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## Original Article

## Underreporting of maternal mortality in Taiwan: A data linkage study

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## ABSTRACT

**Objective:** This study examined the extent to which maternal mortality in Taiwan is underreported in officially published mortality statistics.**Materials and methods:** We used National Health Insurance claims data collected from two million samples, which were linked with the officially published mortality data, to identify women aged 15–49 years, who were admitted to a hospital with pregnancy-related diagnoses during 2000–2009 and died during the pregnancy or within 42 days after the termination of pregnancy.**Results:** Based on these linked data, we identified 26 maternal deaths, only nine of which were reported in the original officially published mortality data; thus, the rate of underreporting was 65% [(26 – 9)/26]. The revised maternal mortality ratio was 14.1 deaths per 100,000 live births (95% confidence interval: 8.7–19.5), which was approximately three times higher than the official reported ratio of 4.9 (95% confidence interval: 1.7–8.1). The most common cause of maternal deaths was amniotic fluid embolism ( $n = 10$ ), followed by eclampsia and preeclampsia ( $n = 4$ ).**Conclusion:** Approximately two-thirds of the maternal deaths in Taiwan were unreported in the officially published mortality data. Hence, routine nationwide data linkage is essential to monitor maternal mortality in Taiwan accurately.

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## Introduction

Maternal mortality is considered a sentinel event, reflecting access to and the quality of prenatal and obstetric care, as well as the health status of reproductive-aged women [1–3]. However, previous studies in developed countries (Austria, Canada, Finland, France, the Netherlands, UK, and USA) have indicated that officially published mortality data underreport the maternal death number [4–15]. According to officially published mortality data, the maternal mortality ratio (MMR) in Taiwan was 19 (deaths per 100,000 live births) in 1980, 12 in 1990, eight in 2000, and seven in 2008 [16]. However, according to the estimation performed by the Global Burden of Disease Study Group, the MMR for Taiwan was 38 in 1980, 26 in 1990, 12 in 2000, and 14 in 2008, approximately two times higher [17]. The only study estimating the underreporting of

maternal deaths in Taiwan was performed by Kao et al [5], who suggested that according to officially published cause-of-death statistics, the MMR was underreported by 37%. No evaluation study has been conducted in Taiwan since that of Kao et al [5] in 1997; therefore, this study was conducted to assess the extent of MMR underreporting in the 2000s in Taiwan by using National Health Insurance (NHI) claims data collected from two million samples, which was linked with the officially published mortality data.

## Materials and methods

## Data sources

The NHI program of Taiwan is a mandatory single-payer health insurance system in which all residents have to participate. The NHI program was implemented in 1995 and covers more than 99.5% of the Taiwanese population [18]. The NHI Research Database has been available to researchers in an electronically encrypted form since 1999. To enhance the analytical value, the NHI claims data

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collected from two million samples were linked with the officially published mortality data by the Collaboration Center for Health Information Application, Ministry of Health and Welfare, Taiwan [19]. The NHI enrollees of 2000 were proportionally sampled using 200 strata (2 for sex, 20 for age, and 6 for region). In this data set, information on each person sampled between 2000 and 2009 was retrieved from the NHI claims database. To avoid the release of personal information recorded in the NHI claims and mortality data, the linked data set was analyzed in an isolated restricted room. Only aggregated statistical tables without a single cell and with a number of counts lower than three were released after careful inspection by the Center for Health Information Application staff.

### Identification of maternal deaths

The World Health Organization (WHO) defines maternal death as “death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes” [20]. This definition contains two components: time and causality [21]. First, we identified all women aged 15–49 years with pregnancy-related diagnoses (the International Classification of Diseases, Ninth Revision, Clinical Modification, ICD-9-CM codes 630–676 or V27) from the NHI inpatient claims data for 2000–2009. Second, based on the dates of admission and death, we determined whether the death was during pregnancy or within 42 days of the termination of pregnancy. Third, according to the WHO definition of maternal death, we excluded women who died because of external causes (accidents, suicide, or homicide).

We further classified the causes of maternal deaths into *direct* and *indirect* causes. Direct causes of death are those resulting from obstetric complications (pregnancy, labor, and puerperium), interventions, omissions, incorrect treatment, or a chain of events resulting from any of these. Indirect obstetric deaths are those resulting from a previous existing disease or a disease that developed during pregnancy and which was not due to direct obstetric causes, but which was aggravated by the physiologic effects of pregnancy [21].

### Analysis

To calculate the MMR, we used the number of hospitalizations for pregnancy-related diagnoses in the sampled data set as a proxy for the number of live births. We calculated the 95% confidence intervals (CIs) for the MMR by using Poisson distribution approximation. Because of the small death number, we did not calculate the MMR stratified by maternal age strata or by the calendar years. The underreporting rate was computed as follows: (number of deaths estimated by investigators – number of deaths officially reported)/number of deaths estimated by investigators. In the officially published mortality data, we also illustrated the distribution of the causes of maternal deaths, as well as of deaths not reported as maternal deaths.

