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SHORT REPORT

How Malignant Mesothelioma Was Coded in Mortality Data in Taiwan During Years When the Specific *ICD* Code Was Not Available?

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Purpose: Malignant mesothelioma (MM) is associated with past exposure to asbestos and the latency period ranged from 20 to 40 years. Asbestos consumption reached a peak in the 1980s in Taiwan, and the MM mortality is expected to increase since 2000s. However, no specific code for MM was available before the *International Classification of Disease, Tenth Revision* (*ICD-10*), which was launched in 2008 in Taiwan. We examined how MM was coded in mortality data in Taiwan during the years when the *ICD, Ninth Revision* (*ICD-9*) was used.

Patients and Methods: Double-coded mortality data (each death coded according to both *ICD-10* and *ICD-9* codes) for the period 2002–2008 were obtained for analysis. Detection rates (similar to sensitivity) and confirmation rates (similar to positive predictive value) for various potential proxy *ICD-9* codes for MM were calculated.

Results: For 113 deaths, for which the underlying cause of death was *ICD-10* code C45 (MM), 14 corresponding *ICD-9* codes were used. Four *ICD-9* codes constituted 77% (87/113) of all MM deaths. The detection rate for code 199 (malignant neoplasm [MN] without specification of site) was 37% (42/113), that for code 163 (MN of pleura) was 18% (20/113), that for code 162 (MN of trachea, bronchus, and lung) was 12% (14/113), and that for code 173 (other MN of skin) was 10% (11/113). The confirmation rates for codes 199, 163, 162, and 173 were 0.9% (42/4759), 14.3% (20/140), 0.03% (14/51,778), and 1.5% (11/717), respectively.

Conclusion: *ICD-9* codes 199, 163, 162, and 173 were most commonly used for MM deaths in Taiwan during the years before the *ICD-10* introduction. However, when we used only *ICD-9* code 163, which was most commonly used as a surrogate measure of MM in mortality studies during the *ICD-9* era, we could detect only one-fifth of MM deaths in Taiwan.

Keywords: *International Classification of Diseases*, *Ninth* and *Tenth Revision*, *ICD-9*, *ICD-10*, malignant mesothelioma, death certificate, bridge coding study, comparability study

Introduction

Malignant mesothelioma (MM) is a sentinel health event indicating past occupational or environmental exposure to asbestos and the latency period ranged from 20 to 40 years.[1,2] As MM is rare and fatal (survival is about one year), mortality rate is therefore a good proxy measure of incidence rate[3–6] Asbestos consumption reached a peak in the 1980s in Taiwan and the MM mortality is expected to increase since 2000s.[7] Monitoring the changes in MM mortality since 2000s is needed to identify the emergent public health problem and designing relevant countermeasures and liabilities issues. However, no specific code for mesothelioma was available until the

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establishment of the *International Classification of Diseases, Tenth Revision* (*ICD-10*), code C45 (MM). Most studies on MM mortality conducted before the introduction of the *ICD-10* used *ICD, Ninth Revision* (*ICD-9*), code 163 (malignant neoplasm [MN] of pleura) as a surrogate for MM diagnosis.[8–16]

However, validation studies have indicated that the use of *ICD-9* code 163 might overestimate and underestimate the true MM mortality rate.[17–23] Because physicians' certification behaviors and coders' coding practices might be distinct among various countries, the extent of the overestimation and underestimation of MM deaths on the basis of *ICD-9* code 163 might vary among countries. Using double-coded mortality data (DCMD) for the period 2002–2008, we examined how MM was coded in mortality data in Taiwan in the years during which the *ICD-9* classification scheme was used. This study's findings can provide a valuable reference for estimating the true MM mortality trends in the years before *ICD-10* was introduced.

Materials and Methods

Data Sources

We used DCMD for analysis in this study. The DCMD for years 2002–2008 were obtained from the Office of Statistics, Ministry of Health and Welfare (MOHW), Taiwan under the project "Establishing the ICD-10 Classification Scheme for Mortality Data and Comparability in Taiwan" with project number DOH96-TD-M-113-049(1/3), DOH97-TD-M-113-96009, and DOH98-TD-M-113-96002 and the corresponding author was the principal investigator of this project. Our study was submitted to the Institutional Review Board of National Cheng Kung University (B-EX-110-018). As this study used secondary or administrative data with the personal IDs scrambled, the study was thus exempt from further review by the Institutional Review Board. The DCMD is owned by the MOHW, Taiwan. Researchers can apply the MOHW to get permission to use the DCMD.

