

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

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ABSTRACT

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

1. INTRODUCTION

Despite the gradual introduction of bans in various countries, asbestos exposure in the construction sector remains a serious risk factor for workers assigned to various tasks due to the widespread use of asbestos in building materials during a large part of the last century, from the 1930s to the 1990s. Moreover, a lack of awareness also of indirect or secondary asbestos exposure may have affected several types of workers, such as carpenters, electricians, plumbers, bricklayers and welders. With regard to cases of malignant mesothelioma (MM) exposed in construction, the widespread interchangeability

of jobs among workers should be emphasized; this is especially true in small and medium construction companies, where recognizing different risk profiles is difficult. Furthermore, construction activities are normally performed without the use of personal protective equipment for the respiratory tract.

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

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

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

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

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

Dement (2009) studied construction and craft workers employed at the Department of Energy nuclear sites in the USA and found significant excess mortality for mesothelioma with an SMR of 5.93, (95%CI 2.56-11.68) [25]. These data were confirmed in the subsequent follow-up in a sample of 24,086 workers with an SMR of 6.38 [26]. High risks of mesothelioma have also been reported for elevator construction workers [27], drywall construction workers [28], and asbestos removal workers [4].

Mesothelioma cases occurring during the home renovation were also described [29, 30]. Franzblau's (2020) [31] study of asbestos-containing materials in abandoned residential dwellings demolished between 2014 and 2017 in Detroit confirmed that asbestos was used in a variety of common construction materials and found asbestos-containing materials in flooring, roofing, siding, and duct insulation as well as in pipe insulation, cement, siding, flooring, roofing, sealants, caulks, and glazes. The type of asbestos generally present was chrysotile. This study confirms an existing asbestos risk for workers and the general population during renovation/demolition work.

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

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

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

2. METHODS

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

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

Safety and Employment Services (FORMEDIL)' [40], as shown on Supplementary Table 1.

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

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

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

3. RESULTS

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

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

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

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

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

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

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

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

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

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

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

4. DISCUSSION

Our findings on an extensive series of Italian cases of mesotheliomas show that the use of asbestos led

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

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

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

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

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

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

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

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

Moreover, in some geographic areas of Italy, several occupational groups (e.g., plumbers, insulators, pipe fitters, carpenters, and electricians) employed in the construction sector can have worked in different industrial settings other than in the maintenance and refurbishment of buildings. For instance, in the coastal area of Northeastern Italy (Trieste-Monfalcone), where shipbuilding and ship repairing

were the predominant industrial activities in the past, construction workers can have been exposed, sometimes accidentally, to asbestos during other work activities in the shipyards, due to the extensive use of asbestos-containing materials for insulation and fire protection.

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

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

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

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

47% among bricklayers, 11% among plumbers and laborers, 6% among carpenters and building contractors, followed by 4.8% among electricians and finally 3.6% among insulators. These data confirm the prevalence of non-specialized “interchangeable” jobs. Of all the jobs analyzed, 64.8% are classified as having certain exposure. For the jobs for which 50% and more are classified as certain exposure, the

most frequent are, in decreasing order, the following: insulators, plumbing workers, carpenters, asphalters, mechanics, machine operators, electricians, and bricklayers (Table 1).

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

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

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

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

Despite the high number of cases considered at the national level, the major limitations of our study must be highlighted. The exposure assessment is qualitative, and the ability to identify the specific modalities is not entirely consistent among regional registries.

Recall bias cannot be excluded due to the collection of data on exposures even many years their occurrence at the time of diagnosis of the disease; however, this possible bias was minimized by the structured questionnaire used, and our analyses are based on job title and exposures reported in the cases' questionnaires evaluated by expert industrial hygienists.

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

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

5. CONCLUSIONS

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

of removing asbestos-containing materials can lead to further significant exposure [11, 33].

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

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APPENDIX

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

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

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

*Used in the ReNaM software.

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

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

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