Economic impact of malignant mesothelioma in Italy: an estimate of the public and social costs

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SUMMARY

Background: *Despite their considerable interest for public health policies and for occupational disease management and assessment, the economic costs of asbestos-related diseases (ARDs) for society have not been fully estimated or even frequently discussed.* **Objectives:** *The aim of this study was to estimate the economic burden of mesothelioma in Italy by assessing the overall societal cost of the disease, applying an econometric model.* **Methods:** *We analyzed two main cost groups, public and social. The first includes expenditure borne by the State and other public bodies (medical care costs, insurance, tax and benefits), while the latter uses the human capital approach to measure the loss of productivity suffered by the economy as a whole.* **Results:** *We provide an estimate of € 33,000 per patient for medical care costs and € 25,000 for insurance and compensation; tax and benefits seem to roughly compensate. We estimated a loss of more than € 200,000 per patient, in terms of loss of production.* **Conclusions:** *This study offers a practical approach for estimating the economic impact of mesothelioma, and provides empirical evidence of the huge economic burden linked to this disease, with its high etiologic fraction.*

RIASSUNTO

«L'impatto economico del mesotelioma maligno in Italia: una stima dei costi pubblici e sociali». **Introduzione:** *Nonostante l'interesse per le politiche di sanità pubblica e per la gestione e la valutazione delle malattie professionali, i costi economici delle malattie amianto-correlate (ARD) per la società non sono stati completamente valutati o discussi.* **Obiettivi:** *L'obiettivo del presente studio è quello di stimare il peso economico del mesotelioma in Italia prendendo in considerazione il costo complessivo di tale patologia per la società, attraverso un modello econometrico.* **Metodi:** *Sono stati considerati due gruppi di costo principali, pubblici e sociali. Il primo comprende le spese sostenute dallo Stato e dagli altri enti pubblici (costi per assistenza medica, costi assicurativi, costi fiscali), mentre il secondo utilizza l'approccio del capitale umano per misurare la perdita di produttività subita dall'intera economia.* **Risultati:** *I costi per cure mediche per paziente sono stati stimati in circa 33.000 euro, i costi assicurativi e di indennizzo in circa 25.000 euro; i costi fiscali sembrano essere più o meno compensati. La perdita di produttività è stata stimata in oltre 200.000*

euro per paziente. **Conclusioni:** *Il presente studio rappresenta un approccio pratico di stima dell'impatto economico del mesotelioma, ed ha fornito una evidenza empirica delle importanti dimensioni dell'onere economico connesso con questa malattia ad elevata frazione eziologica.*

INTRODUCTION

Malignant mesothelioma (MM) is an uncommon, high-mortality neoplasm typically originating from mesothelial cells lining the body's serous cavities, mainly the pleura and the peritoneum, and less frequently the pericardium and the tunica vaginalis of the testis. The correlation with asbestos exposure has been repeatedly demonstrated and the International Agency for Research on Cancer recently confirmed that there is sufficient evidence that all forms of asbestos are carcinogenic for humans (group 1) and cause mesothelioma (and lung, ovarian and laryngeal cancer) (9). The MM attributable risk due to environmental or occupational exposure to asbestos has been reported to be between 86% and 95% in most recent epidemiological studies (16, 28, 29).

Many western countries are currently suffering an epidemic of MM, in relation to the widespread use of asbestos between the 1950s and 1980s in several industrial applications and the long latency (around 40 years) from the start of exposure. Moreover, asbestos is still widely used in many countries in Asia, South America, Africa and in the former Soviet Union; at present, 125 million people are estimated to be exposed to asbestos worldwide (33). In Italy, more than 3.5 million tons of raw asbestos were produced up to the definite ban in 1992, with more than 160,000 tons/year in the period 1976-1980. Asbestos consumption decreased in Italy only during the '80s, around ten years later than in many other western countries (20, 22).

Although the level of individual asbestos exposure is very hard to estimate and not constant over time, at the national level the extent of asbestos consumption in the past can indisputably be used to reliably estimate the MM epidemic after an adequate lag for the latency period.

Despite the interest of the disease for public health policies and for the assessment and management of occupational diseases in general, analyses of the costs for national health care systems generally fail to provide data and surveys of the costs of occupational injury and illness are few and far between (8, 27, 17).

