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Mortality study in an asbestos cement factory in Naples, Italy

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Summary. The objective of this paper is to investigate mortality among 1247 male asbestos-cement workers employed in an asbestos-cement plant located in Naples. The cohort included 1247 men hired between 1950 and 1986. The follow-up began on January 1st 1965. The vital status and causes of death were ascertained up to December 31 2005. Cause-specific mortality rates of the Campania Region population were used as reference. Relative risks were estimated using Standardized Mortality Ratios (SMRs), and the confidence intervals were calculated at a 95% level (95% CI). A significant increase in mortality was observed for respiratory disease (81 deaths; SMR = 187; 95% CI = 149-233), particularly for pneumoconiosis (42 deaths; SMR = 13 313; 95% CI = 9595-17 996) of which 41 deaths for asbestosis (SMR = 43 385; 95% CI = 31 134-58 857), for pleural cancer (24 deaths; SMR = 2617; 95% CI = 1677-3893), for lung cancer (84 deaths; SMR=153; 95% CI = 122-189) and for peritoneal cancer (9 deaths; SMR = 1985; 95% CI = 908-3769). Non-significant increases were also observed for rectum cancer (6 deaths; SMR = 157; 95% CI = 58-342). In conclusion, consistently with other mortality studies on asbestos-cement workers performed in different countries, an increased mortality from asbestosis, lung cancer, pleural and peritoneal mesothelioma was detected in the present cohort.

Key words: asbestos-cement workers, pleural cancer, lung cancer, peritoneal cancer, mortality study.

Riassunto *(Studio di mortalità in una azienda del cemento amianto a Napoli)*. Obiettivo del presente studio è descrivere la mortalità di una coorte di 1247 lavoratori della Eternit di Bagnoli (NA). È stato condotto uno studio di coorte, ristretto agli uomini, che ha incluso 1247 soggetti assunti a partire dal 1950 sino al 1986, con follow up iniziato nel 1965. Lo stato in vita e le cause di morte sono state accertate al 31/12/2005. La mortalità osservata è stata confrontata con quella attesa in base ai tassi di riferimento della popolazione campana. Sono stati calcolati i rapporti di mortalità standardizzati (SMR) per il periodo 1965-2005 ed i corrispondenti intervalli di confidenza al 95% (IC 95%). Un incremento significativo della mortalità è stato osservato per le malattie respiratorie (81 deceduti; SMR = 187; IC 95% = 149-233), in particolare per le pneumoconiosi (42 deceduti; SMR = 13313; IC 95% = 9595-17996; dei quali 41 deceduti per asbestosi; SMR = 43385; IC 95% = 31134-58857), per tumore maligno della pleura (24 decessi; SMR = 2617; IC 95% = 1677-3893), per tumore del polmone (84 decessi; SMR = 153; IC 95% = 122-189) e per tumore maligno del peritoneo (9 decessi; SMR = 1985; IC 95% = 908-3769). Un incremento non statisticamente significativo è stato osservato per il tumore del retto (6 decessi; SMR = 157; IC 95% = 58-342). In conclusione, i risultati del presente studio, coerentemente con l'insieme dell'evidenza epidemiologica relativa agli effetti sulla salute dell'esposizione a cemento-amianto, mostrano un'aumentata mortalità per asbestosi, cancro polmonare, mesotelioma pleurico e peritoneale.

Parole chiave: lavoratori del cemento amianto, tumore della pleura, tumore del polmone, tumore del peritoneo, studio di mortalità.

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INTRODUCTION

Occupational asbestos exposure can determine several diseases, which have been reported for many decades; among them, asbestosis [1- 3], lung cancer [4-6] and mesothelioma [6-8].

Recently the International Agency for Research on Cancer (IARC) confirmed former evaluation that asbestos causes cancer in humans. Regarding cancer sites, evidence is sufficient for lung, larynx, ovary cancers and mesotheliomas, while there is limited evidence for colorectal, pharynx and stomach cancers [9].

Many studies conducted in Europe and North America showed higher mortality risks for lung and pleural cancer in asbestos-cement workers [10-18].