With regard to the DCMD, when a new revision of ICD was introduced, a comparability (bridge coding) study should have been conducted to assess the potential effects of the revision on the continuity of cause-specific mortality trends.[24–26] In a comparability study, each death presented in the mortality data for a single year (or combined years) is coded according to both new and old *ICD* versions, a practice that is called double coding. In Taiwan, *ICD-9* was used mortality data from 1981 to 2007 and *ICD-10* was implemented in 2008. The reason for the delay introduction of the *ICD-10* was the preparation of introduction of automated coding system (Automatic Classification of Medical Entry, ACME) for selecting the underlying cause of death (UCOD) from the US National Center for Health Statistics in 2000. The MOHW used both the manual and automated systems for 7 years (2002–2008) to assess the potential effects of implementing both *ICD-10* and ACME on mortality statistics.[27,28] The DCMD contain both the *ICD-9* and *ICD-10* codes for each diagnostic entities recorded on the death certificate for each decedent, the UCOD and basic demographic information.

Analysis

Most studies assessing the accuracy of cancer death certificates have used two indicators, namely detection rate (similar to sensitivity) and confirmation rate (similar to positive predictive value), proposed by Percy et al.[29] For the detection rate, the denominator is the number of deaths due to a particular cancer or with an *ICD* code verified according to standard references such as clinical, histopathological, or cytological diagnoses identified from hospital medical records, cancer registries, or autopsy reports; in this study, the denominator was the number of deaths in which the UCOD was *ICD-10* code C45. The numerator is the number of deaths with a particular diagnosis or *ICD* code recorded on the death certificate; in this study, the numerator was the number of deaths with various proxy *ICD-9* codes for which the corresponding *ICD-10* code was C45.

For the confirmation rate, the denominator is the number of deaths with a particular cancer diagnosis or *ICD* code recorded on the death certificate; in this study, the denominator was the number of deaths with various potential proxy *ICD-9* codes. The numerator is the number of deaths confirmed according to standard references; in this study, the numerator was the number of deaths for which the corresponding *ICD-10* code was C45.

Herein, we present the two aforementioned rates with 95% confidence intervals (95% CIs) as descriptive statistics (frequencies). Furthermore, we present the confirmation rates by sex and age.

Results

Of 946,181 deaths in DCMD for the period 2002–2008, we identified 113 deaths for which the UCOD was *ICD-10* code C45. Table 1 presents the number of deaths and detection rates for the corresponding proxy *ICD-9* codes. We observed that 14 *ICD-9* codes were used for 113 MM deaths; of these *ICD-9* codes, 4 (ie, 199, 163, 162, and

Table 1 Number of Deaths (No) and Detection Rate (%) of Various Proxy *ICD-9* Codes for 113 Malignant Mesothelioma Deaths According to Double-Coded Mortality Data in Taiwan, 2002–2008

		ICD-10						
ICD-9	**Description**	**C45.0**	**C45.1**	**C45.7**	**C45.9**	**C45**	**%**	**95% CI**
Total		24	11	15	63	113	100	
199	Malignant neoplasm without specification of site	2	2	0	38	42	37.2	24.0–50.3
163	Malignant neoplasm of pleura	19	0	0	1	20	17.7	9.3–26.1
162	Malignant neoplasm of trachea, bronchus, and lung	2	0	11	1	14	12.4	5.5–19.3
173	Other malignant neoplasm of skin	0	0	0	11	11	9.7	3.7–15.8
158	Malignant neoplasm of retroperitoneum and peritoneum	0	9	0	0	9	8.0	2.6–13.4
171	Malignant neoplasm of connective and other soft tissue	0	0	0	6	6	5.3	1.0–9.7
202	Other malignant neoplasms of lymphoid and histiocytic tissue	0	0	0	3	3	2.7	S
235	Neoplasm of uncertain behavior of digestive and respiratory systems	0	0	2	0	2	1.8	S
151	Malignant neoplasm of stomach	0	0	1	0	1	0.9	S
161	Malignant neoplasm of larynx	0	0	1	0	1	0.9	S
164	Malignant neoplasm of thymus, heart, and mediastinum	1	0	0	0	1	0.9	S
200	Lymphosarcoma and reticulosarcoma	0	0	0	1	1	0.9	S
238	Neoplasm of uncertain behavior of other and unspecified sites and	0	0	0	1	1	0.9	S
239	Neoplasms of unspecified nature	0	0	0	1	1	0.9	S

Notes: C45.0 "pleural," C45.1 "peritoneum", C45.2 "pericardium", C45.7 "other sites", and C45.9 "site unspecified". S: Calculation of 95% CI was suppressed when number of death was less than 5.
Abbreviation: *ICD-9, International Classification of Disease, Ninth Revision.*

173) constituted 77% (87/113) of all MM deaths. *ICD-9* code 199 had a higher detection rate (37%, 42/113) than that of code 163 (18%, 20/113).