### Results

According to the linked data, we identified 26 maternal deaths, only nine of which were reported in the original officially published mortality data; the underreporting rate was 65% [(26 – 9)/26]. The revised MMR was 14.1 (95% CI: 8.7–19.5), which was approximately three times higher than the officially reported MMR of 4.9 (95% CI: 1.7–8.1).

For the 26 maternal deaths identified in this study, the most common causes were amniotic fluid embolism ( $n = 10$ ), followed by eclampsia or preeclampsia ( $n = 4$ ) and obstetric hemorrhage ( $n = 3$ ; Table 1). The cause of each of the nine maternal deaths reported in the original officially published mortality data was amniotic fluid embolism.

Table 2 shows a comparison of the revised and original causes of the 17 maternal deaths not reported as maternal deaths in the original officially published mortality data. We found some compatible diagnoses between the revised and original causes, such as preeclampsia or eclampsia comparable to hypertension or epilepsy, puerperal infection comparable to sepsis, and obstetric hemorrhage comparable to coagulation defects. We also noted incorrect coding for cerebrovascular disorders and cardiovascular diseases. Cerebrovascular disorders during pregnancy, childbirth, or the puerperium should be coded using the ICD-9-CM code 674.0 instead of the ICD-9-CM codes 430–434 and 436–437. Similarly, cardiovascular diseases during pregnancy, childbirth, or the puerperium should be coded using ICD-9-CM code 648.6 instead of ICD-9-CM codes 390–398 and 410–459.

### Discussion

The results of this data linkage study indicate that approximately two-thirds of the maternal deaths in Taiwan were unreported in the officially published mortality data. Among the revised causes of maternal deaths, the most common cause was amniotic fluid embolism, followed by preeclampsia or eclampsia. Maternal deaths were incorrectly coded in the officially published mortality data mainly because the death certificates did not contain any pregnancy-related information.

The underreporting rate estimated in this study was 65%, which is higher than that estimated in previous studies (Table 3) and 1.8 times higher than that estimated 20 years ago in Taiwan (i.e., 37%) [5]. One possible reason for the discrepancy between the two estimated rates is that the evaluation methods used were different. In the study by Kao et al [5], public health nurses retrospectively asked the families about the deceased to verify whether the death was related to pregnancy, and based on the relevant information collected, the cause of maternal death was revised. However, in this study, only the discharge diagnoses recorded in the NHI claims data were used to define maternal deaths, and this information may be insufficient for defining maternal deaths, particularly early-pregnancy-related deaths.

Another reason for the discrepancy between the two estimated rates was that the certifying physicians in Taiwan in the 2000s were less likely to report the pregnancy status on the death certificate than those in the 1980s, as the level of litigation regarding maternal deaths was higher in the 2000s. Karimian-Teherani et al [11] suggested that countries with lower levels of litigation and higher rates of autopsies conducted for forensic reasons were associated with a

**Table 1**  
Revised causes of maternal deaths.

Revised cause	No.	%
Direct		
Amniotic fluid embolism	10	38.5
(Pre)eclampsia	4	15.4
Obstetric hemorrhage	3	11.5
Puerperal infection	2	7.7
Indirect		
Cerebrovascular disease	3	11.5
Cardiovascular disease	3	11.5
Others	1	3.8
Total	26	100.0

**Table 2**  
Revised and original causes of death among unreported maternal deaths.

No.	Revised cause	Original cause
1	Embolism	Coagulation defects
2	Embolism	Ill-defined diagnosis
3	(Pre)eclampsia	Ill-defined diagnosis
4	(Pre)eclampsia	Hypertension
5	(Pre)eclampsia	Epilepsy
6	(Pre)eclampsia	Dissecting aneurysm
7	Hemorrhage	Liver disease
8	Hemorrhage	Coagulation defects
9	Puerperal infection	Sepsis
10	Puerperal infection	Sepsis
11	Intracerebral hemorrhage	Intracerebral hemorrhage
12	Intracerebral hemorrhage	Intracerebral hemorrhage
13	Cerebral infarction	Cerebral infarction
14	Cardiovascular disease	Disease of endocardium
15	Cardiovascular disease	Ill-defined diagnosis
16	Cardiovascular disease	Cardiomyopathy
17	Placental problems	Ill-defined diagnosis

lower underreporting level of maternal deaths, because doctors readily revealed the pregnancy status of the deceased women.