Italian studies conducted among asbestos-cement workers in Piedmont [19, 20], Emilia-Romagna [21], Tuscany [22], Lombardy [23-25], Apulia [26, 27], Sicily [28], Marche [29] and Venetia [30] contributed to the epidemiological evidence. Mortality among workers of the asbestos-cement factory located in Naples (Campania region) had not been previously studied [31].

The aim of this paper was to investigate the mortality in 1950-2005 of 1247 asbestos-cement workers employed in the Bagnoli Eternit plant.

Bagnoli Eternit plant, active from 1938 to 1986, was located in the western Naples district and this area has been included by Law no. 388/2000 among Italian polluted sites of national interest for environmental remediation [32]. Other plants were located in the same area namely the Italsider steel plant, active from 1910 until 1992, and the Montecatini chemical plant, active from the 1930s to 1991.

Epidemiologic studies in polluted sites contribute to describe population health status related to environmental risk factors [33, 34]. Particularly, occupational cohort studies can estimate the occupational risk component in the resident population [35].

METHODS

The plant

The Eternit factory located in Bagnoli, a district of Naples, started its activity in 1939. Plant production activities virtually came to halt in mid-1943 and resumed in early 1947. Production ended permanently in 1986.

The Bagnoli Eternit plant information has been compiled based on the scientific paper published in 1960 [31] and the judicial examination carried out in 1980 [36].

The plant consisted of one large hall functionally divided into three Departments. In the Tubes Department asbestos-cement pipes and high-pressure pipes were produced. The asbestos bags deposit was located at the bottom of the Sheet Department, where asbestos-cement plain and corrugated sheets (for roofs, tanks, tubes with square or rectangular sections and chimneys) were produced. Finally, there was the Tile Department, where tiled floors were processed.

Asbestos bags were emptied by hand into the edge runner where asbestos was broken up. Asbestos was then mixed with cement into a mixing tank in 20% proportion. After seasoning, the pipes were finished off by cutting with a circular saw that caused a major emission of dust; a similar dispersion took place during the tubes head turning.

Asbestos fiber types used in the plant were blue long-fiber (crocidolite) and yellow mid-fiber (amosite) from South Africa; white mid-fiber from Canada; white short-fiber (chrysotile) from Italy. The percentage of different asbestos types varied depending on the handworks that were produced: high pressure pipes showed elevated long-fiber asbestos percentage; sheets showed 50% of short-fiber asbestos.

Airborne asbestos fibers concentration data showed high exposure, but there were insufficient data to estimate individual cumulative doses. Only generic dust monitoring data were in fact performed in the Sixties. In 1979, 64 environmental airborne asbestos fiber samplings (differentiated also for crocidolite), were collected in different areas of the plant *(Table 1)*. Average total concentrations of asbestos fibers were in the range of 0.030 and 1.033 ff/cc, while crocidolite values ranged between 0.250 and 0.526 ff/cc. These measurements showed that in 1979 asbestos environmental pollution was still widespread, although the company reported from 1974 to 1978 relevant investments to reorganize the plant and improve safety.

Cohort description

Since its opening, in 1939, the Bagnoli Eternit plant hired 2340 workers (1924 males and 416 females). This study includes 1247 male workers who were hired between 1950 and 1986. The choice of restricting the cohort to workers hired after 01.01.1950 is due to the difficulty of following-up subjects hired before 1950. We studied only males because only 234 females were hired after 1950. Workers were identified on the basis of the factory rosters, where all workers were recorded on the day of hiring and on the day of retirement. Four subjects (0.3%) listed in the factory rosters were excluded from the cohort because of lack of information. These rosters were also the source for defining job histories.

The follow-up period ranged from January 1st, 1965 through December 31 2005 and the study subjects contributed for a total of 39 933 person-years of observation.

Vital status was ascertained for 1225 workers (98.2%), using records provided by the offices of vital statistics of the municipalities of last residence of cohort members. Twenty-two subjects (1.8%) were lost to follow-up. Out of a total of 508 deaths (40.7%), 505 occurred during the follow-up period (1965-2005), and 3 subjects died before 1965.

Causes of death were ascertained by Local Health Unit Epidemiological Services for 70.4% of the deceased subjects. For the remaining 29.6%, individual records were linked to the anonymous Italian mortality file by the National Bureau of Statistics (ISTAT).