Table 2 lists the number of all deaths (N), number of deaths for which the corresponding *ICD-10* code was C45 (n), and confirmation rates for four proxy *ICD-9* codes by age and sex. The confirmation rate for *ICD-9* code 199 (0.9%) was markedly lower than that for *ICD-9* code 163 (14.3%) and was even lower for *ICD-9* code 162 (0.03%, 14/51,778). The confirmation rate for *ICD-9* code 163 was higher in men (15.3%, 15/98) than in women (11.9%, 5/42). For male decedents, the confirmation rate was highest among those aged 45–54 years (50.0%, 6/12) and 55–64 years (27.8%, 5/18). For female decedents, the confirmation rate was highest among those aged 65–74 years (37.5%, 3/8).

Discussion

This study's findings indicate that *ICD-9* codes 199, 163, 162, and 173 were the most commonly used codes for MM deaths in Taiwan in the years before the *ICD-10* was introduced, and these codes constituted three-fourths of all codes used for MM deaths. The performance of *ICD-9* code 163, which was most commonly used as a surrogate measure of MM death, was suboptimal in Taiwan; it detected less than one-fifth of all MM deaths.

Previous validation studies on MM deaths using death certificate data revealed large variations in detection and confirmation rates.[18–22,29] The detection rate was 11% in Canada, 47% for years 1970–1971 in the United States, 61% for men for years 1973–1980 in British Columbia, 55% for years 1968–1981 in Western Australia, 23% for years 1973–1983 in the United States, 13% for years 1982–1989 in

Table 2 Number of All Deaths (N) and Deaths with Corresponding *ICD-10* Code C45 (N) and Confirmation Rates (%) of Selected Proxy *ICD-9* Codes for Malignant Mesothelioma Deaths According to Double-Coded Mortality Data in Taiwan, 2002–2008

	ICD-9 Code 199				ICD-9 Code 163				ICD-9 Code 162				173			
	n	N	%	95% CI	n	N	%	95% CI	n	N	%	95% CI	n	N	%	95% CI
M & F																
All ages	42	4759	0.9	0.6–1.2	20	140	14.3	7.6–21.0	14	51778	0.03	0.01–0.04	11	717	1.5	0.6–2.5
0–44	6	394	1.5	0.3–2.8	0	11	0.0	S	0	1769	0.00	S	1	50	2.0	S
45–54	8	612	1.3	0.4–2.2	6	16	37.5	2.3–72.7	3	4771	0.06	S	2	71	2.8	S
55–64	10	765	1.3	0.5–2.1	6	23	26.1	2.7–49.5	3	7847	0.04	S	2	79	2.5	S
65–74	11	1200	0.9	0.4–1.5	6	33	18.2	2.4–34.0	3	15701	0.02	S	2	153	1.3	S
75+	7	1788	0.4	0.1–0.7	2	57	3.5	S	5	21690	0.02	0.00–0.04	4	364	1.1	S
Males																
All ages	28	2802	1.0	0.6–1.4	15	98	15.3	7.0–23.6	7	35639	0.02	0.01–0.03	5	444	1.1	0.1–2.1
0–44	5	229	2.2	0.3–4.1	0	8	0.0	S	0	944	0.00	S	1	41	2.4	S
45–54	4	369	1.1	0.0–2.2	6	12	50.0	1.0–99.0	1	2840	0.04	S	1	57	1.8	S
55–64	7	457	1.5	0.4–2.7	5	18	27.8	0.3–55.3	2	5207	0.04	S	0	54	0.0	S
65–74	8	714	1.1	0.3–1.9	3	25	12.0	S	2	11109	0.02	S	0	103	0.0	S
75+	4	1033	0.4	0.0–0.8	1	35	2.9	S	2	15539	0.01	S	3	189	1.6	S
Females																
All ages	14	1957	0.7	0.3–1.1	5	42	11.9	0.9–22.9	7	16139	0.04	0.01–0.08	6	273	2.2	0.4–4.0
0–44	1	165	0.6	S	0	3	0.0	S	0	825	0.00	S	0	9	0.0	S
45–54	4	243	1.6	S	0	4	0.0	S	2	1931	0.10	S	1	14	7.1	S
55–64	3	308	1.0	S	1	5	20.0	S	1	2640	0.04	S	2	25	8.0	S
65–74	3	486	0.6	S	3	8	37.5	S	1	4592	0.02	S	2	50	4.0	S
75+	3	755	0.4	S	1	22	4.5	S	3	6151	0.05	S	1	175	0.6	S

