that there is no difference between the PSQI score averages of Nursing Students in the Control Group before and after training. In Amaral et al. (2021) [26] study, it was determined that a group was not given training on sleep quality, and their sleep quality remained the same. Likewise, when Gipson et al. (2019) [27] studied, it was found that there was no change in the sleep quality of students who did not receive sleep hygiene intervention. There was a positive increase in the sleep quality of those in the intervention group. Suen et al. (2010) [28] study concluded that sleep hygiene is essential in sleep quality and that students with poor sleep hygiene have increased sleep problems. In Li et al. (2016) [10] study, it was found that the group that received sleep hygiene training had an increase in their sleep quality compared to the group that did not receive sleep hygiene training and those who did not receive sleep hygiene training. This group's low sleep quality is similar to our research findings.

In a study conducted by Hershner and Brien (2018) [29], it was concluded that the sleep quality of the group receiving sleep hygiene training was better. The study conducted by Strong et al. (2018) [30] found that the sleep quality of adolescents who received sleep hygiene interventions was better. In a different but similar study, Haylı and Aydın's (2023) [31] study also found that the sleep hygiene training applied to the experimental group positively affected their sleep quality, and there was no change in the sleep quality of the control group. It was determined that it was not. The study by Chen et al. (2010) [32] concluded that working women who received sleep hygiene training had better sleep quality and reduced sleep problems. Dietrich et al. (2016) [33] study found that university students who received sleep hygiene training had fewer sleep problems and slept comfortably and peacefully compared to groups that did not receive sleep hygiene training. Likewise, Peach et al. (2016) [34] study concluded that university students' sleep hygiene practices positively affected their sleep quality. In Brick et al. (2010) [35] study, it was found that there was a significant difference between sleep hygiene and sleep quality. The results of the study by Ali et al. (2023) are similar to our research findings [36].

5. Conclusion

Research has shown that nursing students benefit from "sleep hygiene training" to establish regular sleep habits. The study concluded that sleep hygiene

Table 5. Pre- and Post-test PSQI scores in the experimental and control groups.

Variables	Group	N	Mean	SD	t(80)	p	*Cohen d*
Subjective sleep quality	Pre-test	40	-0.78	1.03	-2.29	0.02*	0.51
	Post-test	40	-0.13	1.47			
Sleep latency	Pre-test	40	-0.83	0.75	-8.86	<0.001	1.98
	Post-test	40	0.73	0.82			
Sleep duration	Pre-test	40	0.00	0.32	-1.14	0.26	0.25
	Post-test	40	0.08	0,27			
Habitual sleep activity	Pre-test	40	0.10	0,44	-0.29	0.78	0.06
	Post-test	40	0.13	0,33			
Sleep disturbance	Pre-test	40	-0.93	0,83	-7.19	<0.001	1.61
	Post-test	40	0.05	0,22			
Use of sleeping pills	Pre-test	40	-0.85	1,00	-5.94	<0.001	1.33
	Post-test	40	0.15	0,36			
Daytime dysfunction	Pre-test	40	-0.50	0,72	-4.64	<0.001	1.04
	Post-test	40	0.05	0,22			
PSQI Total	Pre-test	40	-3.78	3,29	-8.08	<0.001	1.81
	Post-test	40	1.05	1,87			

instruction intended to enhance sleep cycles is a feasible recommendation. Regularly assessing nursing students' sleep quality is advised, as is teaching them about physiological, psychological, and environmental aspects of good sleep hygiene. Research should also be conducted to determine how well-applied training and consulting programs improve students' sleep. It should be noted that the study was conducted on volunteers. We cannot exclude the possibility of a spontaneous selection of the samples. Additionally, we cannot guarantee the validity of comparisons due to the non-random nature of the sample selection process.

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Validation of the Work-Related Quality of Life Scale in Rehabilitation Health Workers: A Cross-Sectional Study

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Abstract

Background: *Work-related quality of life (WRQoL) is a multidimensional concept related to life satisfaction. Evaluating WRQoL is essential in healthcare settings since employee satisfaction affects patient service quality. Only a few studies have focused on the quality of life of rehabilitation health workers. We aimed to validate the Italian version of the WRQoL scale on a population of rehabilitation health professionals; the secondary objective was to investigate the work-related quality of life of professionals concerning the work settings in which they operate.* **Methods:** *Participants were recruited from January 2022 to December 2023 according to specific inclusion criteria. Questionnaires were administered through an online survey requiring also personal employment data, and together with the SF-12 questionnaire, a test-retest was performed on 30 therapists. Reliability was assessed with Cronbach's alpha, test-retest stability through intraclass correlation coefficient (ICC), and concurrent validity was calculated using Pearson's correlation.* **Results:** *We enrolled 284 individuals. Internal consistency analysis showed statistically significant results: Cronbach's alpha was > 0.70; construct validity analyses revealed statistically significant data for total scores and subscales, compared to SF-12 scores.* **Conclusion:** *The WRQoL scale is a valid and reliable tool to assess the quality of working life of rehabilitation professionals.*

1. Introduction

Work-related quality of life (WRQoL) is a multidimensional concept related to life satisfaction. Many people consider working a form of social identity, not just a means of survival. Work-related quality of life also includes other essential elements of the personal sphere, such as family, leisure, and social activities. A high quality of working life has been shown to play a key role in reducing strain inside and outside the workplace [1, 2].

Healthcare professionals who interact with patients, relatives, and caregivers often experience emotionally charged situations and high levels of stress. Stress at work can lead to reduced professional performance, wellbeing, and quality of life and high levels of anxiety, depression, or physical exhaustion. A consequence of chronic stress can be

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burnout syndrome, characterised by emotional exhaustion, depersonalisation, and poor personal fulfillment [4].

Evaluating work-related quality of life is particularly important in healthcare settings since employee satisfaction directly affects the quality of performance and patient services [5]. According to current literature, factors associated with a better work-related quality of life are the physical and emotional wellbeing of the individual, organizational and work-related measures (such as turnover and quality of work), an adequate salary, fair pay, a safe and healthy work environment, opportunities for capacity development and career growth, social integration, and shared values and discussions with the work team [6].

The relationship between job satisfaction and work-related quality of life has been studied in different professions [7–9]. Many studies have been conducted on the quality of life of nurses, especially during the COVID-19 pandemic, as well as that of surgeons and emergency room doctors [10–15]. Only a few studies have focused on the quality of life of rehabilitation health workers. For example, the survey conducted by Rostami et al. specifies that studies on this issue are essential since work-related quality of life and job satisfaction affect therapists' health quality and the quality of services they provide [16]. Bowens et al. assessed the quality of life of physiotherapists in Alabama in 2021. They concluded that doctors and employers should evaluate the personal, occupational, and systemic factors contributing to reduced quality of professional life to implement preventive strategies to mitigate burnout [17].

An instrument that aims to evaluate general QoL in healthy subjects was developed in the USA and called SF-12 Health Survey version 2 (SF-12v2); it is a generic short-form health survey created from the original SF-36. It produces two summary measures evaluating physical and mental self-perceived health; for this reason, it represents a suitable and complete tool to assess self-perceived quality of life. SF-12v2 has been successfully tested in several Western European countries on large samples of the general population, proving its brevity, comprehensiveness, reliability, validity, and cross-cultural applicability. Gandek et al., in a cross-validation study, tested the SF-12v2 suggested in the original United States study for nine European countries (Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, and the United Kingdom) [18]. The SF-12v2, since then, has been extensively used in studies involving the general population and disease-specific groups [19].

As regards WRQoL, in 2021, a scoping review by Silarova et al. described seven tools that can be used to measure the work-related quality of life of health professionals, considering aspects such as psychophysical wellbeing, quality of working life, job satisfaction, burnout, and professional identity [20]. The assessment tools that evaluate the most aspects of the quality of working life are the Quality of Work Life and the Work-Related Quality of Life (WRQoL) scales developed by Van Laar et al. in 2007 [21, 22]. The latter consists of a questionnaire first tested in the health sector, applied to different work environments, and translated into nine languages [23–25]. It is composed of 26 items and includes six dimensions in its original form: control at work (CaW), general wellbeing (GWB), home-work interface (HWI), job and career satisfaction (JCS), stress at work (SaW), and working conditions (WC). In 2011, a revised scale was developed, including a seventh dimension, employee engagement (EEn), which evaluates how employees are engaged in the organization and its values. The WRQoL scale provides a multidimensional tool for measuring work-related quality of life thanks to tested and validated psychometric properties. Garzaro et al. translated and validated this scale on an Italian population of nurses and doctors [2].

We aimed to validate the Italian version of the WRQoL scale on a population of rehabilitation health professionals (physiotherapists, speech therapists, orthoptists, psychiatric rehabilitation technicians, occupational therapists, neuropsychomotricity therapists, podiatrists, professional educators) and investigate its psychometric properties. The secondary objective was to investigate the work-related quality of life of professionals concerning the work settings in which they operate and the characteristics of the sample.

2. Methods

2.1 Participants

Participants were recruited from January 2022 to December 2023, and each gave informed consent for participation. The procedures followed were following the Helsinki Declaration as revised in 2008.

The inclusion criteria were as follows: i) employment as a healthcare worker in the field of rehabilitation, ii) possession of a Bachelor's degree or equivalent, iii) registration in the relevant professional register, iv) regular employment, and v) employment in an Italian region. Operators with the following characteristics were excluded from the study: operators not included in the professional register, graduates or holders of the qualification who did not work in the rehabilitation field, or retired professionals: 284 individuals were recruited for the study. Their characteristics are shown in Table 1.

2.2 Procedures

Questionnaires containing the Italian version of the WRQoL scale were administered through an online survey sent by email to professionals working in various Italian regions (Basilicata, Campania, Emilia-Romagna, Lazio, Lombardy, Piedmont, Apulia, Sardinia, Veneto); the link containing the questionnaire was sent to 300 health professionals. The WRQoL scale was administered together with a section requiring personal employment data (date of birth, sex, profession, years of work, type of work structure, Italian region, type of patients mainly treated, type of employment contract) and the 12-Item Short-Form Survey (SF-12) [26]. A test-retest was performed on 30 therapists who gave their consent, i.e., they were given the WRQoL a second time after 24-48 hours.