Table 1 | *1979 environmental airborne generic asbestos fiber and crocidolite samplings collected in different areas of the Bagnoli Eternit plant (Naples, Italy)*

Number of samples	Sampling areas	Generic asbestos fiber (average ff/cc)	Crocidolite (average ff/cc)
4	Seasoning shelf area next to the dressing rooms	0.060	Not detected
4	Seasoning shelf area	0.062	Not detected
4	Seasoning shelf area	0.055	Not detected
4	Seasoning shelf area	0.505	0.260
4	Hallway area aside the workshop	0.200	Not detected
4	Longitudinal hallway – PULPERS establishment area	0.600	0.310
4	Longitudinal hallway – ducts machine area	0.775	0.387
4	Longitudinal hallway – 5mt pipes machine area	0.850	0.425
4	Longitudinal hallway – cutting machine area	0.900	0.460
4	Longitudinal hallway – RCM and TTT/500 lathes area	0.775	0.398
4	Area next to the RCM lathe	0.825	0.422
3	Area next to the BELL lathe	1.033	0.526
4	Area next to the slab machine	1.000	0.510
2	5mt pipes machine back area	0.700	0.360
2	Handmade vessels output area	0.095	Not detected
2	Handmade vessels output area	0.030	Not detected
2	Asbestos warehouse area	0.150	Not detected
4	Area below asbestos loading hoppers	0.550	0.250

The record linkage was based on the following keys: gender, place and date of birth, place and date of death. Overall, causes of death were ascertained for 474 (93.9%) out of 505 subjects deceased after 1965. Causes of death remained unknown after the ISTAT linkage for 31 deceased subjects (6.1%).

All subjects contributed to the total person-years of observation until the latest available record. The underlying causes of death were coded according to the International Classification of Diseases, following the Eighth Revision (before 1980) and the Ninth Revision (from 1980 onwards).

In addition to the cohort mortality study, a validation of death certificates reporting asbestosis or pleural and peritoneal neoplasm was performed by a record linkage, respectively with the Italian Insurance Institute for Occupational Diseases and Injuries (INAIL) and the Italian National Mesothelioma Registry – Campania Regional Centre [37].

Statistical analyses

The number of deaths expected in the cohort was estimated on the basis of Campania mortality rates provided by the Environmental Epidemiology Unit at Istituto Superiore di Sanità on the basis of National Institute of Statistics (ISTAT) data. Cause, gender, age and calendar year-specific mortality rates of Campania population were available only for the period 1970-2002. For the period 1965-69 we thus applied mortality rates of the period 1970-1975, while rates of the period 2000-2002 were used to estimate 2000-2005 mortality.

The relative risks were estimated using Standardized Mortality Ratios (SMRs-%), and the confidence

Table 2 | *Cohort study of asbestos cement workers in Naples, Italy: descriptive information*

Status at follow-up	**no.**	**%**
Alive	717	57.5
Deceased *	508	40.7
Lost to follow-up	22	1.8
Total	1247	100
Year of first exposure	**no.**	**%**
1950-1964	930	74.6
1965-1974	168	13.5
1975-1986	149	11.9
Age when first exposed	**no.**	**%**
< 20	138	11.1
20-29	695	55.7
30-39	300	24.0
40-49	98	7.8
50-59	16	1.3
Duration of exposure, stratified by period of first exposure	**Mean**	**DS**
1950-1964	16.1	10.7
1965-1974	9.6	6.8
1975-1986	4.7	2.5
Time since first exposure, stratified by period of first exposure (latency)	**Mean**	**DS**
1950-1964	41.1	10.8
1965-1974	34.4	5.2
1975-1986	25.5	3.5

**: 33 cause of death not known; 3 deaths occurred before 1965.*

intervals were calculated at 95% confidence level (95% CI), assuming the Poisson distribution of the number of observed deaths.

Duration of exposure was defined as the total duration of employment in the factory. Latency was defined as time elapsed since first employment to the date of death. Year of first exposure was defined as the calendar-year when the worker was first hired in the factory.

Analyses were carried out using OCMAP PLUS v 3.10 (University of Pittsburgh, PA, USA) and STATA 11 (Stata College Station, TX, USA).