In recent years various methods and tools have been developed to establish the costs of occupational diseases, but there is still no real data estimation tool available because of the complexity and multiplicity of factors to be considered (e.g. choice of variables and indicators, gathering data for the selected variables and indicators, determination of their value in money). The economic costs of asbestos-related diseases (ARDs) in particular - generally due to occupational exposure - have not been fully estimated, or even frequently discussed in the scientific literature.

The International Conference on Monitoring and Surveillance of Asbestos-Related Diseases adopted the "Helsinki Declaration on Management and Elimination of Asbestos-Related Diseases", acknowledging measures of the economic impact of these pathologies among top research priorities (10). The issue is complicated by uncertainty about epidemiological measures of the magnitude of asbestos-related lung, ovarian and laryngeal cancer, and just estimating the direct and indirect economic costs of mesothelioma continues to be problematic (6, 21, 34). The WHO estimated the economic burden of mesothelioma in the EU15, based on the average cost of a case in France (€ 125,000), explicitly underlining that approaches to estimating costs have to be adjusted to take account of different treatment patterns and social insurance systems, and related policies in the different countries (35).

Considering the prevalently occupational origin of the diseases, any analysis of mesothelioma's indirect costs cannot exclude the costs for public insurance systems. Furthermore, compared to the majority of occupational diseases, mesothelioma is often disabling soon after diagnosis, patients have a poor quality of life and require considerable support and care – all important sources of indirect costs.

Italy, because of its high asbestos consumption until the ban, the broad spectrum of industries involved and the number of workers and people exposed, is among the countries that are most sensitive to the prevention and control of ARDs and the costs of monitoring them for society. A specific epidemiological system for the surveillance of mesothelioma incidence based on a national register (Italian national mesothelioma register – ReNaM) has been active in Italy since 2000 (11). ReNaM provides information about the demographic, occupational and environmental characteristics of MM cases and regularly produces epidemiological analyses concerning the incidence, length of survival after diagnosis of the diseases, territorial distribution of cases and assessment of the economic sectors involved in the asbestos exposure (3, 22, 24).

The aim of this study was to estimate the economic burden of mesothelioma in Italy by assessing the overall societal cost of the disease.

Methods

The economic burden of the disease was estimated by considering two main cost concepts: public cost, i.e. that borne by public bodies, and social cost, incurred by the economic system as a whole (figure 1).

For both costs the main expenditure items were identified, to define the indicators for estimating costs. Each cost item was expressed in real terms and updated to 2013, to give homogeneous results. Updating was based on the rates of inflation during the period covered by the analysis. The public cost represents the changes in payments borne by the State or other public bodies, and comprises three independent components: i) actual direct cost (medical and insurance), ii) foregone tax revenue due to interruption of work, and iii) reduction of retirement expenditure because of premature deaths. However, the sum of these elements does not fully measure the overall disease-related economic loss for society, for at least two reasons. First, part of the public cost actually consists of a monetary transfer from the public to the private sector, with no impact on the overall product (15). This is the case of insurance payments, which are merely a reallocation between economic subjects. Second, premature deaths due to
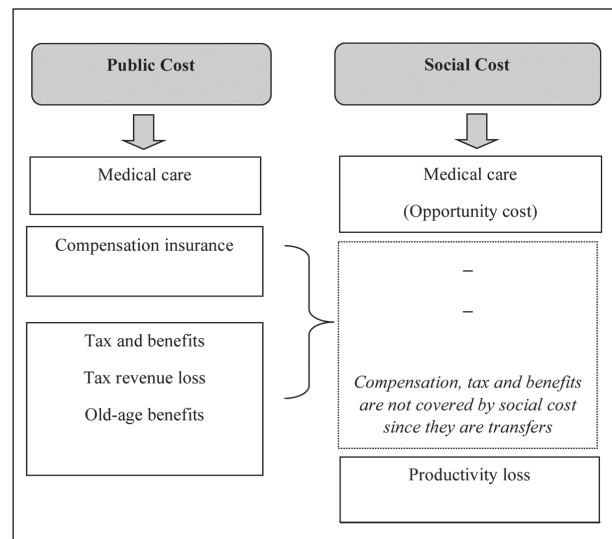
Figure 1 - Public and social costs for malignant mesothelioma included in the model

