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Prevalence of errors in medical certification of maternal deaths in Zambia using a retrospective analysis of maternal death surveillance and response data from 2018 to 2022

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Abstract

Introduction Data on maternal mortality (MM) from many countries in Sub-Saharan Africa, are still not reliable partly due to inappropriate application of World Health Organisation International Statistical Classification of Diseases and Related Health Problems (WHO ICD) - MM. The WHO ICD - MM classification is essential for boosting the quality of MM reporting and increasing international comparability. This process is intended to enhance MM data reporting and make it easier to code the classification of causes of maternal death, leading to improved interventions and policy decisions aimed at improving maternal health outcomes. This study was conducted to ascertain errors in medical certification of the cause of death (MCCD) of maternal deaths by analyzing data from the Maternal Death Surveillance and Response (MDSR) database at the Ministry of Health of Zambia.

Methods This retrospective analysis used MDSR data in Zambia from 2018 to 2022. Errors in medical certification were identified using WHO ICD-MM coding guidelines. Multivariable logistic regression was applied to estimate adjusted odds ratios (aOR) for factors associated with classification errors for immediate, underlying and all the three causes (immediate, underlying, and other contributory causes) of maternal deaths.

Results MCCD prevalence errors for immediate, underlying and all the three causes of maternal death during 2018–2022 was 83.4% (95% CI:82.1%-84.6%), 62.5% (95% CI:60.9%-64.2%), and 24.0% (95% CI:22.5%-25.4%), respectively. Northern and Luapula Provinces had higher odds of MCCD errors of all MM causes (aOR = 2.49; 95% CI:1.80–3.44) and (aOR = 2.31; 95% CI:1.55–3.46), respectively) compared with other provinces.

Conclusion The prevalence of error in MCCD of maternal death for the immediate and underlying causes was high in Zambia. However, variations by province suggest diverse experiences and expertise in abilities to correctly classify maternal deaths by their true

causes. There is need to strengthen training of medical staff responsible for medical certification of maternal causes of death to adhere to the WHO guidelines.

Keywords Medical certification, Maternal mortality, Maternal death surveillance, WHO ICD-10, Zambia

1 Introduction

Despite significant global efforts, maternal mortality remains a critical public health challenge, with the global burden characterized by profound geographic disparities. Between 2000 and 2020, maternal deaths remained unacceptably high; in 2020 alone, approximately 287,000 women died from complications related to pregnancy and childbirth [1]. Alarmingly, nearly 95% of these deaths occurred in low and lower-middle-income countries, the vast majority of which were preventable [1, 2]. In response to this burden, the United Nations (UN) Sustainable Development Goal (SDG) target 3.1 mandates a reduction of the global maternal mortality ratio (MMR) to less than 70 maternal deaths per 100,000 live births by 2030 [3]. Achieving this target requires urgent, targeted interventions within UN member states to bridge the gap in maternal health equity and survival.

Sub-Saharan Africa (SSA) and Southern Asia accounted for around 88% (253 000) of the estimated global maternal deaths in 2020. Furthermore, SSA alone accounted for around 70% of maternal deaths (202 000), while Southern Asia accounted for around 16% (47 000) [1]. However, data on MM from a large number of countries, especially those in SSA, are still not reliable and around 21 UN member states have been reported as not having data on MM for the period 1980 to 2008 [4, 5]. Not only is the data unreliable but also lack consistency and the coverage is generally poor [4, 5]. In order to reduce and effectively amputate some of these MM data hemorrhages, audits and reviews of MM data can crucially facilitate the identification and analysis of the causes of and contributory factors to these deaths. Such audits contribute to improved quality of care subsequently [6].

To address inconsistencies in data, the World Health Organization (WHO) introduced the 'Application of ICD-10 to deaths during pregnancy, childbirth, and the puerperium: ICD-Maternal Mortality (ICD-MM)' [6]. The fundamental principle of ICD-MM is to provide a standardized framework for the classification of both direct and indirect causes of maternal death, ensuring that clinical conditions are attributed to the correct category across different health systems. By applying these specific coding rules, the ICD-MM facilitates the consistent collection and international comparability of data, reducing the likelihood of misclassification. This rigorous approach is vital for ensuring that reported maternal mortality figures reflect the true clinical reality, thereby allowing policy interventions and resource allocation to be based on robust, standardized evidence rather than inconsistent data sets [5].

The ICD-MM classification of causes of maternal death includes three levels of classification (type, group and underlying cause of death). The type of maternal death could be direct, indirect, or unspecified maternal death. Direct obstetric deaths are those resulting from obstetric complications of the pregnancy state (pregnancy, labour and puerperium), from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above. Indirect obstetric deaths are those resulting from previous existing disease or disease that developed during pregnancy and not due

to direct obstetric causes, but aggravated by physiologic effects of pregnancy. Unspecified maternal deaths are deaths during pregnancy, childbirth and the puerperium where the underlying cause is unknown or was not determined [7]. These groups are as follows: (i) pregnancies with abortive outcome, (ii) hypertensive disorders in pregnancy, childbirth, and the puerperium, iii): obstetric haemorrhage, iv): pregnancy-related infection, v): obstetric complications, vi): unanticipated complications of management, vii): non-obstetric complications, viii): unknown/undetermined, ix): coincidental causes [7]. The underlying cause of death is defined as the "disease or injury which initiated the cascade of morbid events leading directly to the death or the circumstances of the accident or violence which produced the fatal injury" [7, 8].

