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Analysis of maternal mortality in Berlin, Germany – discrepancy between reported maternal mortality and comprehensive death certificate exploration

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Abstract

Objectives: The OECD estimates an average maternal mortality rate (MMR) of around 3.4 maternal deaths per 100,000 live births for 2019–2021, based on relevant diagnoses on death certificates. However, Germany does not currently have a registry for recording the number of maternal deaths. The aim of this study is to identify the actual number of maternal deaths in Berlin between 2019 and 2022, as well as sources of underreporting and causes of death.
Methods: Potential maternal mortality cases were identified through a search at the Berlin Central Archive for Death Certificates, inquiring women aged 15–50 years with indications of present or recent pregnancy on the death certificate. To cross match the database, an additional search at the Charité University Hospital Berlin was carried out, checking each individual file for pregnancy-association.
Results: The data search resulted in 2,316 women, 18 of which presented an association to pregnancy. Of these, 12 could be classified as maternal mortality cases (MMR 7.8/100,000). The additional search in a university setting revealed two further maternal mortality cases without prior indication of pregnancy on the death certificate. This results in a total MMR of 9.1/100,000 live births, which is over double the official estimate by the OECD.
Conclusions: Based on our findings in Berlin, it can be estimated that there is significant underreporting regarding maternal death cases in Germany. A more comprehensive recording system is needed to more accurately portray maternal mortality.

Keywords: maternal mortality; underreporting of maternal deaths; public health; maternal mortality registry; MMR

Introduction

Preventing a mother's death is probably one of the leading motivations of an obstetrician and might be a historic foundation of women's healthcare. The decease of a mother during or after pregnancy is a catastrophic situation both affecting the neonate, partner, family, and friends as well as the team of physicians, midwifes and nurses.

Maternal mortality is one of the quality indicators of the healthcare system in any given country. The WHO defines maternal mortality as the death of a woman "from any cause related to or aggravated by pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy" [1] (Figure 1). This definition forms the basis for the calculation of the maternal mortality rate. In addition, a late maternal death is defined as the death of a woman that occurs "from direct or indirect obstetric causes, more than 42 days but less than one year after termination of pregnancy" [1]. Differing timeframes are sometimes used, e.g., by the Pregnancy Mortality Surveillance System (PMSS) implemented by the Centers for Disease Control and Prevention (CDC), which defines a pregnancy-related death as a

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death during pregnancy or within one year of the end of pregnancy [2].

Maternal mortalities can be further categorised into direct and indirect maternal deaths. Direct maternal deaths refer to deaths resulting from the gestation and/or its treatment itself, e.g., obstetric haemorrhage, whereas indirect maternal deaths relate to preexisting conditions or conditions arising during gestation that are not caused by but rather aggravated by the latter, e.g., pre-existing cardiac conditions aggravated by pregnancy. Examples of accidental/incidental deaths include car accidents or homicides.

Globally, a woman dies every 2 min due to a pregnancy related cause leaving the family and society devastated [3]. Maternal mortality is a threatening issue and unequally distributed worldwide, with 95 % of maternal deaths occurring in low and lower-middle income countries [4]. In 2000, improving maternal health was set as one of eight Millennium Development Goals (MDGs), resolving to reduce maternal mortality by three quarters by 2015 [5]. While numbers continue to fall short of this goal, maternal mortality has seen a drop of about 47.4 % in "least developed countries" from 2000 to 2020 [4]. Despite this, a woman in Sub-Saharan Africa is still over 127 times as likely to die from pregnancy-related causes as a woman from the region of Europe and Northern America in her lifetime (Table 1) [4, 6].

Germany does not operate a nationwide registry to gather data on pregnancy-associated deaths. This contrasts with other developed countries such as the United Kingdom, where confidential queries into maternal deaths have provided reliable figures since 1952 and have been regarded as the gold standard worldwide [7]. Since 2012, these enquiries are published triennially under the name "MBRRACE-UK: Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK" and include information on maternal mortality and morbidity in the UK and Ireland as well as lessons and recommendations for future treatment [8].

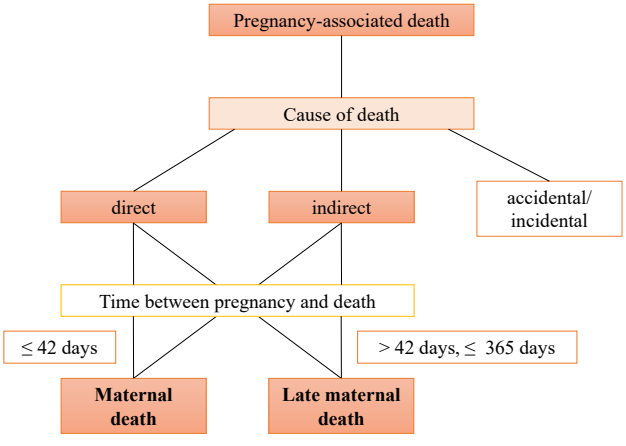

Figure 1: Definition of maternal death and late maternal death depending on the time of maternal death regarding the period between pregnancy and death, adapted from [1].

Table 1: Estimates of maternal mortality ratio (MMR) by United Nations Sustainable Development Goal (SDG) region, 2020, adapted from [4].