The main causes of maternal deaths in various studies are illustrated in Table 4. Amniotic fluid embolism was the main cause of maternal death in six studies, and hemorrhage was the main cause in three studies. Obstetric hemorrhage and embolism were the main causes of maternal deaths in Taiwan during 1984–1988 [5] and 2000–2009, respectively. A previous study indicated that regions with a high ratio of mortality caused by hemorrhage were those characterized by substandard care, such as a low volume of

deliveries or the lack of a 24-hour on-site anesthetist [22]. One possible explanation for the decreasing number of maternal deaths caused by hemorrhage in Taiwan during the past two decades is the improvement in *postpartum* and intensive care.

Nevertheless, in this study, the percentage (38%, 10/26) of maternal deaths caused by amniotic fluid embolism was higher than that in other studies (Table 4). One possible explanation for this was the overreporting of amniotic fluid embolism on the death certificates, because the families of the deceased women were less likely to sue the doctors if the women died because of a reason other than amniotic fluid embolism. We also noted that, although one of the women died because of *postpartum* hemorrhage according to the discharge diagnosis recorded in the NHI claims data, amniotic fluid embolism was recorded on her death certificate by a certifying physician.

Several limitations should be noted when interpreting the results of this study. First, the main criteria used for defining maternal death were the discharge diagnoses recorded in the NHI claims data, which may be insufficient. Therefore, the number of maternal deaths estimated in this study may be higher. Second, because of the low number of maternal deaths identified, we could not analyze the underreporting rate further based on the strata of maternal ages and the calendar years.

In conclusion, approximately two-thirds of the maternal deaths in Taiwan were unreported in the officially published mortality data. Routine nationwide data linkage is essential to accurately monitor maternal mortality in Taiwan. Certifying physicians should be trained to include pregnancy status on death certificates to ensure the ascertainment of maternal death, which is required to determine the magnitude of the problem, assess trends, and

**Table 3**  
Underreporting of maternal mortality ratios (MMR) in various studies.

Area [reference]	Study period	Evaluation method <sup>a</sup>	Officially reported no. of deaths	Officially reported MMR	Revised no. of deaths	Revised MMR	Rate of underreporting
France [4]	1988–1989	Survey	24	9.7	54	21.9	56
Taiwan [5]	1984–1988	Survey	173	34.6	274	54.8	37
The Netherlands [6]	1983–1992	Survey	133	7.1	180	9.7	26
Canada [7]	1988–1992	Linkage	66	3.7	99	5.0	33
Finland [8]	1987–1994	Linkage	31	6.0	78	15.2	60
NC, USA [9]	1993–1997	Linkage	65	12.6	119	23.1	45
New York City, USA [10]	1997	Enhanced	16	13.0	30	24.3	47
Austria [11]	1980–1998	Survey	119	70.0	191	112.4	38
MD, USA [12]	1993–2000	Enhanced	80	22.2	129	13.8	38
NC, USA [13,14]	1999–2000	Linkage	24	10.1	33	13.8	27
MA, USA [13,14]	1999–2000	Linkage	1	0.6	10	6.2	90
France [13,14]	1999–2000	Linkage	47	6.3	68	9.1	31
Finland [13,14]	1999–2000	Linkage	3	2.6	7	6.1	57
Taiwan [this study]	2000–2009	Linkage	9	4.9	26	14.1	65

<sup>a</sup> Enhanced = autopsy report from a medical examiner was reviewed in addition to the survey and data linkage; Linkage = cause-of-death data were linked to another data set (including live birth, still birth, or hospital discharge registration); Survey = questionnaire survey or enquiry of obstetricians who issued the death certificate.

**Table 4**  
Main causes of maternal deaths in various studies [reference].

Cause	[4]	[5]	[6]	[7]	[9]	[10]	[11]	[12]	[13,14]	[13,14]	[15]	This study
Direct												
Embolism	16	48	20	24	19	11	41	24	6	12	31	10
(Pre)eclampsia	5	52	51	16	20	3	25	19	6	9	22	4
Hemorrhage	5	74	11	12	14	2	45	17	6	14	9	3
Puerperal infection	4		10	4	16	1	21	8	5	5	26	
Indirect												
Cerebrovascular disorder	6		18	19	7	2	12		2	4		3
Cardiovascular diseases				3	26		18	39	7	7	53	3
Total	54	274	180	99	119	30	191	129	37	68	261	26

[4]: France; [5]: Taiwan; [6]: the Netherlands; [7]: Canada; [9]: NC, USA; [10]: NY, USA; [11]: Austria; [12]: MD, USA; [13,14]: NC and MA, USA; [13,14]: France; [15]: UK.

identify risk groups, thus allowing the development of appropriate and effective strategies for preventing the morbidity and mortality associated with pregnancy.

### Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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