From existing literature, there is little evidence of attempts to measure the magnitude of error in medical classification of causes of MM in Zambia using the WHO ICD 10 guide. A number of studies conducted so far have tended to present MM as a socio-demographic and economic event ([9] and [10]; as a trends and correlates analysis experience [11] and [12] and as a programs and evaluation analysis [13, 14]. The closest studies to have been conducted with distal links to the WHO ICD 10 classification included one by [15], where MM reviews at a rural hospital in Zambia were conducted but not as nearly exemplified for the proposed application of the WHO ICD 10 standards; and another by [16], where signal functions for emergency obstetric care as an intervention for reducing MM were established but also falling short of the core of this paper and WHO ICD 10 guide recommendations.

By 2018, Zambia had a Maternal Mortality Ratio (MMR) of 252/100,000 live births; an estimate of slightly over twofold reduction from a high MMR of 591/100,000 live births in 2007 [17]. According to the Zambia National Health Strategic Plan 2017–2021, the target was to reduce the maternal mortality ratio from 398 deaths per 100,000 live births in 2013-14 to 162 deaths per 100,000 live births by 2021. Various strategies and interventions have been implemented to curb the MMR, which included enhancement of Maternal Death Surveillance and Response (MDSR). During this period, the aim was to improve MDSR process by: strengthening accountability for health workers and systems responding to maternal deaths; enhancing the Health Management Information System (HMIS) on the component dealing with MDSR for better data collection, management, and use. Therefore, improving oversight and informed decision-making using quality data [18]. Through an established MDSR, Zambia has a semblance of a system of MM data collection, although the system still rocks with quality problems.

Zambia first developed maternal death review guidelines in 2004 based on the WHO guidance core referenced as "Beyond the numbers". In 2008, Zambia approved the National Reproductive Health Policy, whose focus was to amplify the highest possible level of quality and affordable integrated reproductive health services to all Zambians. In the same year, the Ministry of Health (MoH) recommended that any maternal death should be a notifiable event. As the focus on MM grew, perinatal death reviews were also later included and as such, all health facilities in Zambia are required to conduct maternal and perinatal death reviews, derive lessons from the reviews and suggest appropriate strategies to further reduce avoidable maternal and perinatal deaths from identified causes. In 2013, WHO provided guidance on MDSR that would strengthen the collection and utilization of maternal death information and guide on appropriate response. MDSR builds on the principles of public health surveillance and promotes routine

identification and timely notification of maternal deaths. MDSR is a form of continuous surveillance that contributes to strengthening of vital registration, better counting of maternal deaths and provides better information for action to improve maternal health.

Maternal and perinatal mortality data is collected from health facilities and communities through active surveillance, using specific notification forms, and is reported to the MoH Headquarters. The data is then shared with the National Maternal and Perinatal Death Surveillance and Response (MPDSR) Committee on a weekly basis for action and review. In this paper, we measured the magnitude and associated systemic factors of error in medical classification of causes of MM by analysing data from the MDSR database in the MoH to identify implications of ICD-MM paying attention to the nine most captured causes of MM worldwide [4]. The findings of this study are significant to informing maternal health strategies aimed at improving maternal health outcomes in the country.

2 Methods

2.1 Demographic overview of Zambia

Zambia is a land linked country in Southern Africa. It is located between latitudes 8° and 18° south and longitudes 22° and 34° east and covers a total area of 752,612 square kilometers (km^2). The country is bordered by the Democratic Republic of Congo to the north, Tanzania to the north-east, Malawi to the east, Mozambique, Zimbabwe, Botswana and Namibia to the South, and Angola to the west. Zambia is administratively divided into ten provinces namely: Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, Northern, North Western, Southern and Western provinces. At the time of the 2022 Census, Zambia had 116 districts, 156 constituencies and 1,858 wards. Lusaka is the Capital City of Zambia and seat of the government. The government comprises of the Central and Local Government [19].

According to the 2022 Census of Population and Housing, Zambia's population stood at 19,693,423, with a median age of 18.3 years and a growth rate of 3.5% annually, the Total Fertility Rate (TFR) was 4.6 (5.5 in rural areas and 3.9 in urban areas), indicating a young and growing population [19]. Furthermore, the life expectancy at birth in 2022 was 67 years (69 years for females and 64 years for males). Zambia's healthcare system includes public and private sectors, structured from Health Posts (basic primary care), Health Centres (outpatient and maternal care), District Hospitals (secondary care), Provincial/General Hospitals (specialized care), to Central/Teaching hospitals (tertiary care) [20].