2.3 Data Analysis

A descriptive analysis was performed to analyze the characteristics of the sample. Percentage, mean, and standard deviation (SD) of variables were calculated. The scale's internal consistency

Table 1. The mean age of study subjects was 35; 75.7% were female; the largest group was represented by physiotherapists (42.6%) with a permanent contract (46.5%). The mean working duration was 9.27 years, mainly in rehabilitating neurological diseases in Central Italy (82.4%).

	average±SD	N°(%)
Age	35.0±10.3	284
Age range		
≤ 30		134 (47.2)
31-49		118 (41.5)
≥ 50		32 (11.3)
Gender		
Male		69 (24.3)
Profession		
Physiotherapist		121 (42.6)
Occupational therapist		54 (19.0)
Speech therapist		47 (16.5)
Neuro and psychomotricity therapist		22 (7.7)
Orthoptist		6 (2.1)
Professional educator		18 (6.3)
Podiatrist		10 (3.5)
Psychiatric rehabilitation technician		6 (2.1)
Working years	9.27±9	
Type of structure		
Outpatient clinic		44 (15.5)
Nursing home		16 (5.6)
Private studio		50 (17.6)
Home service (cooperative/ASL)		33 (11.6)
Daycare center		13 (4.6)
Rehabilitation center		72 (25.4)
Hospital		56 (19.7)
Type of patients		
Pediatric		80 (28.2)
Geriatric		43 (15.1)
Neurological		88 (31.0)
Orthopedic		61 (21.5)
Cardio-respiratory		10 (3.5)
Pelvic floor rehabilitation		2 (0.7)
Type of contract		
Full-time/part-time permanent contract		132 (46.5)
Full-time/part-time fixed-term contract		44 (15.5)
Freelance		102 (35.9)
Occasional performance contract		6 (2.1)
Area		
North		28 (9.9)
Center		234 (82.4)
South		22 (7.7)

Table 2. Reliability analysis. The table shows the ICC value for each scale domain, calculated based on test and re-test results, both for the total scale and each domain.

	Test	Re-test	ICC	95% CI
Tot	81.22±16.939	78.67±20.742	0.940	0.735-0.986
CaW	12.56±3.358	10.56±3.609	0.872	0.434-0.971
GWB	17.22±3.993	17.44±3.575	0.946	0.760-0.988
HWI	9.56±3.432	10.33±3.041	0.811	0.161-0.957
SaW	5.22±1.922	5.00±1.500	0.888	0.505-0.975
JCS	11.00±4.301	10.33±4.528	0.932	0.696-0.985
WC	13.33±2.739	12.67±4.243	0.649	-0.556-0.921
EEn	9.00±3.708	8.89±3.257	0.943	0.749-0.987

was examined by Cronbach's alpha, which should have a value greater than 0.7 to be statistically significant. The intraclass correlation coefficient (ICC) was calculated to measure reliability, which must be at least 0.70 to be statistically significant. Construct validity was evaluated using Pearson's correlation to determine the association between the WRQoL scale and the Italian version of the SF-12. Differences between groups in scores were calculated using independent samples t-tests and ANOVA (the significance level was set as a p-value less than or equal to 0.05).

Regarding scoring, the WRQoL scale is divided into seven subscales to be rated on a Likert-type scale, from 1 (strongly disagree) to 5 (strongly agree). Consequently, the maximum score corresponds to 130, obtained through the sum of scores in each domain; the items included in each domain are shown below.

CaW: items 1, 9, 19, 24; GWB: items 2, 7, 11, 13, 17; HWI: items 3, 4, 20; SaW: items 5, 15; JCS: items 6, 8, 14, 16; WCs: items 10, 12, 18, 25; EEn: items 21, 22, 23.

3. Results

3.1 Reliability

Internal consistency analysis showed statistically significant results for the entire scale and all subscales. The scale showed a Cronbach's alpha value equal to 0.95, with the following subdomain scores: EEn: 0.858, WCs: 0.854, JCS: 0.810, SaW: 0.843, HWI: 0.819, GWB: 0.897, and CaW: 0.797 (Table 2).

All alpha-deleted analyses showed that all items contributed to the internal consistency of the entire scale and different domains.

3.2 Construct Validity

Test re-test reliability was assessed, requiring the questionnaire to be completed 24-48 hours after the first administration. It was measured through ICC (Table 3).

Construct validity was calculated through correlation with the SF-12 domains, considering its construct (PCS12=Physical Composite Site; MCS12=Mental Composite Site). The analysis showed a statistically significant correlation between the mental health domain of SF-12 and the WRQoL scale total score and subscales. Specifically, all the correlations were positive, except for the one between Stress at Work (SaW) and MCS12, which was negative (Table 3).

3.3 Cross-Cultural Analysis

Cross-cultural analysis was performed through independent samples t-tests and ANOVA to determine whether the scores on the subscales differed according to the sample's demographic characteristics (Supplementary Table 1 shows t or F values).

There were no statistically significant differences in age and gender. As for professions, differences were found in CaW, WCs, and total scores

Table 3. Construct validity. The total score and all the subscales of the WRQoL scale showed a statistically significant correlation with SF-12 domains (Physical Composite Site and Mental Composite Site); in particular, the correlation between WRQoL scale domains and total and MCS12 was statistically significant (p<0.01).

	PCS12	MCS12
Tot	0.181**	0.489**
CaW	0.116	0.342**
GWB	0.147*	0.567**
HWI	0.166**	0.410**
SaW	-0.078	-0.250**
JCS	0.157**	0.355**
WCs	0.166**	0.295**
EEn	0.157**	0.361**

*JCS=Job and Career Satisfaction; SaW=Stress at Work; WCs=Working Conditions; EEn=Employee Engagement *p<0.05 **p<0.01.*

(p <0.01). Differences were found between people working in different types of structures regarding scores in CaW, JCS, WcS, Een domains and total score of WRQoL (p<0.01). Other statistically significant values were found between the type of patients with whom rehabilitation professionals deal most in the domains CaW and WcS (p<0.05) and between professionals who work in different areas of Italy in the domains WcS, Een, and total score (p<0,05) (Supplementary Figures 1-12).

4. Discussion

The primary objective of this study was to evaluate the psychometric properties of the WRQoL scale in a cohort of rehabilitation professionals, while the secondary objective was to identify associations between data collected from the sample and WRQoL scale scores.

The WRQoL scale obtained statistically significant results for construct validity due to its correlation with SF-12. This means the WRQoL construct is comparable to the SF-12 construct, a gold standard for measuring general QoL. Thus, it is possible to suppose that the WRQoL scale reflects the general health conditions of the considered population; moreover, it was found to be a reliable tool with an ICC value > 0.7.

Construct validity analyses showed that WRQoL scale scores correlated with the mental health domain of the SF-12 scale, which aligns with the current literature. General mental health is associated with Quality of Working Life [27–29].

The descriptive analysis showed that most participants were under 30, primarily females. The most recurrent profession was physiotherapist, while podiatrist was the least represented profession. This result is consistent with the fact that physiotherapists are generally the most represented professionals in the various rehabilitation structures in Italy.

Most operators worked in a rehabilitation center, while only 4.57% worked in daycare centers. Most therapists rehabilitated neurological and pediatric patients (30.98% and 28.16% respectively). The prevalent type of contract was a full-time/part-time permanent contract; almost all professionals worked in central Italy. Mean scores were similar to those obtained in the study of Garzaro et al., which was the first Italian validation of this version in a sample of health workers represented by nurses and physicians [2]. Regarding scores, there are no available cut-offs for the WRQoL Scale, but on this type of worker, the scale shows neither ceiling effect nor floor effect.

Through cross-cultural analyses, it was noted that different professions obtained different scores in the control domains at work, working conditions, and total scores. This difference indicates that neuropsychomotricity therapists feel less ability to have control at work and consequently don't feel involved enough in their organization or are less able to express their opinion. In contrast, speech and neuropsychomotricity therapists are less satisfied with their work conditions. On the other side, physiotherapists seem to report the best working conditions, according to the total score. A large part of the questionnaires were administered just two years after the start of the COVID-19 pandemic, so the results may be since many rehabilitation professionals were on the front line in terms of physical and psychological contact with patients and were thus unable to maintain adequate physical distancing and

COVID-19 mitigation measures [30]. Therefore, speech and neuropsychomotricity therapists primarily work with children and are more involved. In addition, children with neurodevelopmental disorders may have difficulty adapting to abrupt changes, and this can often lead to irritability in patients and provocative or aggressive behaviors toward the therapist [31, 32]. Indeed, it is known that the quality of life of healthcare workers could be correlated to their work and, therefore, to patient response [33]. This result suggests better investigating working situations regarding rehabilitation professionals who deal with children in the various structures in Italy, giving them more support and benefits in proportion to the stress experienced.

Cross-cultural analysis also showed a statistically significant difference between people who work in different types of structures in the following domains: control at work, job and career satisfaction, working conditions, employee engagement domains, and total score of WRQoL. It emerged that professionals who provide home services are less satisfied with their jobs and have fewer opportunities to have control at work, which indicates they don't feel fully involved in decision-making processes or cannot express their opinions in the workplace.

Compared to other groups, people employed in nursing homes feel less engaged in the organization and its values, while therapists working in a private studio seem to live in the best conditions, especially as regards their job and career satisfaction and the sphere of control at work.

Home services professionals often work alone and without adequate confrontation with colleagues and their employers; moreover, their worst quality of working life could be due to the many trips to the territory to provide therapies. Finally, another aspect to consider in the assessment of WRQoL could be the compensation and its relationship with the time needed to move from one patient's house to another.

Regarding the type of patients in charge, professionals involved in pelvic floor rehabilitation have a better situation in their workplaces regarding control at work and working conditions compared with the other groups. However, therapists who declared to deal with pelvic floor dysfunctions are only two of the whole sample.

Finally, the different area analyses showed that the North of Italy offers better workplace conditions and how employees are engaged in their organization and its values compared to the Center and South of Italy.

This result suggests a better investigation of working conditions and general quality of life of rehabilitation therapists in the center and south of Italy and why this investigated aspect result is inadequate; to date, there are not many rehabilitation professionals in different Italian regions. This would be useful for employers and health directors in providing solutions and consequently improving their performance at work and the quality of rehabilitation services.