RESULTS

A total of 1247 men were included in the cohort *(Table 2)*. As indicated in the Methods section, follow-up was completed for 98.2% of the subjects. 508 subjects died, 3 of which before 1965. During 1965-2005, the cohort contributed 39 933 person-years of observation. Causes of death were ascertained for 93.9% of the 505 subjects deceased after 1965.

Mortality for all causes was slightly lower than expected (505 observed; SMR 93.4; 95% CI: 85.4-101.9) *(Table 3)*. The cohort showed statistically significant increase in mortality for all malignancies (195 observed; SMR 124.5; 95% CI: 107.6-143.2), peritoneal malignancies (9 observed; SMR 1985.3; 95% CI: 907.7-3768.8), respiratory tract cancers (114 observed; SMR 184.6; 95% CI: 152.3-221.8), lung cancer (84 observed; SMR 153; 95% CI: 122.0-189.4), pleural malignancy (24 observed; SMR 2616.6; 95% CI: 1676.5-3893.3). Rectal cancers mortality was higher than expected, the excess was not statistically significant (6 observed; SMR 157.1; 95% CI: 57.7-342.0). No increase was found for laryngeal cancer (5 observed; SMR 96.8; 95% CI: 31.4-225.9) and stomach cancer (6 observed; SMR 52.9; 95% CI: 19.4-115.2).

A statistically significant increase in mortality was observed for respiratory diseases (81 observed; SMR 187.2; 95% CI: 148.7-232.7), particularly for pneumoconiosis with SMR equals to 13 313.2 (95% CI: 9595-17 995.7) based on 42 observed, 41 of which were asbestosis (SMR 43 385.3; 95% CI: 31 133.7-58 856.9).

Table 3 | *Cohort study of asbestos cement workers in Napoli, Italy: males cause-specific mortality in 1965-2005*

Cause of death (ICD9)	Obs	Exp	SMR	95% CI
All causes (000-999)	505	540.9	93.4	85.4-101.9
Malignant neoplasm (MN) (140-208)	195	156.6	124.5**	107.6-143.2
MN digestive organs and peritoneum (150-159)	48	48.4	99.1	73.1-131.4
MN stomach (151)	6	11.3	52.9	19.4-115.2
MN intestine and rectum (152-154)	14	10.8	129.9	71.0-218.0
MN rectum (154)	6	3.8	157.1	57.7-342.0
MN peritoneum (158)	9	0.5	1985.3**	907.7-3768.8
MN respiratory tract (160-165)	114	61.6	184.6**	152.3-221.8
MN larynx (161)	5	5.2	96.8	31.4-225.9
MN lung (162)	84	54.9	153.0**	122.0-189.4
MN pleura (163)	24	0.9	2616.6**	1676.5-3893.3
MN genitourinary (179-189)	14	20.9	67.0	36.6-112.3
MN bladder (188)	6	9.3	64.4	23.6-140.1
MN nervous system (190-192)	3	3.8	78.5	16.2-229.5
MN unspecified site (199)	7	3.2	220.7	88.7-454.7
MN lynphohematopoietic system (200-208)	5	10.6	47.3	15.3-110.3
Diabetes (250)	8	17.6	45.4*	19.6-89.5
Cardiovascular diseases (390-459)	124	217.4	57.1**	47.5-68.0
Ischemic heart diseases (410-414)	41	86.6	47.3**	34.0-64.2
Respiratory diseases (460-519)	81	43.3	187.2**	148.7-232.7
Bronchitis, emphysema, asthma (490-493)	30	30.2	99.5	67.1-142.0
Pneumoconiosi (500-505)	42	0.3	13 313.2**	9595.0-17 995.7
Asbestosis (501)	41	0.1	43 385.3**	31 133.7-58 856.9
Digestive system disease (520-579)	34	45.9	74.1	51.3-103.5
Genitourinary disease (580-629)	6	8.7	69.3	25.4-150.8
Unspecified causes (780-799)	6	4.5	134.4	49.3-292.6

**: $p < 0.05$; **: $p < 0.01$; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

Table 4 | *Cohort study of asbestos cement workers in Naples, Italy: male mortality for all causes and cardiovascular diseases in 1965-2005 by latency in the factory*