2.2 Data source and study setting

This was a retrospective analysis of the MDSR data for the period 2018–2022 in Zambia. The data were captured from all the ten provinces in the country, 114 districts and different health facilities. These facilities included: health posts, health centres, level 1 hospitals, level 2 hospitals, and level 3 hospitals. During the period 2018–2022, the MDSR had captured 3,643 maternal deaths. The dataset includes data on primary cause of death, secondary or underlying cause of death, and other contributing factors, useful for this manuscript.

Maternal death data is collected using a maternal death notification form from all health facilities and communities through active surveillance by the MoH. Each health

facility has identified Maternal and Perinatal Death Surveillance and Response (MPDSR) Coordinators responsible for data collection and reporting to the district level. At the District level, the District Nursing Officer responsible for Maternal Newborn and Child Health (MNCH) compiles this data and sends it to the province. The Provincial Principal Nursing Officer in charge of MNCH compiles all district notifications and sends it to the Chief Safe Motherhood Officer at MoH Headquarters for national compilation and at the end of each week, the data is shared with the National MPDSR Committee for action.

It should be noted that since this study utilized a near-census of notified maternal deaths from 114 out of 116 districts in Zambia ($n = 3,347$), it provides a high level of statistical precision and national representativeness, precluding the need for traditional sampling power calculations.

2.3 Determining underlying causes of death by WHO ICD 10 MM classification

The first attempt in understanding the study was to conduct an analysis to determine the correct underlying causes of MM as prescribed by the 2012 WHO ICD 10 Classification of MM. The Zambia MDSR dataset classifies three aspects, together, as the "train of events" or causes to explain the final outcome which in this case is a MM. The three categories include "Primary cause", literally used interchangeably with "the immediate cause of death" defined in this respect as the disease, injury, or complication that directly results in death, i.e., the ultimate consequence of the underlying cause of death [21]. The other category is referred to as the "underlying cause of MM" defined by the WHO as the disease or injury that initiated the train of morbid events leading directly to death; and the third aspect captured in the Zambia MDSR dataset is known as "other contributory causes" of MM defined as "any other disease present but not directly related to the MM".

With the aforementioned, data was managed by carrying out quality checks using R software, involving checking for blank values, blank rows, validity of values entered (where entries were harmonized by removing unwanted characters in the data like punctuation marks and other characters) and harmonizing data types in all columns. Total records were 3,643 which included maternal deaths from 2018 to 2022. A complete-case analysis approach was adopted; specifically, blank and duplicated records were dropped in IRIS and Stata during statistical analysis ($n = 296$), as these records lacked the essential clinical variables required for automated and manual ICD-MM coding. Therefore, the final records came to 3,347 used for statistical analysis. This exclusion rate was relatively low (8.1%), ensuring that the remaining dataset remained nationally representative.

Using IRIS 5.8.0 software and based on the guidelines by WHO, data was reshaped and formatted to IRIS standard using R software and exported to SQL Server IRIS tables. Once the data was in IRIS, the Zambia dictionary for MCCD terms (Obtained from the Department of National Registration, Passport and Citizenship (DNRPC) Coding Office) mapped to WHO Mortality ICD 10 Codes was loaded and IRIS performed batch processing on all records. Given the objective of the study, IRIS Software is ideally the recommended standard software used to assign ICD Codes to each cause; it also determines underlying cause of death and confirms the order of causes in the MCCD data indicated by physicians. IRIS was executed by setting maternal flags as appropriate i.e. Pregnancy status set to 0-At the time of death and 1-to if pregnancy contributed to

the death. The final results of IRIS were saved to SQL Server database, which was then exported to csv and loaded to R Software for further analysis.

A flag was created for each record to indicate if errors were found in Cause 'a' (the immediate cause of death), Cause 'b' (underlying cause of MM) where Cause a and b combined are Part 1, part 2 (other contributing conditions) or if all of them had errors. The flag was coded as 0 - no error was found during ICD coding, 1 – yes error was found during ICD Coding, and a column to describe the error for corrective action was generated.

2.4 Research variables

2.4.1 Dependent variables

The study utilized three binary dependent variables, all referring to medical certification errors (defined as a mismatch between clinician-reported causes and WHO ICD-MM standards):

a. Medical certification error in the immediate cause: (Coded 0 "No error"; 1 "Yes, had error").
b. Medical certification error in the underlying cause: (Coded 0 "No error"; 1 "Yes, had error").
c. Comprehensive medical certification error: Defined as cases where errors were present across all recorded causes (immediate, underlying, and contributory) (Coded 0 "No error"; 1 "Yes, had error").

2.4.2 Independent variables

The study used 'system factors' as independent variables. These variables were/are: year when woman died (2018, 2019, 2020, 2021, and 2022); province (Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, Northern, North-western, Southern and Western); place where woman died from (health facility, on way to the health facility, community); facility level of care (health post, health centre, level 1 (District Hospitals), level 2 (General Hospitals), level 3 (Teaching Hospitals), community); number of days in the health facility (< 1, 1–3, 4+, unknown); referral (No, Yes, Self-referral, unknown); HIV status (positive, negative, unknown).