Some studies have also reported how work-related stress evolves into a greater perception of poor physical and mental health. These two dimensions represent the two domains of the SF-12 scale, which evaluates the quality of life related to health.

The SF-12 was found to have a statistically significant association with the WRQoL scale. In particular, the mental health domain (MCS) included in the SF-12 scale showed a significant association with all WRQoL scores, meaning that mental health correlated with WRQoL scale scores. Current literature from even before the pandemic has shown that, like all healthcare professionals, rehabilitation professionals are at high risk of burnout. There are common mechanisms of burnout in the different professional groups considered, and therefore, further research on occupational health in rehabilitation settings is needed to prevent burnout [34]. As regards the physical health domain of SF-12 (PCS), it showed a correlation with all the subscales of WRQoL, except for "Control at Work" and "Stress at Work"; however, these two domains investigate aspects that are not related to physical health, while the other ones have an impact on it.

4.1 Limitations of the Study

Most questionnaires were completed by professionals operating in the center of Italy, with limited participation from professionals working in other Italian regions. Therefore, future multicenter studies should investigate the WRQoL scale through

a more homogeneous distribution of professionals from different regions. Finally, it would be interesting to study the responsiveness of the WRQoL scale to changes over time, for example, after a specific measure is adopted in the organization.

5. Conclusions

The WRQoL scale is a valid and reliable tool to assess the quality of working life of rehabilitation professionals. The WRQoL scale is a useful tool for coordinators and employers in different work settings to periodically evaluate employee work satisfaction and possibly guide them in business and management decisions.

Supplementary Material: Table S1; Supplementary Figure 1. Difference in CaW between professionals; Supplementary Figure 2. Difference in WcS between professionals; Supplementary Figure 3. Difference in Total score between professionals; Supplementary Figure 4. Difference in CaW between professionals who work in different types of structure; Supplementary Figure 5. Difference in CaW between professionals who work in different types of structure; Supplementary Figure 6. Difference in WcS between professionals who work in different types of structure. Supplementary Figure 7. Difference in Een between professionals who work in different types of structure; Supplementary Figure 8. Difference in Total score between professionals who work in different types of structure; Supplementary Figure 9. Difference in CaW between professionals who deal with different types of patients; Supplementary Figure 10. Difference in WcS between professionals who deal with different types of patients; Supplementary Figure 11. Difference in WcS between professionals who work in different areas of Italy; Supplementary Figure 12. Difference in Een between professionals who work in different areas of Italy.

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Validation of the Work-Related Quality of Life Scale in Rehabilitation Health Workers: A Cross-Sectional Study

Table S1. Cross-cultural analyses. The table shows all the differences found between the analyzed groups, the number of observations, the mean score for each domain and for the total score, and the standard deviation; also, t and F values are indicated with the statistical significance level and p value.

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
CaW	Age (range)	22-30	134	12.87	3.25	F=0.293
		31-49	118	13.17	4.085	
		>50	32	13.28	3.752	
	Gender	Male	69	13.59	3.349	t=1,450
		Female	215	12.86	3.752	
	Profession	Physiotherapist	121	13.37	3.576	F=3.753**
		Occupational therapist	54	13.28	3.328	
		Speech therapist	47	11.72	3.910	
		Neuro and psychomotricity therapist	22	10.73	3.869	
		Orthoptist	6	13.67	4.367	
		Professional educator	18	13.94	2.689	
		Podiatrist	10	13.70	2.830	
		Psychiatric rehabilitation technician	6	15.17	2.927	
	Type of structure	Outpatient clinic	44	11.25	4.087	F=5.462**
		Nursing home	16	13.25	4.171	
		Private studio	50	15.18	3.243	
		Home service (cooperative/ASL)	33	12.61	2.968	
		Daycare center	13	13.92	2.9	
		Rehabilitation center	72	12.58	3.275	
		Hospital	56	13.11	3.721	
	Type of patients	Pediatric	80	11.90	3.919	F=2,943*
		Geriatric	43	13.47	4.067	
		Neurological	88	13.08	3.163	
		Orthopedic	61	13.87	3.524	
		Cardio-respiratory	10	14.20	2.658	
		Pelvic floor rehabilitation	2	16.50	4.950	
	Area	North	28	14.46	4.185	F=2,896
		Center	234	12.81	3.602	
		South	22	13.64	3.303	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
GWB	Age (range)	22-30	134	16.86	4.457	F=2.949
		31-49	118	17.75	3.911	
		>50	32	18.66	4.171	
	Gender	Male	69	17.62	4.624	t=0,428
		Female	215	17.37	4.112	
	Profession	Physiotherapist	121	17.56	4.274	F=1.674
		Occupational therapist	54	18.67	3.737	
		Speech therapist	47	16.72	3.955	
		Neuro and psychomotricity therapist	22	15.73	5.426	
		Orthoptist	6	16.33	3.386	
		Professional educator	18	17.06	3.918	
		Podiatrist	10	16.60	4.502	
		Psychiatric rehabilitation technician	6	19.17	4.446	
	Type of structure	Outpatient clinic	44	16.07	4.976	F=1.531
		Nursing home	16	17.31	3.260	
		Private studio	50	17.44	4.554	
		Home service (cooperative/ASL)	33	17.12	3.689	
		Daycare center	13	18.54	3.821	
		Rehabilitation center	72	17.42	4.188	
		Hospital	56	18.48	3.852	
	Type of patients	Pediatric	80	16.99	4.877	F=1,135
		Geriatric	43	16.81	3.911	
		Neurological	88	17.85	3.792	
		Orthopedic	61	17.44	4.311	
		Cardio-respiratory	10	19.30	3.020	
		Pelvic floor rehabilitation	2	20.50	2.121	
	Area	North	28	17.75	4.070	F=0,106
		Center	234	17.41	4.289	
		South	22	17.23	4.011	
HWI	Age (range)	22-30	134	10.36	3.017	F=1.471
		31-49	118	10.22	2.962	
		>50	32	11.22	2.524	
	Gender	Male	69	10.45	3.179	t=0,166
		Female	215	10.38	2.878	
	Profession	Physiotherapist	121	10.37	3.006	F=1.121
		Occupational therapist	54	10.83	2.697	
		Speech therapist	47	10.04	2.949	
		Neuro and psychomotricity therapist	22	9.50	3.622	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
		Orthoptist	6	10.83	1.329	
		Professional educator	18	11.61	2.304	
		Podiatrist	10	9.60	3.134	
		Psychiatric rehabilitation technician	6	11.33	3.445	
	Type of structure	Outpatient clinic	44	9.95	3.242	F=1.392
		Nursing home	16	11.56	2.732	
		Private studio	50	9.94	3.067	
		Home service (cooperative/ASL)	33	11.09	2.602	
		Daycare center	13	10.85	2.824	
		Rehabilitation center	72	10.08	2.987	
		Hospital	56	10.71	2.755	
	Type of patients	Pediatric	80	10.41	3.088	F=0,704
		Geriatric	43	10.79	2.891	
		Neurological	88	10.25	2.933	
		Orthopedic	61	10.11	3.017	
		Cardio-respiratory	10	11.70	1.767	
		Pelvic floor rehabilitation	2	10	1.414	
	Area	North	28	10.89	3.370	F=0,954
		Center	234	10.29	2.950	
		South	22	10.95	2.278	
JCS	Age (range)	22-30	134	12.40	3.892	F=1.423
		31-49	118	12.46	4.065	
		>50	32	13.69	4.067	
	Gender	Male	69	12.36	4.044	t=-0,497
		Female	215	12.64	3.980	
	Profession	Physiotherapist	121	12.80	4.057	F=1.721
		Occupational therapist	54	12.70	3.785	
		Speech therapist	47	11.53	4.413	
		Neuro and psychomotricity therapist	22	10.95	3.970	
		Orthoptist	6	11.67	3.141	
		Professional educator	18	13.28	2.886	
		Podiatrist	10	13.80	3.994	
		Psychiatric rehabilitation technician	6	14.50	2.074	
	Type of structure	Outpatient clinic	44	11.30	4.568	F=4.302**
		Nursing home	16	12.06	4.793	
		Private studio	50	14.34	3.566	
		Home service (cooperative/ASL)	33	11.73	3.044	
		Daycare center	13	13.85	2.609	
		Rehabilitation center	72	11.67	3.768	
		Hospital	56	13.50	3.995	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
	Type of patients	Pediatric	80	11.78	4.109	F=2,014
		Geriatric	43	12.26	4.446	
		Neurological	88	12.67	3.654	
		Orthopedic	61	13.20	3.881	
		Cardio-respiratory	10	14.90	3.107	
		Pelvic floor rehabilitation	2	16	5.657	
	Area	North	28	14.07	4.189	F=2,273
		Center	234	12.43	3.966	
		South	22	12.14	3.745	
SaW	Age (range)	22-30	134	5.82	1.931	F=1.752
		31-49	118	6.28	2.382	
		>50	32	6.38	2.282	
	Gender	Male	69	5.67	2.140	t=-1,796
		Female	215	6.20	2.174	
	Profession	Physiotherapist	121	6.06	2.267	F=0.534
		Occupational therapist	54	6.26	1.935	
		Speech therapist	47	6.28	2.123	
		Neuro and psychomotricity therapist	22	5.73	2.334	
		Orthoptist	6	5.17	1.169	
		Professional educator	18	6.33	2.029	
		Podiatrist	10	5.50	2.677	
		Psychiatric rehabilitation technician	6	5.50	2.881	
	Type of structure	Outpatient clinic	44	6.32	2.399	F=1.048
		Nursing home	16	5.88	1.962	
		Private studio	50	6.42	2.167	
		Home service (cooperative/ASL)	33	5.64	1.917	
		Daycare center	13	5.62	1.895	
		Rehabilitation center	72	5.78	2.196	
		Hospital	56	6.38	2.212	
	Type of patients	Pediatric	80	6.18	2.175	F=0,343
		Geriatric	43	5.93	2.324	
		Neurological	88	6.08	2.129	
		Orthopedic	61	6.16	2.267	
		Cardio-respiratory	10	5.30	1.418	
		Pelvic floor rehabilitation	2	6	2.828	
	Area	North	28	6.50	1.915	F=0,596
		Center	234	6.03	2.231	
		South	22	6.05	1.864	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
WCs	Age (range)	22-30	134	13.6	3.559	F=1.572
		31-49	118	12.85	4.248	
		>50	32	13.94	4.288	
	Gender	Male	69	14	3.750	t=1,639
		Female	215	13.11	3.996	
	Profession	Physiotherapist	121	13.98	3.982	F=4.532**
		Occupational therapist	54	13.43	3.087	
		Speech therapist	47	11.49	4.117	
		Neuro and psychomotricity therapist	22	10.73	4.233	
		Orthoptist	6	15.83	1.169	
		Professional educator	18	14.39	3.346	
		Podiatrist	10	14.9	3.814	
		Psychiatric rehabilitation technician	6	14.83	3.656	
	Type of structure	Outpatient clinic	44	10.91	4.136	F=6.351**
		Nursing home	16	14.19	4.151	
		Private studio	50	15.36	3.729	
		Home service (cooperative/ASL)	33	12.09	3.096	
		Daycare center	13	13.77	3.586	
		Rehabilitation center	72	13.56	3.688	
		Hospital	56	13.48	3.761	
	Type of patients	Pediatric	80	12.23	4.336	F=2,860*
		Geriatric	43	13.70	3.655	
		Neurological	88	13.15	3.496	
		Orthopedic	61	14.39	3.997	
		Cardio-respiratory	10	15.20	2.573	
		Pelvic floor rehabilitation	2	15	7.071	
	Area	North	28	15.18	4.199	F=3,601*
		Center	234	13.09	3.846	
		South	22	13.50	4.262	
EEn	Age (range)	22-30	134	9.75	2.890	F=0.133
		31-49	118	9.55	3.428	
		>50	32	9.66	2.890	
	Gender	Male	69	9.97	3.120	t=0,947
		Female	215	9.56	3.115	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
	Profession	Physiotherapist	121	9.85	3.122	F=1.911
		Occupational therapist	54	9.72	3.043	
		Speech therapist	47	8.79	3.148	
		Neuro and psychomotricity therapist	22	8.5	3.556	
		Orthoptist	6	11.67	2.066	
		Professional educator	18	10.11	2.847	
		Podiatrist	10	10.6	2.547	
		Psychiatric rehabilitation technician	6	11.5	2.074	
	Type of structure	Outpatient clinic	44	8.59	3.392	F=2.935**
		Nursing home	16	9.25	2.978	
		Private studio	50	10.92	3.043	
		Home service (cooperative/ASL)	33	9.76	2.916	
		Daycare center	13	10.62	2.599	
		Rehabilitation center	72	9.17	2.917	
		Hospital	56	9.86	3.147	
	Type of patients	Pediatric	80	9.39	3.355	F=0,976
		Geriatric	43	10	2.936	
		Neurological	88	9.35	3.081	
		Orthopedic	61	9.98	3.041	
		Cardio-respiratory	10	10.70	2.359	
		Pelvic floor rehabilitation	2	12	4.243	
	Area	North	28	11.04	3.636	F=3,370*
		Center	234	9.47	3.009	
		South	22	10	3.207	
Total	Age (range)	22-30	134	85.06	17.330	1.202
		31-49	118	85.67	19.766	
		>50	32	90.66	18.597	
	Gender	Male	69	87.16	19.479	t=0,626
		Female	215	85.55	18.248	
	Profession	Physiotherapist	121	87.52	18.868	F=2.758**
		Occupational therapist	54	88.43	15.807	
		Speech therapist	47	79.77	19.130	
		Neuro and psychomotricity therapist	22	74.82	20.339	
		Orthoptist	6	91.50	14.502	
		Professional educator	18	90.39	14.439	
		Podiatrist	10	90.3	19.38	
		Psychiatric rehabilitation technician	6	94.83	16.618	