Latency	Obs	Exp	SMR	95% CI
All causes				
0-19	34	60.66	56.1**	38.8-78.3
20-29	122	111.18	109.7	91.1-131.0
30-39	165	164.29	100.4	85.7-117.0
≥ 40	184	204.72	89.9	77.4-103.8
Total	505	540.9	93.4	85.4-101.9
Cardiovascular diseases				
0-19	10	19.50	51.3*	24.6-94.3
20-29	28	43.24	64.8*	43.0-93.6
30-39	40	64.90	61.6**	44.0-83.9
≥ 40	46	89.72	51.3**	37.5-68.4
Total	124	217.4	57.1**	47.5-68.0

**: p < 0.05; **: p < 0.01; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

The number of deaths for cardiovascular diseases, was statistically significant lower than expected (SMR 57.1; 95% CI: 47.5-68.0): it could be indicative of Healthy Worker Effect (HWE) [38-40]. To investigate HWE we stratified mortality from all causes and cardiovascular diseases by latency *(Table 4)*. All causes mortality was lower than expected in the category 0-19 years of latency (SMR 56.1; 95% CI: 38.8-78.3); this effect disappeared after 20 years of latency as all cause mortality became similar to the expected one. Cardiovascular disease mortality remained significantly lower than expected, without any significant SMRs increase in every latency category.

For pleural and peritoneal malignant neoplasms (MN) SMRs increased by latency, with highest values for ≥ 40 years latency *(Tables 5 and 6)*.

Pleural cancer mortality increased with exposure duration, the highest SMR is in the category 10-19 years, the increase is evident for 0-4 to 5-9 years. In the categories 20-29 and 30 + years the SMR point estimates decreased, the confidence intervals remained wide, always excluding the null value. For pleural MN the SMR for 0-4 years of exposure was significantly increased *(Table 5)*.

Table 6 | *Cohort study of asbestos cement workers in Naples, Italy: male mortality for Peritoneum malignant neoplasm in 1965-2005 by latency and duration of exposure in the factory*

MN Peritoneum	Obs	Exp	SMR	95% CI
Latency				
0-19	0	0.1	-	-
20-29	1	0.1	1001	25-5580
30-39	1	0.1	985	25-5490
≥40	7	0.2	3954**	1590-8148
Total	9	0.5	1985**	908-3769
Duration of exposure				
0-4	1	0.1	912	23-5079
5-9	4	0.1	6376**	1738- 16 327
10-19	0	0.1	-	-
20-29	2	0.1	1901*	230-6869
≥ 30	2	0.1	4262**	516-15 398
Total	9	0.5	1985**	908-3769

**: p < 0.05; **: p < 0.01; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

Table 5 | *Cohort study of asbestos cement workers in Naples, Italy: male mortality for pleural malignant neoplasm in 1965-2005 by latency and duration of exposure in the factory*

MN Pleura	Obs	Exp	SMR	95% CI
Latency				
0-19	0	0.1	-	-
20-29	4	0.2	2078**	566-5319
30-39	8	0.3	2516**	1086-4957
40-49	12	0.3	3733**	1929-6520
Total	24	0.9	2617**	1676-3893
Duration of exposure				
0-4	2	0.2	850*	103-3071
5-9	4	0.1	3274**	892-8383
10-19	10	0.2	4096**	1964-7532
20-29	5	0.2	2234**	725-5214
≥ 30	3	0.1	3266**	674-9544
Total	24	0.9	2617**	1676-3893

**: p < 0.05; **: p < 0.01; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

Table 7 | *Cohort study of asbestos cement workers in Naples, Italy: male mortality for lung cancer in 1965-2005 by latency and duration of exposure in the factory*

Lung cancer	Obs	Exp	SMR	95% CI
Latency				
0-19	3	4.6	65	13-190
20-29	23	11.7	197**	125-296
30-39	31	19.4	160*	109-227
≥ 40	27	19.2	140	93-204
Total	84	54.9	153**	122-189
Duration of exposure				
0-4	12	12.8	94	48-163
5-9	4	7.1	56	15-144
10-19	23	14.7	156	99-235
20-29	33	14.1	235**	162-330
≥ 30	12	6.2	195*	100-339
Total	84	54.9	153**	122-189