2.5 Statistical analysis

The statistical analyses performed were bivariate and multivariable binary logistic regression using Stata version 14. The frequency and percentage distributions of maternal deaths by various factors were determined at the univariate level. Bivariate binary logistic regression was performed to produce unadjusted Odds Ratio (uOR) for system factors on errors in medical certification. Multivariable binary logistic regression was performed to determine adjusted effects of errors in the medical certification adjusted for the various system factors. This produced the adjusted Odds Ratio (aOR) for the various system factors on errors in medical certification. Both the uORs and aORs were considered significant at p-value < 0.05. All independent variables with a p-value of less than 0.2 in the bivariate analysis were included in the multivariable analysis model. Multicollinearity was checked in all the predictor variables to separate the independent effects of the interrelated variables using the variance inflation factor (VIF). There were

no concerns with multicollinearity since the overall VIF value was 1.25 and all the VIF values for individual predictor variables were less than 5 [22].

3 Results

3.1 System characteristics of maternal deaths in Zambia 2018–2022

Table 1 shows the distribution of maternal deaths for the period 2018–2022 by various factors. Results by year show that, 2018 accounted for the highest percentage of the maternal deaths (22.3%), followed by 2020 (21.3%), whilst 2021 and 2022 accounted for

Table 1 Distribution of maternal deaths by various factors in Zambia, MDSR 2018–2022

Factors	Number	%
Year		
2018	745	22.3
2019	593	17.7
2020	713	21.3
2021	646	19.3
2022	650	19.4
Province		
Central	352	10.5
Copperbelt	445	13.3
Eastern	345	10.3
Luapula	167	5.0
Lusaka	700	20.9
Muchinga	198	5.9
Northern	360	10.8
Northwestern	233	7.0
Southern	329	9.8
Western	218	6.5
Place of death		
Community	284	8.5
Facility	2,970	88.7
On the way	93	2.8
Facility Level of Care		
Community	283	8.5
Health Post	84	2.5
Health Centre	370	11.1
Level 1	848	25.3
Level 2	693	20.7
Level 3	1,069	31.9
Is this referral		
No	269	8.0
Yes	2,731	81.6
Self-referral	258	7.7
Unknown	89	2.7
Days in health facility		
< 1	1,252	37.4
1–3	1,170	35.0
4+	638	19.1
Unknown	287	8.6
HIV Status		
Negative	2,099	62.7
Positive	433	12.9
Unknown	815	24.4
Total	3,347	100

19% each. Lusaka province had the highest percentage of the maternal deaths (20.9%) and the lowest was in Muchinga province (5.9%). 32% of the maternal deaths had occurred in Level 3 hospitals, and the lowest was in Health Posts (2.5%). In terms of days of stay in the health facility, 37.5% of the deceased women had stayed less than a day, followed by those who had stayed 1–3 days (34.9%). Results in Table 1 also show that most maternal deaths were referrals (81.4%), and happened in a health facility (88.8%). 13% of the deceased women were HIV positive.

3.2 Distribution of errors in medical certification of the causes of maternal deaths

Table 2 shows that there were 83.4% certification error in the primary/immediate and antecedent cause of death, 62.5% error in the underlying/secondary cause of maternal death, and 41.9% certification error in other (part 2) causes. Table 2 also shows that 2 out of 10 maternal deaths had certification errors in all causes of maternal deaths (Part 1 and 2 combined).

3.3 Factors associated with errors in medical certification across all causes of maternal deaths in Zambia

In Table 3, bivariate and multivariable binary logistic regression results for system factors associated with errors in coding across all causes of maternal deaths in Zambia for the period 2018–2022 are indicated. Results show that Northern, Luapula, Copperbelt, and Southern Provinces have higher odds of error in medical certification of all causes of maternal deaths (aOR: 2.47, 2.31, 2.17, and 1.72 respectively) compared with Central province (ref). Western, Lusaka and Muchinga Provinces have lower odds of errors in coding of all causes of maternal deaths (aOR: 0.21, 0.26, and 0.52 respectively). The number of days spent in a health facility has a bearing in coding errors. The higher the number of days a woman spent in the health facility, the lower the odds of errors in coding of all causes of maternal deaths. For women who spent between 1 and 3 days and 4 + days in health facility, the odds of errors in medical certification of all causes of death were lower (aOR: 0.70, 95% CI: 0.57–0.86) and (aOR: 0.39, 95% CI: 0.39–0.68), respectively.