WRQoL	Socio-demographic variables	Groups	N	Mean	±SD	t or F values
	Type of structure	Outpatient clinic	44	77.48	21.501	F=3.785**
		Nursing home	16	86.88	19.761	
		Private studio	50	93.32	18.728	
		Home service (cooperative/ASL)	33	83.30	13.799	
		Daycare center	13	91	14.68	
		Rehabilitation center	72	83.67	17.439	
		Hospital	56	89.05	17.392	
	Type of patients	Pediatric	80	82.14	20.253	F=1,727
		Geriatric	43	86.35	18.471	
		Neurological	88	85.88	16.759	
		Orthopedic	61	88.75	18.768	
		Cardio-respiratory	10	95.20	11.915	
		Pelvic floor rehabilitation	2	100.5	26.163	
	Area	North	28	93.46	21.473	F=2,690*
		Center	234	84.96	18.111	
		South	22	86.82	17.584	

*$p<0.05$ **$p<0.01$

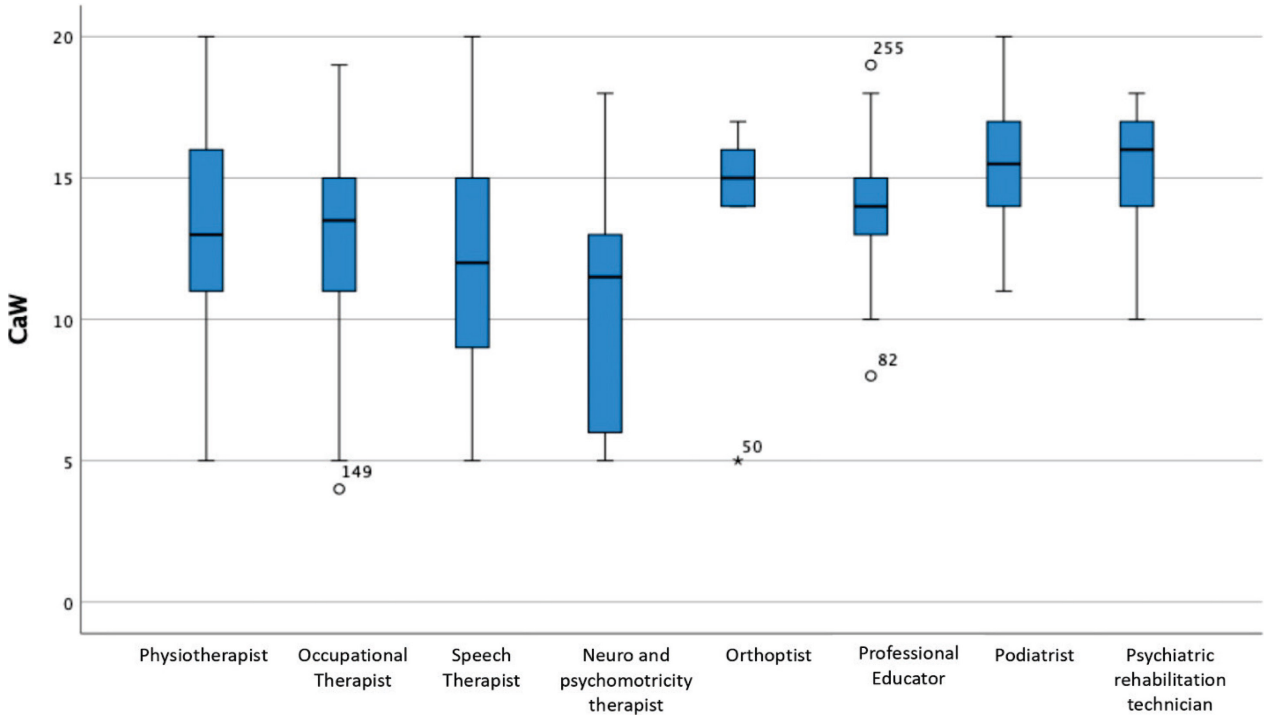

Figure 1. Difference in CaW between professionals

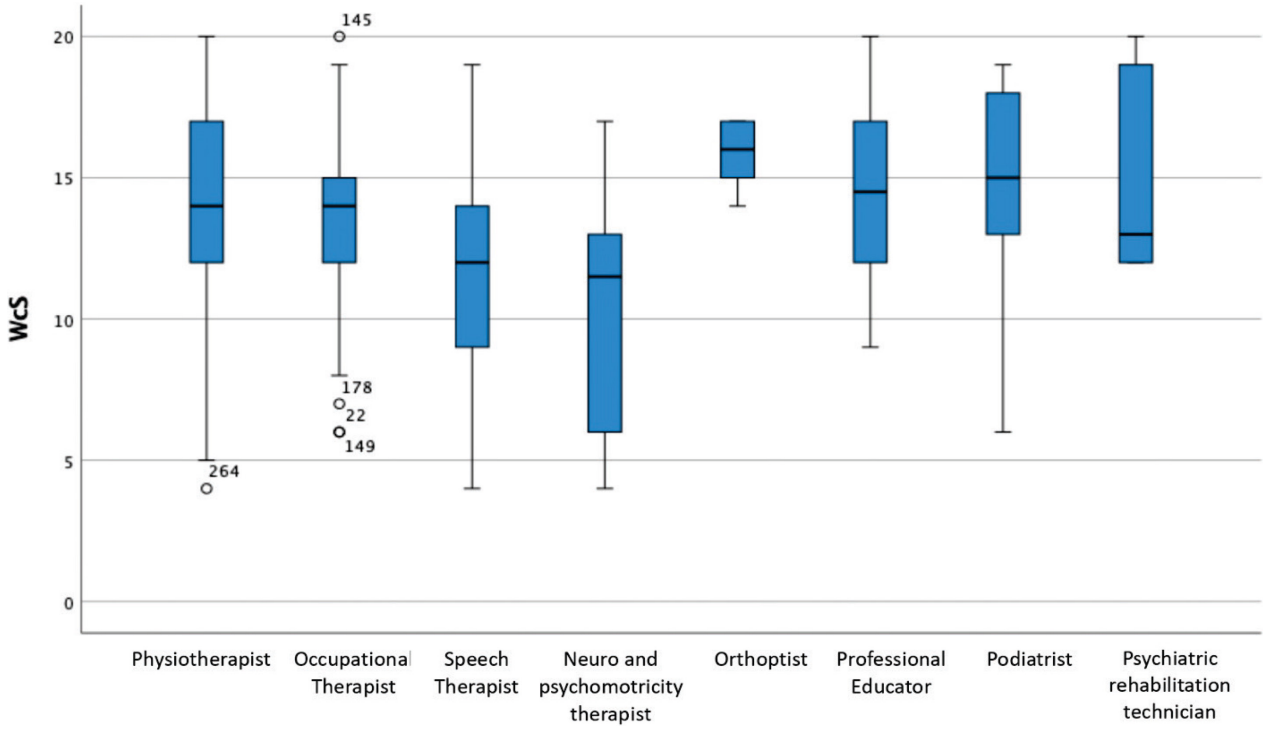

Figure 2. Difference in WcS between professionals

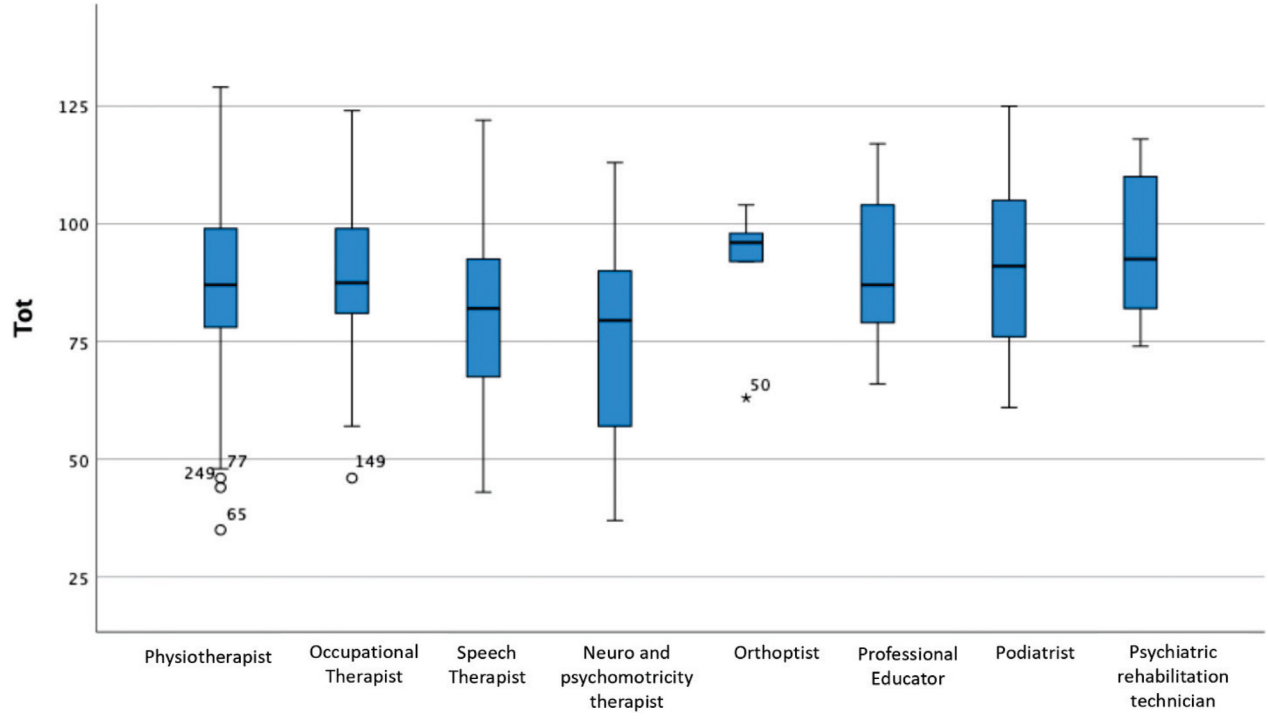

Figure 3. Difference in Total score between professionals

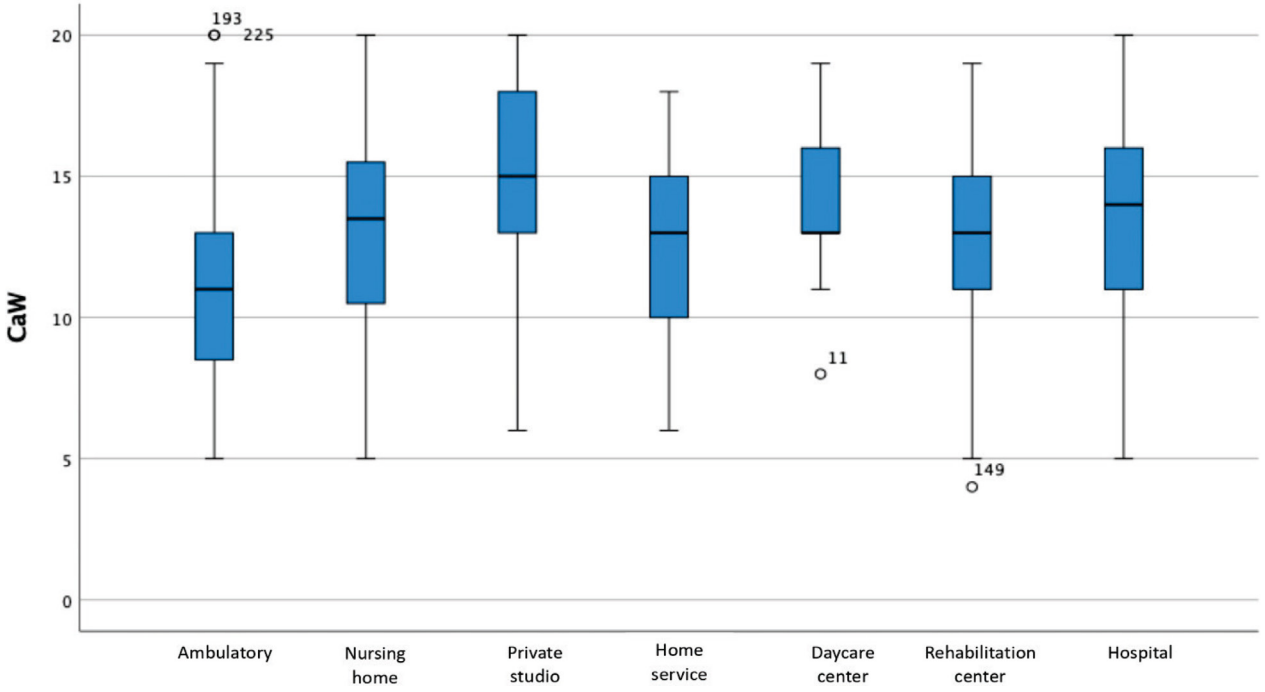

Figure 4. Difference in CaW between professionals who work in different types of structure.

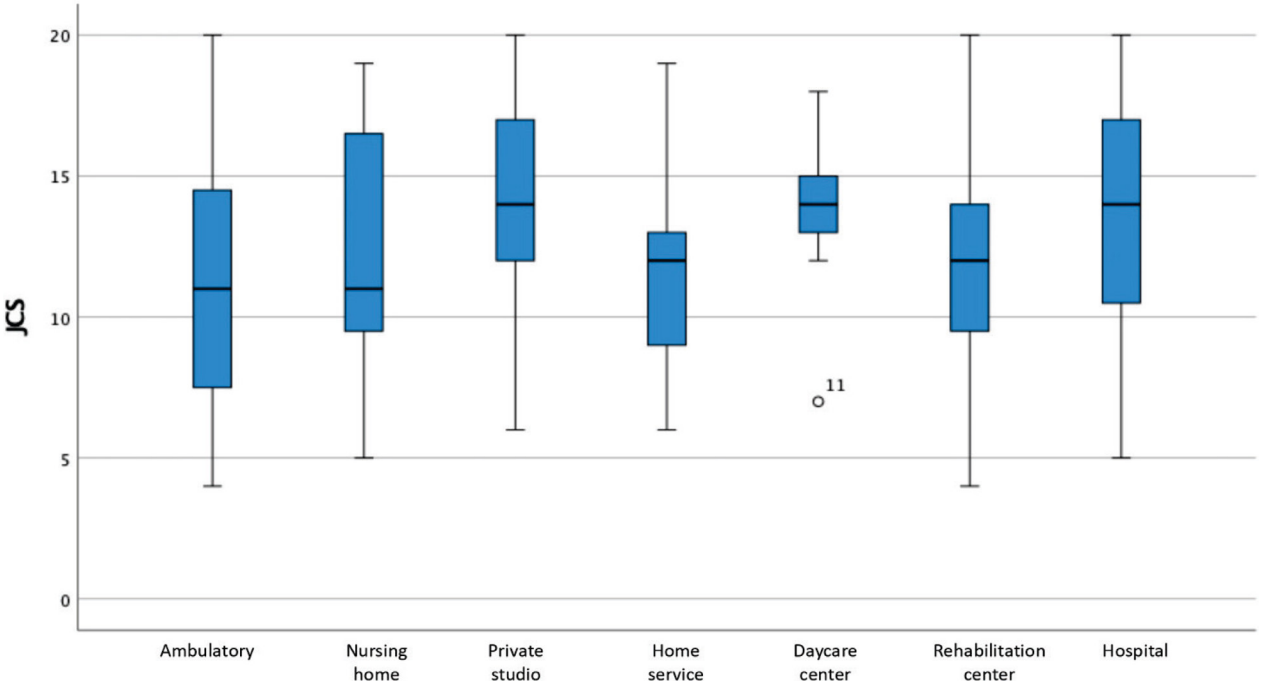

Figure 5. Difference in CaW between professionals who work in different types of structure.