**: p < 0.05; **: p < 0.01; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

Table 8 | *Cohort study of asbestos cement workers in Naples, Italy: male mortality for asbestosis in 1965-2005 by latency and duration of exposure in the factory*

Asbestosis	Obs	Exp	SMR	95% CI
Latency				
0-19	0	0.00	-	-
20-29	5	0.01	50 149**	16 278-117 028
30-39	16	0.04	43 580**	24 909-70 771
≥40	20	0.04	45 694**	27 912-70 569
Total	41	0.09	43 385**	31 134-58 857
Duration of exposure				
0-4	1	0.02	4965*	124-27 664
5-9	0	0.01	-	-
10-19	16	0.02	70 597**	40 351-114,645
20-29	16	0.03	63 746**	36 435-103 520
≥30	8	0.01	54 048**	23 335-106 495
Total	41	0.09	43 385**	31 134-58 857

**: $p < 0.05$; **: $p < 0.01$; MN: malignant neoplasm; Obs: observed; Exp: expected; SMR: standardised mortality ratio; 95% CI: confidence intervals calculated at 95% level.*

SMR for lung cancer showed a statistically significant increase in the latency categories 20-29 and 30-39, and in the 20-29 years exposure duration category *(Table 7)*.

Only one death for asbestosis, out of 41, was observed in the category 0-9 years of duration of exposure *(Table 8)*. Analysis by latency was not regarded as informative because of the long survival of this disease.

Twenty-eight out of 33 deceased subjects were recorded in the National Mesothelioma Register, Campania section. Twenty-seven of them (82%) were recorded as mesothelioma cases: 8 had an histological confirmation, whereas 19 had a clinical and radiological confirmation, or a death certificate with a diagnosis of malignant mesothelioma *(Table 9)*.

Out of 41 subjects deceased for asbestosis *(Table 10)*, 29 (70.6%) were compensated by INAIL for asbestosis, 5 (12.2%) were compensated for silicosis, 2 (4.8%) for other diseases and 5 (12.2%) received no compensation.

DISCUSSION

This study contributes to the description of the health impact of asbestos-cement production at the national level in Italy, and at the local level for the polluted site of Bagnoli – Coroglio (Naples).

Our results confirmed significant increase in mortality for pleural, peritoneal, and lung cancer, consistently with the recent IARC evaluation (9). Moreover, we recorded a non-significant decrease for stomach cancer, and an increase of colorectal cancer, and no increase for laryngeal cancer.

More disaggregated mortality data are available at Local Health Unit (ASL) level [41] and show no evidence of different stomach cancer mortality between ASL NAPOLI 1 (including Bagnoli district) and Campania region. So the stomach cancer mortality decrease in the cohort could be attributable more to SMR wide variability (SMR 52.9; 95% CI: 19.4-115.2), than to local characteristic (for example diet) of the Bagnoli area residents.

Considering non-cancer causes of death, we found 41 observed *vs.* 0.09 expected deaths for asbestosis. Moreover asbestosis was the underlying cause of death for 41 cohort members and a contributory cause for further 45 subjects.

The statistically significant decrease in mortality from cardiovascular diseases, has been deepened stratifying SMR for all causes and cardiovascular diseases by latency.

Results didn't show a clear HWE in the cohort, since we didn't observe a SMR increase with increasing latency categories for cardiovascular diseases.

The lung cancer SMR (153; 95% CI: 122-189), was comparable to that recorded in a meta-analysis estimating a pooled SMR (158; 95% CI: 144-173) in asbestos cement workers [42].

SMRs for lung cancer by exposure duration and latency showed a curvilinear trend, which decreased after 40 years of latency and 30 years of exposure. This finding is compatible with those found in other cohorts of asbestos cement workers [14, 20, 29, 43].

In the present study 24 pleural MN and 9 peritoneal MN deaths were observed. The analysis showed an increase of SMRs for both these neoplasms by latency: the highest values were recorded for latency ≥ 40 years (12 pleural MN and 7 peritoneal MN).