Table 2 Distribution of errors in medical certification of the causes of maternal Deaths, MDSR 2018–2022

Certification error in cause of death	Number	%	95% CI
Certification error in primary (Immediate and Antecedent) causes			
No	555	16.6	15.4–17.9
Yes	2,792	83.4	82.1–84.6
Certification error in secondary (Underlying) cause			
No	1,254	37.5	35.8–39.1
Yes	2,093	62.5	60.9–64.2
Certification error in other (Part 2) causes			
No	1,943	58.1	56.4–59.7
Yes	1,404	41.9	40.3–43.6
Certification error across all (both Part 1 and Part 2) causes			
No	2,545	76.0	74.6–77.5
Yes	802	24.0	22.5–25.4
Total	3,347	100	

Table 3 Bivariate and multivariable logistic regression results of system factors associated with certification errors of all causes for a maternal death, MDSR 2018–2022

Factors	Bivariate		Multivariable	
	uORs	CI	aORs	CI
Year				
2018 (Ref)	1.00		1.00	
2019	1.12	0.87–1.43	0.95	0.72–1.25
2020	0.94	0.74–1.20	1.11	0.85–1.45
2021	0.99	0.77–1.27	1.25	0.95–1.65
2022	1.03	0.81–1.32	1.12	0.85–1.46
Province				
Central (Ref)	1.00		1.00	
Copperbelt	1.04	0.76–1.41	2.17***	1.48–3.18
Eastern	0.77	0.55–1.08	1.04	0.72–1.50
Luapula	1.92***	1.30–2.82	2.31***	1.55–3.46
Lusaka	0.10***	0.06–0.16	0.26***	0.15–0.45
Muchinga	0.54**	0.35–0.83	0.52**	0.33–0.81
Northern	2.37***	1.74–3.24	2.49***	1.80–3.44
Northwestern	0.84	0.57–1.23	0.87	0.59–1.29
Southern	1.49*	1.08–2.06	1.72**	1.23–2.41
Western	0.23***	0.14–0.40	0.21***	0.12–0.36
Place of death				
Community (Ref)	1.00		1.00	
Facility	0.52***	0.40–0.67	0.51*	0.27–0.99
On the way	0.65	0.38–1.08	0.38**	0.19–0.78
Facility Level of Care				
Community (Ref)	1.00		1.00	
Health Post	1.22	0.74–2.02	2.31	0.96–5.53
Health Centre	0.83	0.59–1.15	1.78	0.80–3.96
Level 1	0.74*	0.55–0.99	1.57	0.68–3.61
Level 2	0.91	0.68–1.23	1.65	0.71–3.83
Level 3	0.24***	0.18–0.33	0.79	0.33–1.93
Is this a referral				
No (Ref)	1.00		1.00	
Yes	0.52***	0.40–0.68	0.75	0.35–1.61
Self-referral	0.61**	0.42–0.88	0.68	0.32–1.45
Unknown	0.78	0.47–1.32	0.99	0.40–2.44
Days in health facility				
< 1 (Ref)	1.00		1.00	
1–3	0.63***	0.53–0.76	0.70***	0.57–0.86
4+	0.40***	0.31–0.51	0.52***	0.39–0.68
Unknown	0.42***	0.30–0.58	0.63*	0.43–0.93
HIV Status				
Negative (Ref)	1.00		1.00	
Positive	0.79	0.62–1.01	1.11	0.85–1.44
Unknown	0.35***	0.28–0.44	0.73*	0.56–0.96
Constant			0.65*	0.44–0.97
n	3,347		3,347	

Ref: Reference category; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

3.4 Factors associated with errors in medical certification in immediate causes of maternal deaths in Zambia

Results in Table 4 show multivariable logistic regression results of system factors associated with errors in medical certification of immediate cause of maternal deaths in Zambia 2018–2022. In this respect, Lusaka Province had higher odds of error in the

Table 4 Multivariable logistic regression results of system factors associated with certification errors of primary (immediate and antecedent) cause of maternal deaths, MDSR 2018–2022

Factors	Coding errors in primary (immediate and antecedent) cause			
	Bivariate		Multivariable	
	uORs	CI	aORs	CI
Year				
2018 (Ref)	1.00		1.00	
2019	0.79	0.60–1.04	0.89	0.67–1.18
2020	1.34*	1.01–1.79	1.22	0.91–1.64
2021	1.08	0.81–1.43	1.00	0.75–1.35
2022	1.21	0.90–1.61	1.13	0.84–1.53
Province				
Central (Ref)	1.00		1.00	
Copperbelt	0.64*	0.44–0.93	0.64*	0.41–1.00
Eastern	0.57**	0.38–0.84	0.53**	0.35–0.81
Luapula	0.82	0.50–1.36	0.91	0.54–1.52
Lusaka	2.66***	1.72–4.11	2.38**	1.39–4.09
Muchinga	1.05	0.63–1.74	0.98	0.58–1.64
Northern	0.69	0.46–1.02	0.67	0.45–1.01
Northwestern	0.73	0.47–1.14	0.72	0.46–1.14
Southern	0.64*	0.43–0.95	0.63*	0.42–0.96
Western	0.46***	0.30–0.70	0.43***	0.28–0.66
Place of death				
Community (Ref)	1.00		1.00	
Facility	0.53**	0.35–0.78	0.61	0.24–1.54
On the way	0.57	0.29–1.12	0.54	0.21–1.38
Facility Level of Care				
Community (Ref)	1.00		1.00	
Health Post	0.76	0.36–1.59	1.08	0.35–3.33
Health Centre	0.56*	0.35–0.89	0.79	0.29–2.16
Level 1	0.46***	0.30–0.70	0.67	0.24–1.89
Level 2	0.40***	0.26–0.62	0.55	0.19–1.57
Level 3	0.82	0.54–1.26	0.75	0.25–2.24
Is this a referral				
No (Ref)	1.00			
Yes	0.58**	0.39–0.87	1.06	0.40–2.78
Self-referral	0.46**	0.28–0.76	1.01	0.39–2.64
Unknown	0.46*	0.24–0.88	0.90	0.30–2.71
Days in health facility				
< 1 (Ref)	1.00		1.00	
1–3	0.90	0.72–1.11	0.91	0.72–1.15
4+	1.03	0.80–1.34	0.93	0.69–1.23
Unknown	1.37	0.94–2.01	0.85	0.57–1.28
HIV Status				
Negative (Ref)	1.00		1.00	
Positive	0.79	0.61–1.01	0.79	0.61–1.04
Unknown	1.87***	1.46–2.41	1.04	0.78–1.39
Constant			14.12***	8.09–24.63
N	3,347		3,347	