mesothelioma reduce the labor force available and therefore the country's productive capacity. Public cost accounts for the income reduction only for the share captured by public bodies through taxation, disregarding the share of income lost by workers' families and firms (net labor income and profit). We therefore introduced a more comprehensive measure of social cost, estimating productivity loss by using the human capital approach developed by Jorgenson and Fraumeni (13). We had also to include the opportunity cost for expenditure for medical care: that is, the value of the alternative use of the resources used to treat the disease.

Calculating the direct medical costs of mesothelioma is problematic because there is no standard treatment protocol for this cancer, because the relapsing rate is high with all current treatments, and survival in population-based studies remains poor (23). Moreover, very few studies have dealt with assessment of the medical costs of mesothelioma (31, 32, 35).

The lack of published studies on the medical costs of this pathology, at the time of implementation of this project, which was concluded at the end of 2013 and of which this article is the final product, made it necessary to refer to the specific case of the Veneto Region. Specifically, our basis was the Judgment no. 1196/08 of the Ordinary Court of Venice, gener-

ally referred to as the *Sentenza Fincantieri-Cantieri Navali Italiani SpA* [Fincantieri/Italian Naval Shipyards Judgment], which awarded compensation to the Veneto Region for the costs of medical treatment of workers with mesothelioma, provided by the Regional public health service (see Appendix online at www.lamedicinadellavoro.it).

Medical costs were calculated on the basis of the standard Regional charges, using the Diagnosis-Related Groups (DRG) system. The DRG is a method for classifying all patients discharged from a hospital ward or day hospital in homogeneous groups as regards the resources employed, using the information in the Hospital Discharge Form (HDF). The DRG item charges are established at regional level on the basis of standard production costs.

Costs for workers' compensation in Italy consist in the annuities paid to the patient (direct annuity) and/or to surviving family members (survivor annuity) by the *Istituto nazionale per l'assicurazione contro gli infortuni sul lavoro – INAIL* (Italian workers' compensation authority), computed by considering a number of variables and applying a specific evaluation method (19). From the INAIL insurance database we extracted and analyzed all the direct annuities for disability payable at 31/12/2011 by site of mesothelioma, sex and degree of permanent disability. When the annuity-holder dies of causes connected to the occupational disease, according to Italian legislation (article no. 85 of Italian Decree of the President of the Republic (DPR) no. 1124/1965), the surviving family members are entitled to up to the whole of the deceased's annual income, divided in proportion to the degree of kinship. For cost analysis, all the survivor annuities payable at 31/12/2011 by location of mesothelioma were considered, as well as the relatives' degrees of kinship with deceased mesothelioma sufferers having the right to the annuity. For calculation details see Appendix (available online at www.lamedicinadellavoro.it).

Premature deaths affect public budgets on the one hand by reducing present to future flows of old-age benefits and on the other by reducing the current and future flows of consumption and income taxes. Tax and benefit costs were calculated using the European Community Household Panel (ECHP) and Community Statistics on Income and Living Con-

ditions (EU-SILC) as primary data sources. The following assumptions were made for the calculation of changes in labor income taxes and old-age benefits: 1) individuals were still working at the time of diagnosis unless over retirement age; 2) the sector and type of occupation at diagnosis were the same at the time of last exposure; 3) 50% of the old-age benefit was paid to the family after the worker's death. For point 3, we considered that, according to Italian law, the surviving spouse and under-age children are in fact entitled to 60% to 100% of the deceased's pension, the proportion being lower for dependents having other sources of income, but unfortunately no information was available on the household composition of mesothelioma cases.

Calculating consumption tax was slightly more complicated, because EU-SILC does not collect data on consumption expenditure, and consumption tax rates differ for different goods purchased. Therefore, we estimated the share of earnings that would have actually been consumed, and then applied an appropriate average tax rate to total expenditure (see Appendix). Information on the occupational sector (industry), age, sex and year of incidence of each occupational case of mesothelioma occurring in the period 1993-2008, provided by ReNaM, was used to calculate total and mean costs for taxes and benefits (11).