Note: S: Calculation of 95% CI was suppressed when number of death was less than 5.
Abbreviations: *ICD-9, International Classification of Diseases, Ninth Revision; ICD-10, International Classification of Diseases, Tenth Revision.*

Massachusetts, 34% for years 1967–1986 in North America, 74% for years 1984–1988 in Italy, 40% for years 1981–1999 in Scotland. The confirmation rate was 35% for years 1970–1971 in the United States, 60% for men for years 1973–1980 in British Columbia, 81% for years 1968–1981 in Western Australia, 13% for years 1982–1989 in Massachusetts. A recent study using DCMD for year 1996 in the United States indicated that the detection rate was 57%, 19%, and 13% for ICD-9 code 199, 162.9, and 163, respectively; and the confirmation rate for the aforementioned three ICD-9 codes were 4.0%, 0.3%, and 70.8%, respectively.[30] In our study, the detection and confirmation rates for *ICD-9* code 163 in Taiwan were 18% and 14%, respectively, which are lower than those in other studies. One possible reason is that the Chinese-language terminology for the diagnosis of mesothelioma is "間皮瘤" and can be literally translated as "tumor between skins"; this translation is the potential reason why 11 deaths were coded with *ICD-9* code 173 (other MN of skin).

The true detection rate for MM deaths in Taiwan would be even lower because the denominator of the detection rate used in this study was the number of deaths with *ICD-10* code C45 instead of actual standard references such as clinical, histopathological, and cytological diagnoses from hospital medical records, cancer registries, or autopsy

reports. In other words, many decedents had pathologically proven MM, but the certifiers did not record MM on the death certificates. According to a study that used the Taiwan Cancer Registry, the estimated number of MM deaths was approximately two to three times higher than the number of recorded MM deaths.[29]

Regarding the implications of the aforementioned validation studies, most researchers studying MM mortality by using *ICD-9* code 163 have been concerned with the confirmation rate (ie, overestimation problem); therefore, they have employed multiple factors for adjustment: 0.73,[10] 0.8,[8] 1–0.068,[11] and 1.4.[9] Only the study by Iwatsubo et al was concerned with confirmation rate as well as detection rate (ie, underestimation problem) and coding errors. According to their study, 922 deaths were coded with *ICD-9* code 163 in 1992 in France, and the estimated true number ranged from 521 to 724 after the consideration of the three adjustment factors. However, they considered only the confirmation rate, detection rate, and coding errors for *ICD-9* code 163. No study has considered the confirmation rates for other *ICD-9* codes. The findings of the present study suggest that *ICD-9* codes other than 163, such as 199 and 162, would have been more accurate despite having low confirmation rates (0.9% and 0.03%, respectively); nevertheless, *ICD-9* code 163 constituted half of all MM deaths (42+14/113). Further research is required to evaluate the validity of confirmation rates of *ICD-9* codes other than 163 in estimating MM mortality.

A strength of this study is the use of DCMD for a 7-year period, which provided an optimal opportunity to examine the coding practices related to MM deaths during the years before *ICD-10* was implemented. However, this study has several limitations that should be noted when interpreting the findings. First, we employed the number of deaths with *ICD-10* code C45 as the standard reference to calculate detection and confirmation rates; this underestimated the true number of deaths compared with those derived using standard references such as pathological diagnoses or cancer registries. Second, caution should be exercised when applying the detection and confirmation rates to years before 2002 because the number of deaths would be small. Third, only three-character *ICD-9* codes were used in Taiwan; therefore, we could not use the more detailed four-character *ICD-9* codes 199 and 162 to calculate the confirmation rate, which would be higher than the current estimates derived using the three-character codes. Fourth, some of the coding errors were due to misinterpretations of the Chinese terminology for diagnosis, which would not occur in other countries.

Conclusion

According to DCMD for the period 2002–2008 in Taiwan, *ICD-9* codes 199, 163, 162, and 173 were the most commonly used codes for MM deaths in the years before the *ICD-10* was introduced. However, when we used only *ICD-9* code 163, which was most commonly used as a surrogate diagnosis of MM in mortality studies conducted during the years when *ICD-9* was applied, we could detect only one-fifth of the true MM deaths in Taiwan. Therefore, we suggest the use of confirmation rates of multiple *ICD-9* codes to more accurately estimate MM mortality before 2002 in Taiwan for future liability issues.

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Disclosure

The authors report no conflicts of interest in this work.

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