Ref: Reference category; *** p<0.001, ** p<0.01, * p<0.05

immediate cause of maternal death (aOR: 2.38; 95% CI: 1.39–4.09). Copperbelt, Eastern, Southern and Western Provinces had lower odds of errors in classifying immediate cause of maternal deaths (aOR: 0.64, 0.53, 0.63) and (0.43) respectively.

3.5 Factors associated with errors in medical certification in underlying causes of maternal deaths in Zambia

Underlying causes are the train that start the process and are therefore cardinal in policy formulation and review as well as intervention. Results in Table 5 show multivariable logistic regression results of system factors associated with errors in medical certification of underlying causes of maternal deaths in Zambia 2018–2022. Eastern, Northern and Copperbelt Provinces have higher odds of errors in medical certification of underlying cause of maternal death (aOR: 1.60, 95% CI 1.11–2.30; 1.51, 95% CI 1.07–2.14; aOR: 1.46, 95% CI 1.00-2.12; respectively). Lusaka, Muchinga, and Western Provinces have lower odds of errors in medical certification of underlying causes of maternal deaths (aOR: 0.29, 0.47, and 0.66 respectively). There were lower odds of the errors in medical certification underlying causes of death for women who spent 4 + days in the health facility were (aOR: 0.65, 95% CI: 0.51–0.82).

4 Discussion

The WHO ICD-MM provides a standardized system for classifying and coding maternal deaths to ensure consistent data collection, analysis, and reporting. Its purpose is to improve the quality and comparability of maternal mortality information so countries can design better interventions and policies to reduce preventable maternal deaths [23, 24].

In this study, we analysed data from the 2018-2022 MDSR database in the MoH to establish the prevalence of error in medical certification for immediate, underlying and all the three causes of maternal deaths in Zambia. We further examined the institutional and contextual level factors associated with error in medical certification of causes of maternal deaths using multivariable logistic regression analysis. The study found that region, place of death and number of days a woman spent in the health facility before occurrence of death were significantly associated with error in medical certification for all causes of maternal deaths in Zambia.

Study results revealed that the prevalence of medical certification errors for immediate (83.4%), underlying (62.5%) and all the three causes (24.0%) of maternal death was high in Zambia. Although the WHO recommended that the application of ICD-MM will decrease errors in coding of causes of death and improve cause of maternal death attribution [7], it remains unclear as to why the prevalence of medical certification errors were too high in the MoH 2018–2022 MDSR database. A study in Malawi revealed poor agreement between causes of death assigned by healthcare providers and those determined using the ICD-MM classification system were responsible for errors in medical certification of causes of maternal deaths [25]. Prior studies have reported inadequate training of health professionals on ICD-MM standard procedures and weak MDSR data collection and monitoring systems as major causes of errors in medical certification of cause of death [26–29].

The high prevalence of medical certification errors for maternal death causes in Zambia highlights the urgent need for actions that prioritize strengthening the accuracy and

Table 5 Multivariable logistic regression results of system factors associated with certification errors of underlying causes of maternal deaths, MDSR 2018–2022