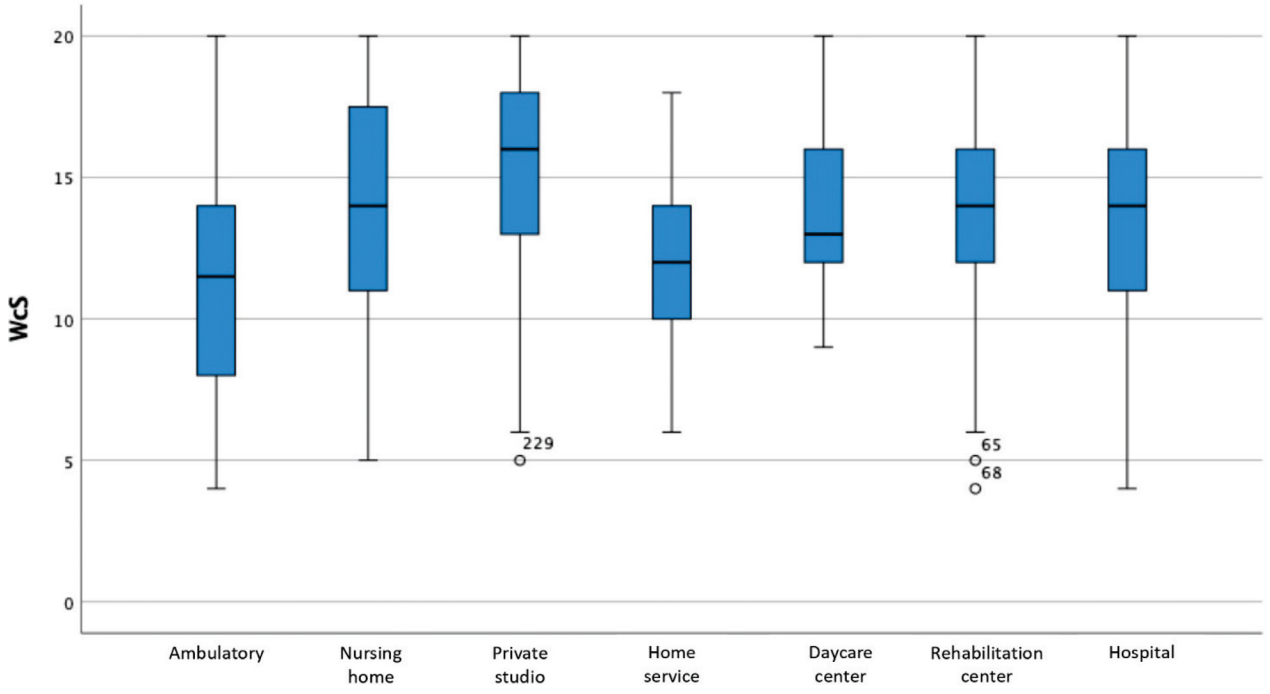

Figure 6. Difference in WcS between professionals who work in different types of structure.

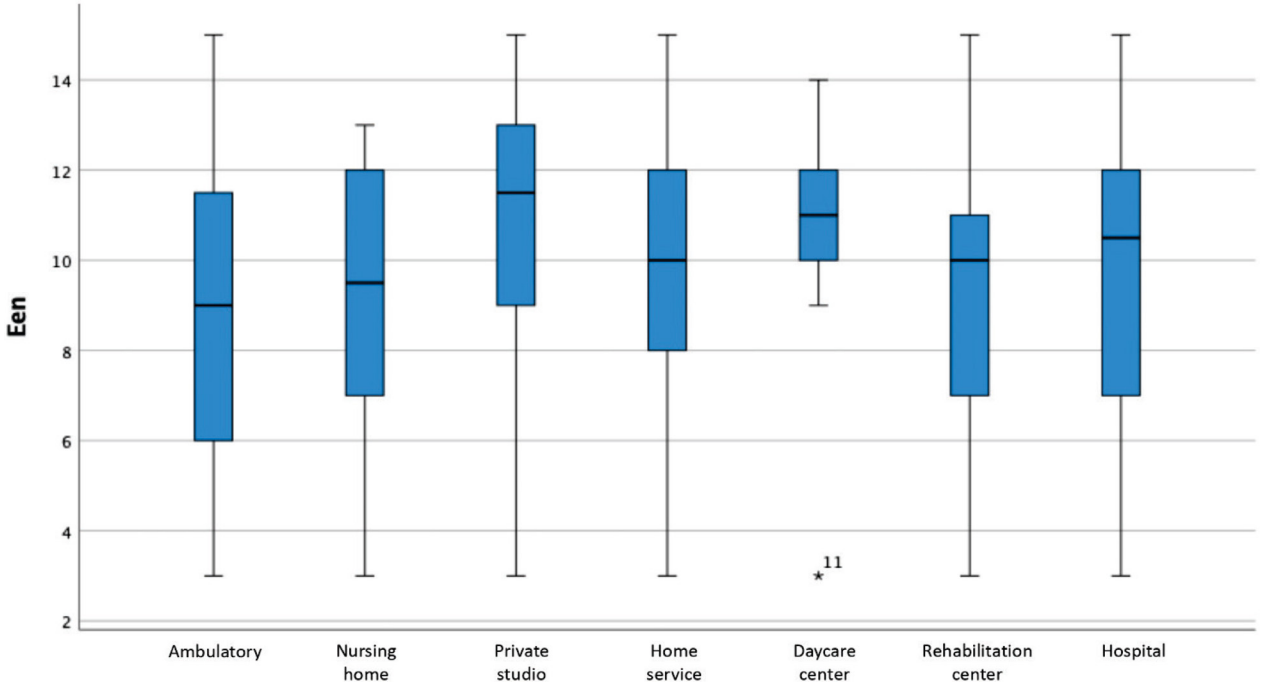

Figure 7. Difference in Een between professionals who work in different types of structure.

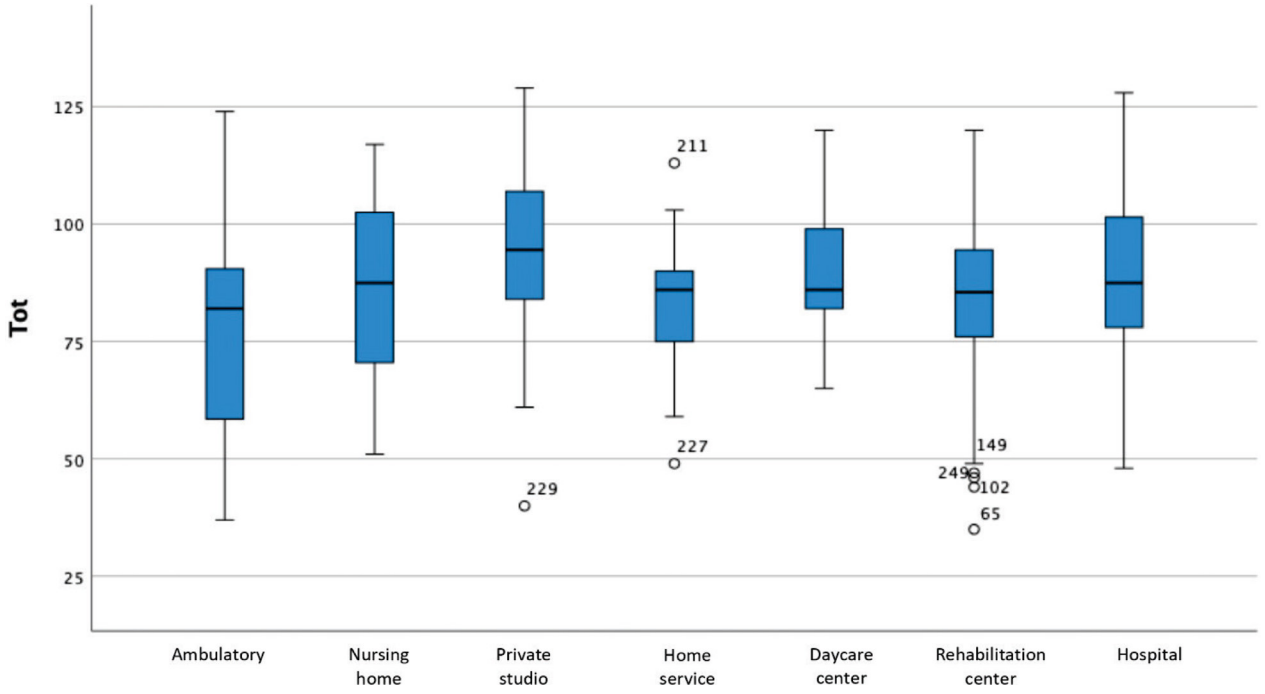

Figure 8. Difference in Total score between professionals who work in different types of structure.

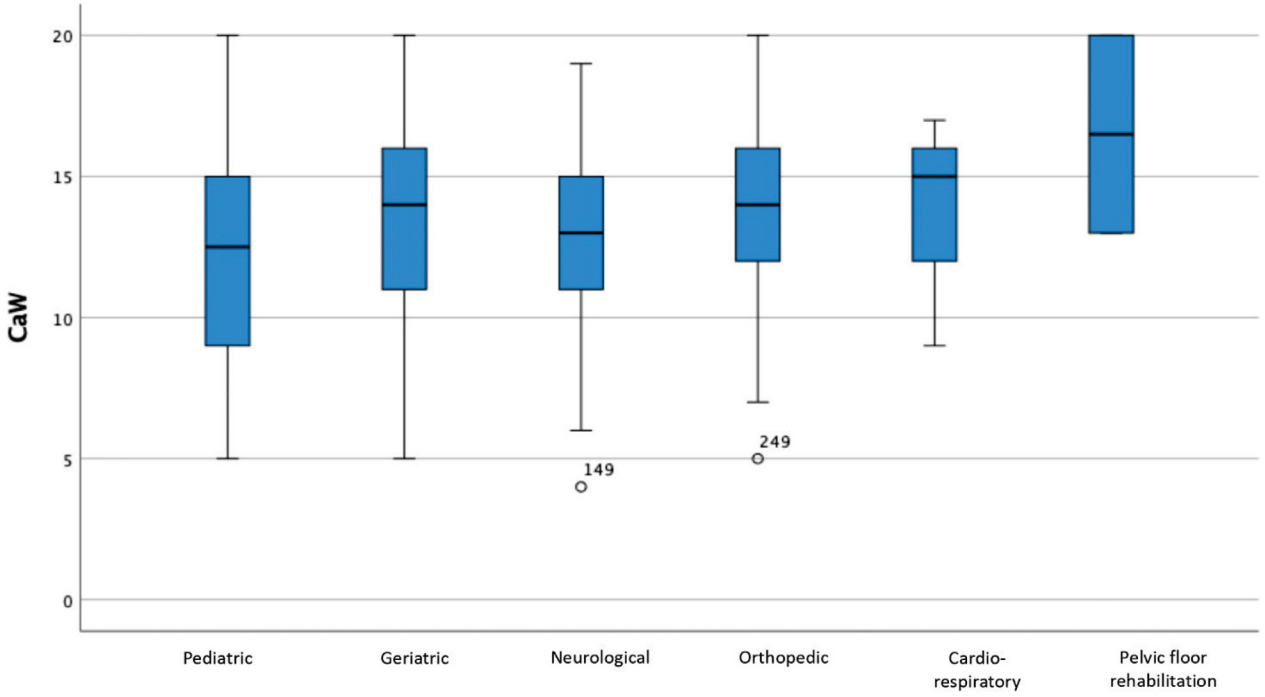

Figure 9. Difference in CaW between professionals who deal with different types of patients.