To measure the overall economic impact of labor force reduction we adopted an approach based on human capital loss, using Jorgensen and Fraumeni's standardized method (13). Among different methods proposed in the economic literature (2) this is the one most widely applied, also in the Organization for Economic Co-operation and Development (OECD) estimates (18). Productivity loss was calculated based on ReNaM incident MM cases stratified by sex, age, industrial sector and year of occurrence, and mean cost was estimated.

Results

The average age at diagnosis of mesothelioma among the 11 workers exposed to asbestos in the Fincantieri shipyard was 65 years (SD 10.31, range 50-84). The duration of the disease, calculated from when the patient was first admitted to hospital, corresponding presumably to the date of first diagnosis,

to death, was about two years (from eight months to six years). In all, 40% of the admissions were under DRG item 410 (Chemotherapy without acute leukemia as secondary diagnosis); about 20% came under DRG 82 (Respiratory neoplasms). Most of the remaining 40% fell under DRG 75 (Major chest procedures) accounting by itself for 31% of the total health service expenditure which the Veneto Region claimed had to be reimbursed. The average medical expenditure for diagnosis and care for each patient, in hospital or on a day-hospital basis, was estimated in 2013 at about € 30,000.

For 2012 the estimated compensation insurance costs added up to more than € 8.5 million; 93% of this sum was payable to disabled men. About 94% of the cost was for workers with pleural mesothelioma. The mean weighted degree of disability was 72% for men and 74% for women, and the corresponding mean annuity came to about € 14,000. For 2012 the total sum of annuities to surviving relatives divided by degree of kinship amounted to about € 52 million, 98% going to spouses. The mean annual per-capita annuity to a spouse, who was by far the most common recipient, was about € 11,000.

The main variables used to calculate tax and benefit costs, for the period covered by ReNaM (1993-2008), broken down by sex, age, year of incidence and economic sector are reported in table 1.

Since in the majority of cases the disease develops late in life, savings in old-age benefits between 1993 and 2008 partially balanced the tax revenue losses and reduced the total public cost to € 30,000 per patient. The overall public expenditure for mesotheliomas related to occupational asbestos exposure occurring from 1993 to 2008 amounted therefore to more than € 250 million.

Based on fairly recent social system reforms (known in Italy as the "Dini reform" in 1995, and the "Fornero reform" in 2013) old-age benefits were reduced because of changes in their computation rules. The net tax and benefit transfer due to premature deaths calculated in 2013 had virtually no impact on the government budget. Foregone taxes from an active population actually compensated the old-age benefit saved for retired workers (net of dependents' pensions), doubling the total per capita public cost, to € 60,000 (table 2).

The average social loss per capita was estimated as almost € 230,000 (€ 200,000 for human capital loss and € 30,000 for medical cost) (table 2), since in the majority of cases mesothelioma develops after retirement, when the worker's human capital is zero by definition. The human capital per person in the active population is in fact much higher, more than € 600,000 (table 1).

Finally, we offer an estimate of € 33,000 for medical care, € 25,000 for insurance and compensation costs and € 196,000 for productivity loss, while tax and benefits seems to be compensatory. Considering an expected number of 1200-1500 mesothelioma cases per year in Italy in the future, the overall cost of the disease in this country for the public health system and for the collectivity can be estimated at between € 300-350 million per year.

DISCUSSION

Econometric analyses of the costs of illness are attracting growing interest in the scientific community due to the necessity of providing governmental and administrative authorities with more familiar and easier-to-use instruments to measure the burden of diseases for society and to assess the likely effectiveness of any countermeasures or interventions to be programmed.