Factors	Coding errors in Secondary Cause			
	Bivariate		Multivariable	
	uORs	CI	aORs	CI
Year				
2018 (Ref)	1.00		1.00	
2019	1.07	0.85–1.35	0.89	0.70–1.14
2020	0.58***	0.47–0.72	0.68**	0.54–0.87
2021	0.91	0.73–1.14	1.21	0.94–1.55
2022	0.66***	0.53–0.82	0.75*	0.58–0.95
Province				
Central (Ref)	1.00		1.00	
Copperbelt	1.09	0.80–1.48	1.46*	1.00–2.12
Eastern	1.46*	1.04–2.04	1.60*	1.11–2.30
Luapula	1.44	0.94–2.21	1.43	0.92–2.23
Lusaka	0.19***	0.15–0.26	0.29***	0.20–0.42
Muchinga	0.51***	0.36–0.73	0.47***	0.33–0.69
Northern	1.51*	1.08–2.12	1.51*	1.07–2.14
Northwestern	0.83	0.58–1.18	0.83	0.58–1.20
Southern	1.00	0.72–1.39	1.01	0.72–1.42
Western	0.72	0.50–1.03	0.66*	0.45–0.95
Place of death				
Community (Ref)	1.00		1.00	
Facility	0.84	0.65–1.09	0.78	0.38–1.59
On the way	1.27	0.76–2.11	0.94	0.46–1.93
Facility Level of Care				
Community (Ref)	1.00		1.00	
Health Post	1.24	0.73–2.09	1.60	0.67–3.79
Health Centre	1.35	0.97–1.87	1.86	0.84–4.10
Level 1	1.28	0.97–1.70	1.85	0.81–4.20
Level 2	1.30	0.97–1.75	1.79	0.78–4.13
Level 3	0.51***	0.39–0.67	1.41	0.59–3.33
Unknown	0.68**	0.52–0.88	1.19	0.88–1.62
Is this a referral				
No (Ref)	1.00		1.00	
Yes	0.84	0.65–1.10	0.90	0.42–1.91
Self-referral	1.09	0.76–1.57	0.81	0.39–1.68
Unknown	1.35	0.80–2.29	1.10	0.45–2.68
Days in health facility				
< 1 (Ref)	1.00		1.00	
1–3	0.80*	0.68–0.95	0.84	0.69–1.02
4+	0.50***	0.41–0.61	0.65***	0.51–0.82
Unknown	0.68**	0.52–0.88	1.19	0.88–1.62
HIV Status				
Negative (Ref)	1.00		1.00	
Positive	0.92	0.73–1.14	1.15	0.90–1.46
Unknown	0.35***	0.30–0.42	0.74**	0.60–0.92
Constant			2.46***	1.67–3.63
N	3,347		3,347	

Ref: Reference category; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

standardization of MDSR database reporting systems. For example, investing in capacity building training programmes for healthcare professionals responsible for maternal death medical certification and coding could help enhance data reliability. A study conducted in Tanzania in 2020, found the use of an independent team of obstetrician expert as important in improving the accuracy of medical certification of causes of maternal deaths [29].

We found that medical certification errors across all causes of maternal death were more likely to occur in Copperbelt, Luapula, Northern, and Southern provinces than in Central province. On the other hand, medical certification errors on all causes of maternal death were likely to occur in Lusaka, Muchinga and Western provinces. The probable reasons for these results are because Copperbelt province experienced the second highest greater volume of maternal deaths during the analysis period, which may strain healthcare workers responsible for classification of causes of death, thus increasing the likelihood of medical certification errors due to work overload and time pressure to complete the process. Luapula province being predominantly rural, may have fewer trained healthcare professionals in medical certification of maternal deaths, which contribute to high errors in documenting underlying causes of maternal deaths. On the other hand, Lusaka being the capital city is likely to have as sufficient number of well trained and experienced medical doctors who participate in the classification process of medical cause of death.

Proper classification of cause of maternal deaths is essential for understanding and addressing the problem of maternal mortality in SSA [25, 30]. In this study, results show that an increase in the number of days a deceased woman spent in the health facility was associated with lower odds of the errors in coding of both underlying cause and all causes of maternal death. Although there is no specific documented literature that can validate this finding, the probable explanation is the fact that women who spend more days in the health facility seeking medical care are more likely to be attended to properly and to undergo more extensive medical examination compared to emergency cases. This process can result in better-documentation of medical histories, which in turn could contribute to reduced likelihood of medical certification errors of cause of maternal death.

We found that deaths that occurred in the health facility and on the way to the health facility had less chances of experiencing coding errors compared to deaths that occurred in the community. This finding can be explained by the fact that deaths that occur in facilities are more likely to have adequate formal medical records, reducing the likelihood of error in coding processes. Conversely, deaths that occur in communities may sorely rely on verbal autopsies as a way of reporting the medical cause of death. Research on mortality data quality in various African and Asian countries has revealed challenges in accurately capturing causes of death, particularly for deaths occurring outside health facilities. Studies in Tanzania, Thailand, and Ghana have shown that deaths in health facilities or enroute to facilities are less prone to coding errors compared to community deaths [31–34]. This finding highlights the need to improve death reporting systems in community settings to enhance the accuracy and reliability of mortality data.

This study has contributed to the existing literature on the retrospective application of the 2012 WHO ICD-MM classification system in SSA. Specifically, it contributes to understanding the determinants of medical certification errors in cause of maternal

death in Zambia. Our findings emphasize the need for strengthening capacity building training on ICD-MM for health worker professionals responsible for medical certification of maternal deaths in the country. Furthermore, for health policy makers, our findings provide information that may be relevant in strengthening existing maternal health interventions at systemic level in order to further reduce maternal mortality cases in the country. The study's novelty come from its analysis of the MoH MDSR database (2018–2022) to establish the prevalence of medical certification errors in cause of maternal death in Zambia and that our research methodology could be replicated in other countries in SSA, where such data is available.