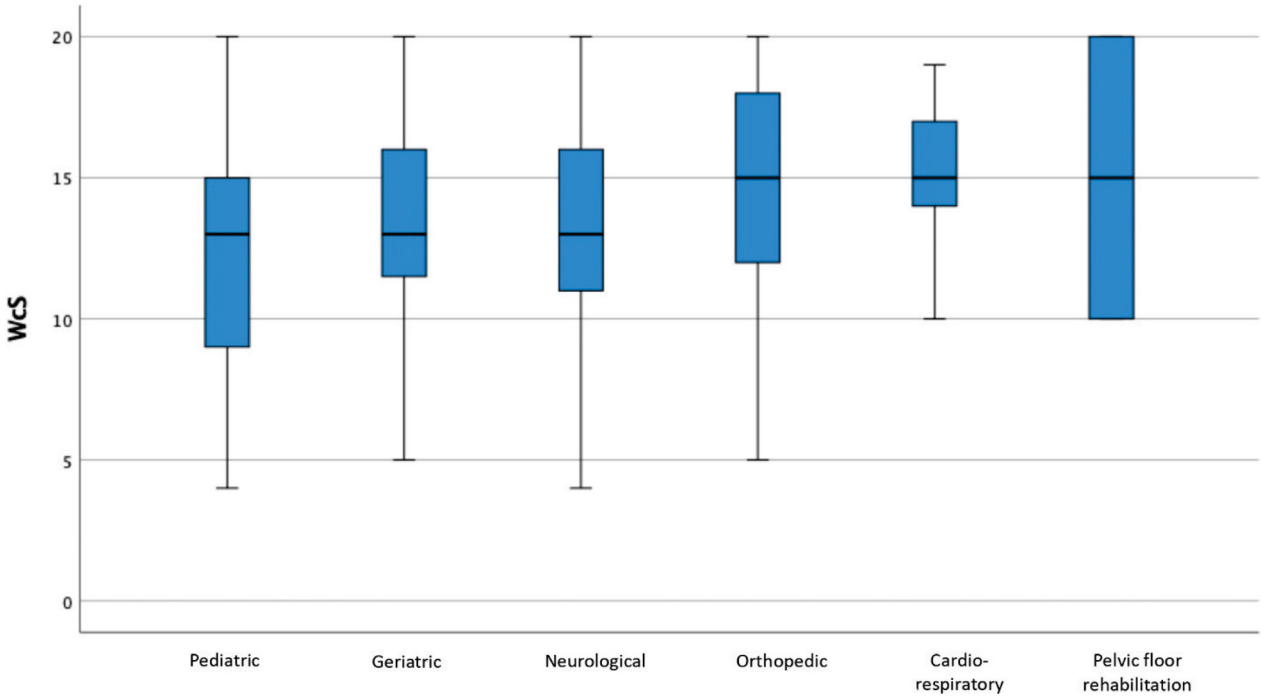

Figure 10. Difference in WcS between professionals who deal with different types of patients.

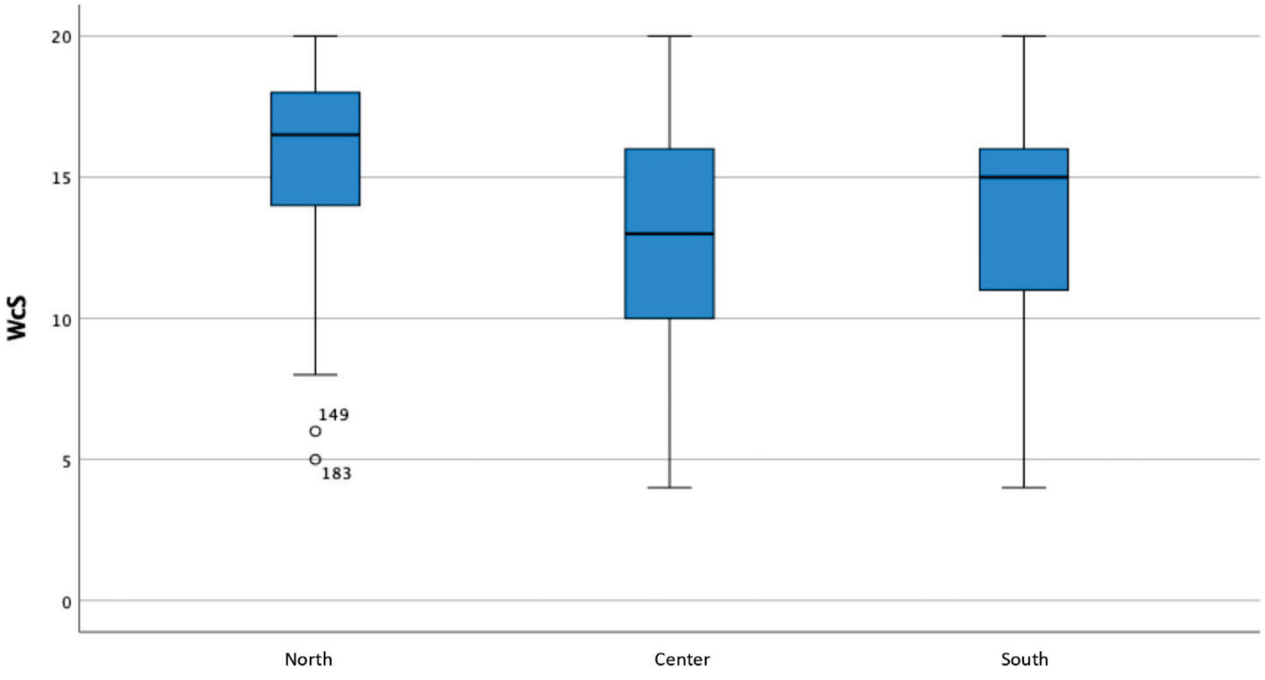

Figure 11. Difference in WcS between professionals who work in different areas of Italy.

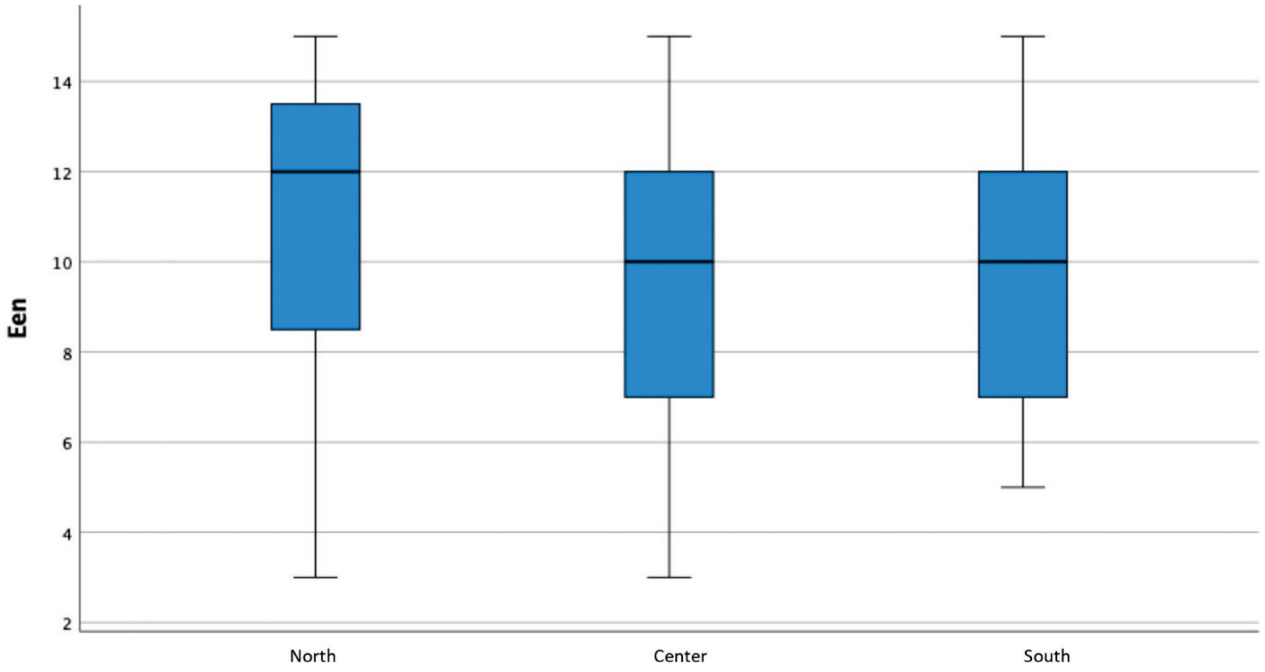

Figure 12. Difference in Een between professionals who work in different areas of Italy.

La Medicina del Lavoro

Case Report

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Return to Work After Release From Prison

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Keywords: Ex-prisoner; Female Employment; Psychiatric Evaluation; Job Fitness; Social Reintegration

Summary

Work preservation is crucial for the reintegration of ex-prisoners and the prevention of recidivism. We describe the application of an interdisciplinary diagnostic protocol (occupational health visit, psychiatric interview, psychological counselling and testing) in the case of a dairy industry worker (female, 45-year-old), released on half-freedom after approximately a year of detention in prison for attempted murder. This crime can seriously hamper job resumption. The evaluation revealed a slightly depressed mood (consistent with recent life events), in the absence of major psychiatric disorders or other disturbances that could compromise working abilities or represent a danger for the coworkers. The patient was, therefore, judged able to resume her job. At six months follow-up, she had fully served her sentence and had returned to her previous job, with good relations with her colleagues. However, she encountered hostility from her employer, which induced her to find a new job as a secretary. Her mental health status was improved. The interdisciplinary approach described here may allow ex-prisoners to return to work by helping the company physician to formulate the judgement of job fitness, offering at the same time suggestions for a rational occupational reintegration.