Even though prevention is expected to have a real impact on practice, very few studies have attempted to estimate preventable costs in the fields of environmental and - even more - occupational health (35). We used mesothelioma in this study as a model of disease for which an external cause, i.e. asbestos exposure, is almost always identified, mainly in occupational settings. A multi-dimensional model was built up that assessed both the direct (medical, compensation) and indirect (tax and benefits, human capital) costs borne by society as a whole for this cancer. This approach estimated a total cost of almost € 250,000 for each case of mesothelioma of occupational origin. In a French study the average direct cost of mesothelioma was assumed equal to € 33,422, i.e. the average direct cost of respiratory system cancers (30). In our study using DRG-based discharge costs, reconstructed through National Health Service reimbursement requests from the

Table 1 - Taxes, benefits and social costs for occupationally exposed mesothelioma cases, from the Italian National Mesothelioma register (ReNaM). Italy, Euros per capita, 2013

	Number of observations	Net old-age benefits (€)	Labor income tax (€)	Consumption tax (€)	Net transfer (€)	Human capital (€)
Total	8,367	96,219	46,483	21,376	28,358	192,284
Sex						
Men	7,319	100,212	50,107	22,101	28,003	206,918
Women	1,048	68,330	21,176	16,316	30,838	90,080
Year of incidence						
1993	82	95,043	25,360	14,865	54,817	115,137
1994	122	92,629	36,673	17,150	38,806	161,861
1995	233	97,805	41,713	18,989	37,103	181,026
1996	257	95,594	46,520	19,989	29,085	201,457
1997	258	94,884	46,979	19,922	27,983	204,009
1998	391	96,619	52,282	21,572	22,765	224,913
1999	403	95,441	42,559	20,232	32,650	181,023
2000	639	91,780	50,956	21,932	18,892	216,800
2001	707	93,385	51,955	22,280	19,149	222,189
2002	735	94,165	48,908	21,877	23,380	206,195
2003	742	95,093	47,341	21,753	25,999	196,442
2004	716	98,510	49,759	22,593	26,159	202,946
2005	839	98,311	45,077	21,484	31,750	182,025
2006	769	98,107	42,362	21,051	34,694	168,435
2007	772	98,550	41,431	21,167	35,953	161,311
2008	702	98,157	46,454	22,136	29,567	181,116
Age (yrs)						
0-24	1	119	232,482	67,861	-300,224	822,044
25-34	10	15,448	259,254	77,410	-321,216	942,924
35-44	79	46,066	242,686	70,370	-266,990	904,878
45-49	188	70,930	209,632	57,510	-196,212	809,924
50-54	406	88,691	184,741	49,472	-145,523	734,270
55-59	816	105,940	152,326	40,310	-86,696	630,124
60-64	1,244	121,148	103,069	30,391	-12,312	452,202
65-69	1,575	123,885	0	21,078	102,807	0
70-74	1,578	101,195	0	13,338	87,857	0
75-79	1,301	81,556	0	8,745	72,811	0
80-84	750	53,933	0	5,189	48,745	0
85+	419	32,002	0	3,214	28,788	0
Economic sector						
Agriculture	186	61,073	14,307	13,202	33,564	64,745
Industry	6,505	96,464	47,200	22,051	27,213	194,687
Services	1,632	100,252	48,058	19,825	32,369	200,179
Unknown	44	58,896	18,203	13,761	26,933	83,182

Source: ReNaM, European Community Household Panel (ECHP) (1993-2000)
Community Statistics on Income and Living Conditions (EU-SILC) (2004-2007) and Italian Survey of Household Income and Wealth (SHIW) (1993-2010)

Table 2 - Estimated costs per patient. Italy, Euros, 2013

Group of Costs		Type of cost (€)	1993-2008[b] (€)	2013[b] (€)
Public costs	Medical care	Outpatient[a]	5,533.00	5,533.00
		Inpatient[a]	28,122.00	28,122.00
	Insurance	Direct annuity	14,000.00	14,000.00
		Annuity to surviving relatives	11,000.00	11,000.00
	Tax and Benefits	Tax revenue loss	67,859.00	68,288.00
		Retirement expenditure (-)	-96,219.00	-68,155.00
	Total		30,295.00	58,788.00
Social costs	Human Capital	Productivity loss	192,284.00	196,292.00
	Medical cost	Opportunity cost	33,655.00	33,655.00
	Total		225,939.00	229,947.00

[a] Including expenditure for physicians, tests, prescriptions, hospital, assistance devices and therapy.
[b] All amounts are in 2013 Euros

employers responsible, we obtained a comparable average medical care cost per worker of about € 30,000. This estimate, however, is far higher than that computed in one study in 2000 in UK and one in 2008 in Spain (5, 32), possibly reflecting intervening changes in specialized medical treatment. This is worth noting since the WHO relied mainly on the UK study to assess country-level medical care costs (35).