Table 9 | *Deaths for pleural and peritoneal malignant neoplasms observed in the cohort and reported by the Italian National Mesothelioma Registry – Campania Regional Centre*

	Pleural mesothelioma	Peritoneal mesothelioma
Deaths recorded in the Mesothelioma Registry with histological exams	8	0
Deaths recorded in the Mesothelioma Registry with clinical and radiological data or with a death certificate with diagnosis of malignant mesothelioma	12	7
Deaths ascertained in the Mesothelioma Registry as no mesothelioma	1	0
Deaths not recorded in the Mesothelioma Registry	3	2
Total	24	9

Table 10 | *Cohort study of asbestos cement workers in Naples, Italy: Institute for Occupational Diseases and Injuries (INAIL) compensation of 43 subject deceased for asbestosis in 1965-2005*

INAIL Compensation	no.	%
Asbestosis	26	63.40
Asbestosis, pleural plaque	1	2.44
Asbestosis, peritoneal mesothelioma	1	2.44
Silicosis	5	12.20
Asbestosis, contact dermatitis and other eczema	1	2.44
Contact dermatitis and other eczema	1	2.44
Nervous system desease	1	2.44
No occupational desease compensation	5	12.20
Total	41	100.00

SMR for pleural cancer increased from 0-4 to 5-9 and especially from 10-19 years of asbestos fibers exposure. In the subsequent categories of duration of exposure, the point estimates of SMR decreased while the confidence intervals remained very wide, even if always excluding the null value. Given the extremely small number of expected cases, this pattern cannot be further commented.

Strengths and limits of this study are listed below.

Cohort identification was carried out using plant personnel records, which are considered the best source for cohort enumeration for plant-based cohorts [44]. We reconstructed a satisfactory proportion of the entire study population: out of 1251 male workers, 1247 (99.7%) were included in the cohort.

Health outcomes were assessed by mortality data derived from ISTAT death certificates. They were non-differentially misclassified in the cohort group and in the reference population. Unspecified causes of death, representing an indirect indicator of mortality data quality, constituted 1% of overall mortality. In order to validate death certificates for asbestosis, pleural and peritoneal MN, we performed a record linkage with the National Institute for Occupational Diseases and Injuries (INAIL) and the National Mesothelioma Registry (ReNaM) data. Results were satisfactory: 71% of asbestosis deaths were compensated by INAIL, and 83% of pleural and peritoneal MN were recorded in ReNaM as malignant mesothelioma.

Concerning exposure assessment, data on airborne asbestos fibers concentration showed heavy and widespread exposure until the factory shut down. There were insufficient data to estimate individual cumulative doses. We analyzed duration of exposure, consisting in duration of employment in the factory, as dose surrogate. In studies encompassing such a long period of observation, the exposure estimation given by duration is often the only choice and may not be improved by exposure measurements because of their inaccuracy [45].

We couldn't make separate fiber type evaluation, such as chrysotile, crocidolite and amosite, because they were used in the plant in different percentages depending on the final products.

An inception cohort approach was adopted, in order to avoid survival bias. The study population thus consisted of workers hired between 1950 and 1986; the workforce active in 1950, but hired before this date, was excluded.

Vital status was ascertained for 98% of the cohort subjects and the cause of death was known for 94% of the deceased subjects. The incomplete ascertainment of cause of death could have produced a slight underestimation of cause specific SMRs. 55 years observation period was long enough to recognize the majority of asbestos related health effects.

Regional population was chosen as reference because national rate is a weighted average of heterogeneous Italian regional rates, while local mortality rates are not stable enough to assume the absence of random error and could also be influenced by the Bagnoli Eternit cohort data.

Tobacco smoke has an etiological role for lung and laryngeal cancers. No individual information on smoking habits were available for the study, as is often the case in occupational cohort investigations. There are no indications that the proportion of smokers in Bagnoli Eternit factory was different than in the general population and, moreover, if any confounding was present, it should act in the same direction for both laryngeal and lung cancer. Recent evaluations of asbestos exposure and smoking interaction on lung cancer risk support a multiplicative synergism [46, 47].

In summary, the Bagnoli Eternit asbestos cement cohort showed an increased mortality for asbestosis, lung cancer and pleural and peritoneal mesothelioma, consistent with the available epidemiological evidence. Extension of follow-up, and assessment of mesothelioma risk among population resident in Bagnoli area and among family members of Eternit workers thus appear to be warranted.

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Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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