1. Introduction

Work preservation after release from prison is a main issue for social reintegration and to prevent recidivism [1, 2]. After detention, however, workers experience complex health challenges and problems resettling into the community. Consequently, interventions to improve employment should focus not just on starting or resuming a job but also on ensuring that work is of good quality and that the individual has the skills and support to sustain employment [3]. In this context, the judgment of job fitness may be particularly challenging and require collaboration between the occupational physician (analysis of task features and related risks) and the psychiatrist (job adaptation to mental status, evaluation of possible risk for coworkers). This synergistic approach may serve multiple purposes: to provide indications about working capabilities and modalities of job maintenance, minimize health risks, and improve prescription compliance, allowing a safe and well-informed return to work.

We describe here the application of an interdisciplinary diagnostic protocol (used successfully at our Institute since the beginning of the 2000s for work-related psychopathological issues [4, 5]) in the case of a female worker in a half-freedom regime after detention for attempted murder. This conviction can severely hinder a return to employment. No previous case report has documented the possible role of this integrated strategy for work resumption after jail for serious crimes.

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2. CASE STUDY

A 45 year-old woman (ex-prisoner in half-freedom) was referred to our Institute by her company physician for diagnostic in-depth investigations aimed at job fitness evaluation, in accordance to the Italian Legislative Decree n. 81/2008 (article 39, paragraph 5). The subject was evaluated using an interdisciplinary protocol: occupational medicine, psychiatry, and psychology (counselling and testing).

2.1. Medical and Occupational History

Nothing relevant was found in family, physiological and remote pathological anamnesis. Legally separated from her husband, without children. Active smoker (10 cigarettes/day) since age 35. After completing her studies (high school degree), the patient started working at the age of 20 at the municipal dairy of her hometown as an administrative office worker.

At the age of 39, after separating from her husband, with whom she was sharing the office at work, the patient was diagnosed with reactive anxious-depressive syndrome and asked for a task change. She was, therefore, transferred to the management and storage (cold room) of unsold or expired dairy products. Equipped with safety shoes and subjected to annual sanitary surveillance (occupational risk factors: mechanical traumatic agents, manual handling of loads, cold microclimate, chemical disinfectants). Day shifts (08.00-14.40, Monday to Saturday). Occupational activity had been interrupted 17 months before our evaluation due to incarceration.

2.2. Judicial Vicissitudes

After the breakup with her husband, the patient began a relationship with another partner, who turned out to be addicted to illicit substances, not inclined to work and violent. During a quarrel, the patient, fearing to be physically attacked (as already happened previously), stabbed the man in the abdomen with a kitchen knife, causing laceration of his spleen and haemoperitoneum. The man was saved by emergency surgery, and the patient was tried and convicted for attempted murder (with plea bargaining of the sentence and recognition of mitigating circumstances). After about a year in prison, she was granted home detention and then half-freedom (with the possibility of returning to work).

2.3. Physical Examination

At our evaluation, the patient was severely underweight (height: 163 cm; weight: 42 kg; body mass index: 15.8). Nothing else was relevant.

2.4. Neuropsychological Evaluation

Global cognitive function was largely normal, with a mild selective deficit in the verbal working memory capacity (without interference on the level of autonomy in daily life activities).

2.5. Psychiatric Evaluation

At the psychiatric interview, the patient retraced her life story, focusing on the separation from her husband and her most recent legal vicissitudes. These traumatic events had an important emotional impact, configuring a situation of acute stress in a subject with personality aspects characterized by emotional fragility, poor insight capacity and a tendency to manifest depressive symptoms in response to environmental triggers.

A slightly depressed mood, consistent with the life events reported, was found. The woman was strongly intolerant of the continuation of the interruption of her work activity, in particular of the loss of her rhythm of life, her work role, and the monthly economic income, which were fundamental for maintaining her autonomy.

No major psychiatric disorders or other psychological disturbances that could compromise working abilities were identified.

2.6. Diagnostic Conclusion and Advice for Work rRsumption

Overall, the multidisciplinary evaluation highlighted a slightly depressed mood, consistent with recent life events, in the absence of major psychiatric disorders. Presence of marked discomfort due to

the interruption of work activity and the consequent absence of economic remuneration. The patient was judged able to resume the job she did before the legal events, with the prescription to avoid particularly stressful conditions.

2.7. Follow-up

At six months follow-up, the patient had served her full sentence and was once again a free woman. At the same time she had returned to work, with good relations with her colleagues but encountering a certain hostility from her employer, who (according to the patient) called her "privileged" for having returned (considering her past), and often left her alone to manage two cold rooms, without giving her the opportunity of getting a license to drive the forklift. Therefore, also due to the recent onset of lumbar disc herniation with limitation in the movement of loads, she had resigned and found a new job as a secretary at an insurance company.

The state of health was improved overall, with weight gain and regression of the depressive disorder.

3. Discussion

In all countries of the civilized world, work plays a pivotal role in prisoners' rehabilitation and social reintegration [6]. In Italy, article 15 of the Penitentiary Regulation (Law n. 354/1975) identifies work as one of the elements of re-educational treatment, establishing that, except in cases of impossibility, the convicted person should be guaranteed employment. This principle applies even more to prisoners in half-freedom, as in the case described here. Indeed, half-freedom represents an example of individualized treatment with progressive reintegration, that is granted precisely to allow the prisoner to spend part of the day outside the penitentiary institution to participate in work, educational or otherwise useful activities for resocialization (Italian Penitentiary Regulation, art. 48). Unfortunately, employment of convicts encounters considerable difficulties in practical application, due to prisons overcrowding, as well as various other political and organizational problems. Less than a third of Italian prisoners are working [7].

Occupational and social reintegration at the end of the sentence is even more problematic, especially for women [8] or high-profile offenders [9]. When searching for a job, former prisoners experience several barriers and difficulties related to their deficits in human and social capital (e.g., low education, poor employment experience, limited skills), psychiatric disturbances (e.g., substance use disorders), and the stigma associated with having a criminal record [10]. Generally, incarcerated women have lower education and more significant gaps in their occupational histories. Moreover, under a male model of corrections, females have less access to training and education while in prison, and it is harder for them to find a job upon release because they frequently have to care for others [8].

Unemployment after release from prison is strongly associated with detrimental health effects (especially mental problems), economic difficulties, and a high risk of committing new crimes [2, 8].

In the case of individuals wishing to return to work after violent crimes (such as the woman described here), the company occupational physician ("medico competente" ex Italian Legislative Decree n. 81/2008, who must by law evaluate the fitness and the suitability for the specific task) generally faces a double problem: not only evaluating the compatibility of the job with the changed psychophysical conditions of the individual, but also excluding that his/her re-employment could constitute a risk for other workers. In the reported case, the company physician referred the subject to us for a second-level evaluation. We, therefore, used the interdisciplinary approach, which has already been proven successful (at our Institute), to diagnose work-related psychological problems, to define job fitness in subjects with psychiatric disorders, and to address such patients towards an appropriate therapeutic path to promote their psychological well-being and occupational reintegration [4, 5].

After occupational medicine examination, psychiatric interview, and psychodiagnostic testing, no major psychiatric disorders were identified. However, the patient presented a slightly depressed mood, reactive to the separation from her husband (a well-known major stressful event [11]) and mostly to her recent imprisonment. This is not surprising as

the prison climate is notoriously detrimental to the mental health of inmates, especially women [12, 13].

The state of unemployment was a further factor of serious discomfort, and the patient was strongly motivated to return to work. Given the absence of physical or psychological disturbances that could prevent the resumption of the previously performed task, compromise her working abilities, or constitute a danger to her coworkers, we suggested that employment recovery, besides not being contraindicated, could have an important therapeutic and rehabilitative value. Indeed, our advice was followed, and the patient resumed work without encountering relational problems with her colleagues and with a significant improvement in her mental health.

However, at follow-up, she reported hostility from her employer, which, in combination with the concurrent onset of back problems, had led her to seek a different job. This confirms, once again, that occupational recovery after detention is a process that encounters considerable obstacles and prejudices [8-10].

Some prisons offer educational and skill development programmes, work programmes, and supervised work release. These operate on the assumption that improving the prison population's limited education and work experience will increase the likelihood of successfully securing future employment. Following the release, support programmes for employment, provided by statutory and non-statutory services, vary in their approach from focusing singularly on employment to those which offer more holistic interventions, incorporating help in finding work, preparation for employment, support, and psychological guidance [3]. There is currently encouraging (though limited) evidence for the effectiveness of such interventions. For example, prisoners who had participated in a supervision program of the Israeli Prisoner Rehabilitation Authority showed better integration into employment, a higher wage level, and a lower rate of reincarceration [1]. A recent meta-analysis of randomised controlled trials (conducted in the USA) demonstrated a significant increase in the number of people starting employment and the amount of time worked following release. However, no evidence of effectiveness was found on indicators of sustained employment [3].

We believe that programs aimed at prisoner employment should include psychophysical evaluation, possibly task-oriented. From this perspective, the multidisciplinary approach successfully used for the subject of this report seems promising. Studies on other similar patients are needed in the future to confirm our uncommon preliminary observation. However, the experience documented in the single case described, which demonstrates the real possibility of work resumption for a female worker convicted for a violent crime, may serve as a reference for the resolution of other similar cases.

4. Conclusion

In the case reported here, our evaluation favoured the resumption of employment and improvement of mental health conditions. The interdisciplinary approach utilised can allow ex-prisoners to keep their jobs or find new employment, helping the company occupational physician formulate the judgment of fitness and suitability for the job while at the same time offering suggestions for a rational return to work.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. The ethics committee of ICS Maugeri IRCCS approved the utilization of the patient's clinical data (in anonymous form) for the present scientific report.

Informed Consent Statement: Informed consent was obtained from the subject involved in the study.

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

Author Contribution Statement: S.M.C. and F.S. are responsible for the manuscript's design, interpretation, and writing; D.M. performed the occupational medicine evaluation and the follow-up and contributed to the psychological assessment. C.N. performed the psychiatric evaluation and contributed to the psychological assessment.

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