Some limitations of our method need to be mentioned. Medical costs were actually assessed only on a small number of cases involved in legal proceedings. Despite the still wide variability mainly due to the various therapeutic schedules used (14), the mean age at diagnosis of mesothelioma sufferers in the Fincantieri Judgment (65 years), as well as their survival calculated from diagnosis to death was in line with the figures given at a national level by Re-NaM (11). Moreover, the DRG system only covers the clinical conditions of in-patients or day-hospital patients, without taking account of general practitioners' prescriptions. Only some studies, to our knowledge, took account of primary care and pharmaceutical costs, estimating them as a proportion of specialized care expenditure, leading to an increase of about half the total direct medical cost (30, 31).

An interesting study, first published in *La Medicina del Lavoro* in 2015, analyzed in detail the health care provided to a sufficiently large group (65 cases) of probable pleural mesothelioma under discussion in four criminal trials in the Lombardy Region, who died between 2002 and 2015; the study provided economic information regarding the health expenditures sustained by the Regional Health Service (RHS) for in-hospital care, outpatient services and drugs for these patients. For each pleural mesothelioma case the costs (on average) were about € 67,000, € 37,000 of which were spent after the date of diagnosis. Drugs made up the largest part of health expenditure (about € 37,000 per person) (31). The 2015 report seems to confirm the per capita hospitalization cost estimates reached in our study.

A strength of this study is that it produces economic indicators that fit the specific Italian welfare and social context, including the expenditure for public compensation services. Since mesothelioma is the most commonly recognized and compensated occupational cancer, a realistic average cost can be calculated by analyzing all the annuities being paid by INAIL at end-2011. The efficiency of the compensation system for occupational mesothelioma was assessed by comparison with data from epidemiological surveillance systems and a substantial number of workers with mesothelioma remain without compensation, in Italy and other countries (1, 4, 23, 25). Under-claim and recognition is of course an even more important problem for other occupational cancers due to lower etiologic fraction and the multiplicity of causative agents involved. When applying our method to other diseases this variable must be considered.

By using almost complete national incidence data we were able to make a more accurate and comprehensive assessment of the societal burden of mesothelioma. Cancer cases recorded in the Italian Mesothelioma Registry were considered for the calculation of costs related to work loss, mainly the so-called social cost. This measures the reduction of the labor force, and therefore the country's productive capacity, due to premature deaths and is actually the most important cost item, as shown elsewhere (30).

If all mesothelioma incident cases are considered, annual average expenditure in the coming years can be estimated at € 300-350 million per year in Italy. This overestimates the real costs, on one hand, because it does not consider non-occupational mesotheliomas separately, i.e. those due to residential, familiar or other lifetime activity exposures to asbestos. From the ReNaM exposure assessment the non-occupational fraction of mesotheliomas in Italy amounts to about 10 per cent of all the incident cases (11). Besides workers' compensation, other components are still applicable in those cases and higher productivity loss costs can be expected from environmental asbestos exposure, because of patients' lower mean age at diagnosis. In the light of the high and rising mean age at diagnosis in mesothelioma patient cohorts (for countries like Italy where asbestos use and production have been banned), the estimated social and insurance costs could well level off in the next few years.

Overestimation of social costs in our analysis for a single year is possible because of the impossibility of simultaneous direct annuity and annuity to surviving relatives. In addition there are some immeasurable costs, the so-called "intangible" costs including primary care and non-medical direct costs, such as those for social care, household expenditures, and psychological trouble affecting either the cancer patients or their families and caregivers (7, 26).

In conclusion, this study offers a reliable estimate of the societal costs of mesothelioma in Italy for policy makers and other stakeholders, to be used to allocate public health care and insurance resources more efficiently for support to mesothelioma patients and their families in the next few decades. Valuable economic arguments are also provided about the cost-effectiveness of removing and re-placing asbestos-containing materials still on-site in many dwellings and workplaces. Measuring the financial burden of mesothelioma can empower the legitimation and the economic advantage of promoting bans in current asbestos-user countries.

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