5 Limitations and strengths of the study

In terms of strengths, this is the first study in Zambia that has been done with a view to measure magnitude of error in the classification of causes of maternal mortality; and thus a novelty in literature on Zambia. The study relied on actual primary data captured as actual events and facts of death; meaning therefore that the accuracy, validity and reliability of the data was incomparable. In the same way, the study used IRIS software to generate results on errors in all causes of MM. The software has the batch processing capabilities to process multiple records in a short time; IRIS is fully integrated with comprehensive medical coding rules and guidelines that also offers guidance in sequencing.

Notwithstanding, the major limitation in the usage of IRIS in this study was having a more updated and contextualized IRIS dictionary of terminologies mapped to common conditions and abbreviations used in Zambia. The dictionary used was slightly modified for the Zambia setup although not recent and needing frequent updates. Lack of this led to having some codes undetected by IRIS leading to coding errors including other erroneous codes entered by physicians. Exporting MCCD data to IRIS tables requires expertise in understanding the structure of IRIS tables and the knowledge of R and SQL database management skills. The study's data was cleaned and quality-checked, but some observations were excluded from the analysis due to missing data on key variables. This may affect the results if lower level analysis is to be done. The study could not use certain variables (e.g., distance to health facilities and level of staff care) due to incomplete or poorly captured data, limiting the analysis of more system-related factors. The other major weakness was the non-classification of health facilities as either rural or urban. Residence plays a pivotal role in understanding a number of factors associated with MM in Zambia; this study would have been richer had the residence variable been included which was not the case.

Despite the limitations, this study has provided useful information to understand the magnitude of error in medical classification of causes of maternal deaths in Zambia. This information can be used to strengthen capacity building of medical practitioners in the correct classification of causes of maternal deaths according to the WHO ICD-MM.

6 Conclusion

This study has established that the prevalence of medical certification errors for the immediate, underlying and all the three causes of maternal death is high in Zambia. This is despite the fact that the magnitude of error varied by type of cause of maternal death. These results highlight critical gaps in the accuracy of health data, potentially undermining effective health policy-making and targeted interventions to reduce maternal

mortality further in Zambia. Region (province), place where death occurred and number of days a woman spent in the health facility were associated with medical certification errors for causes of maternal deaths in Zambia. Therefore, the Ministry of Health and other stakeholders supporting interventions aimed at reducing maternal mortality in Zambia should strengthen training of medical staff responsible for medical certification of maternal causes of death to adhere to the WHO guidelines. Emphasis on training should be placed on Copperbelt, Northern, Luapula and Southern provinces where the likelihood of recording of medical certification error was highest. There is need for further research to understand reasons behind regional disparities in error of medical certification of causes of maternal deaths.

6.1 Implications for practice and policy

To reduce errors in maternal death certification and improve MDSR data quality, policymakers and stakeholders in Zambia should prioritize standardized training of more healthcare providers on accurate maternal death certification in line with the ICD-10 coding. Strengthening MDSR committees at all levels, conducting regular data audits, and enhancing transparent data sharing between facilities and national levels are crucial. Policymakers should develop clear MDSR guidelines, mandate reporting, and allocate resources for capacity building of relevant health personal. Engaging communities in reviews and fostering partnerships with non-state stakeholders can further improve response strategies in timely accessing of maternal health services. All these steps can enhance data-driven decision-making, ultimately reducing preventable maternal mortality and improving health outcomes.

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Author contributions
CCM conceptualization, methodology, and review of the draft manuscript. MEK and MP methodology, statistical analysis, interpretation of results, and writing draft manuscript. MP wrote the discussion of findings. MS participated in the statistical analysis, and interpretation of findings. CO, CM and BM conducted data analysis in IRIS and provided input into the methodology and draft manuscript. BM provided technical support in the statistical analysis in IRIS. BN provided technical support in the data cleaning and analysis. BN, CC, WK, NM, MS, and GS participated in the review of the draft manuscript. CCM reviewed the final manuscript. CCM provided technical guidance in the development of the manuscript. MEK was responsible for coordinating the manuscript. All authors have read and approved the final version of the manuscript.

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Data availability
Access to the datasets used in this manuscript requires a written request to the MoH Headquarters in Zambia.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval
Secondary data from Zambia's MDSR data provided the basis for the statistical analysis. The anonymized MDSR files in Excel format for the years 2018–2022 were made available by the MoH HQ. All identifiable information about the deceased woman, including her name was removed from the datasets. The use of the anonymised MDSR datasets for the manuscript was approved by the MoH, therefore there was no need for informed permission or ethical clearance to participate. The data was used by the authors in compliance with all applicable usage guidelines. Every attempt has been made to guarantee accuracy in the results' interpretation and reporting.

Consent to participate
The data used in this study is based on routinely collected data on maternal deaths in Zambia. The data are collected as part of the MoH's mandate to ensure that data causes of maternal deaths are known so that among others there is improvement in service delivery and preventable maternal mortality are ended. The data are about women who are deceased and thus, cannot consent to participate in our study. However, the MoH HQ provided permission for the use of the anonymised MDSR datasets for the manuscript.

Consent for publication
No images, individual details or videos of the deceased women and those who conduct the MDSR are part of this manuscript.

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