SDG region	MMR point estimate, 2020	Lifetime risk of maternal death (1 in), 2020
World	223	210
Sub-Saharan Africa	545	40
Northern Africa and Western Asia	84	420
Central and Southern Asia	129	340
Eastern and South-Eastern Asia	74	850
Latin America and the Caribbean	88	580
Oceania (excluding Australia and New Zealand)	173	170
Australia and New Zealand	4	16,000
Europe and Northern America	13	5,100

The OECD estimates a maternal mortality rate for Germany of 3.4/100,000 live births for 2019–2021 [9] (as of time of writing, no data is available for 2022). This estimation is based on numbers from the Federal Statistical Office and takes into account all cases with the relevant ICD-10 diagnoses O00-O99 (excluding late maternal deaths, ICD-10 O96 and O97) on the death certificate [9]. Figures for cause of death are submitted yearly to the Federal Statistical Office by the offices for statistics in each state, in the case of Berlin by the Office for Statistics Berlin-Brandenburg (Amt für Statistik Berlin-Brandenburg).

The independent IQTIG (Institute for Quality and Transparency in the Healthcare Sector) collects data on the quality of perinatal healthcare in Germany and evaluates the number of maternal deaths in the setting of a hospital birth each year. This provides another source of maternal mortality data in Berlin.

The Berlin death certificate includes a section for additional information in women, which asks for information on a current pregnancy at the time of decease as well as a previous pregnancy, having ended no more than 3 months prior to dying, using checkboxes (Figure 2).

Such checkboxes have also been implemented in other countries [11–13]; however, they are not currently used in the identification of maternal death cases in Germany. It can

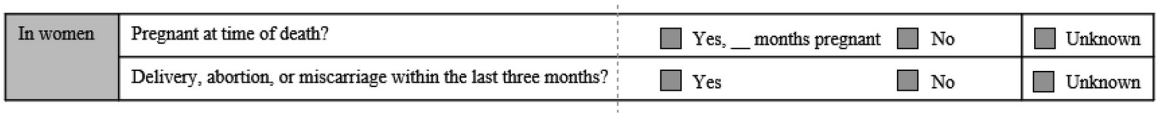

Figure 2: Pregnancy checkboxes on Berlin death certificates, translated from the Berlin death certificate [10].

be assumed that the actual number of maternal deaths in Germany lies higher than official estimates [14].

The aim of this current analysis is to identify the actual number of maternal deaths that occurred in the city of Berlin between the years of 2019 and 2022, to identify the extent of and the reasons for underreporting, and to analyse the prevalent causes of maternal death.

Methods

Maternal mortality cases were identified through research at the Central Archive for Death Certificates (Zentralarchiv für Leichenschauscheine, ZfL) in Berlin. This archive compiles information of all persons who decease in the city of Berlin, regardless of place of registered residence. Included into the analysis were all female deaths between 01.01.2019 and 31.12.2022. Women born between 01.01.1969 and 31.12.2007 were included, corresponding to an age between 15 and 50 at the time of death. To identify potential maternal mortality cases, we searched the database at the ZfL Berlin. All death certificates matching the criteria were inspected for pregnancy association through the 'additional information in women' (Figure 2), the cause of death, and further medical information given on file.

To identify underreported cases in which pregnancy-associated mortalities were not indicated as such on the death certificate, an additional comprehensive search was carried out at the database of Charité University Hospital Berlin. In this, all deaths fulfilling the criteria regarding date of birth, gender, and date of decease, and that occurred in the Charité University Hospital Berlin (Campus Mitte, Campus Virchow and Campus Benjamin Franklin) were analysed further using hospital records. The discharge notes as well as the latest bloodwork were examined, searching for pregnancy-association.

Following the identification of all cases, a single-study analysis was carried out by contacting the signatories of the death certificate with an inquiry into pseudonymised patient records. The patients were categorised into maternal deaths, late maternal deaths, and accidental/incidental cases according to WHO criteria. Maternal mortality cases were grouped by cause of death in accordance with the ICD-MM guidelines (Table 2) [15].

Ethical approval to conduct this study was received from Charité University Hospital (EA1/156/23). Additionally, our study group consulted with a data protection specialist from Charité as well as a lawyer.

All patient data was collected in a pseudonymised form and stored on internal, password-protected hospital servers, that were only accessible for J. Koenigbauer and J. Callaghan. Descriptive analyses were carried out using SPSS IBM 29 Statistics. The MMR was calculated based on the number of births given by the Office for Statistics (Amt für Statistik) Berlin-Brandenburg [16].

Table 2: ICD-10 MM groups of underlying causes of death during pregnancy, childbirth, and the puerperium; adapted from [15].

Type	Group name/number
Maternal death: direct	1. Pregnancies with abortive outcome
Maternal death: direct	2. Hypertensive disorders in pregnancy, childbirth, and the puerperium
Maternal death: direct	3. Obstetric haemorrhage
Maternal death: direct	4. Pregnancy-related infection
Maternal death: direct	5. Other obstetric complications
Maternal death: direct	6. Unanticipated complications of management
Maternal death: direct	7. Non-obstetric complications
Maternal death: unspecified	8. Unknown/undetermined
Death during pregnancy, childbirth, and the puerperium	9. Coincidental causes

Results

Search at the Berlin Central Archive for Death Certificates

The search at the ZfL Berlin led to the identification of 18 pregnancy-associated deaths between 2019 and 2022 (Figure 3). Of these, eight were identified through the section 'additional information in women' (Figure 2). Ten cases were found by examining the cause of death and medical history given on the death certificates.

Cross analysis of all women deceased in the university hospital setting

The additional search at the university hospital included 490 of the 2,316 women (21.2 %) (Figure 3). An analysis of the discharge notes and latest bloodwork revealed five pregnancy-related cases not previously identified through the search at the ZfL Berlin.

Feedback from death certificate signatories

Of the seven institutions contacted, five were able to give details on the requested case/cases (Figure 4). In one case, co-

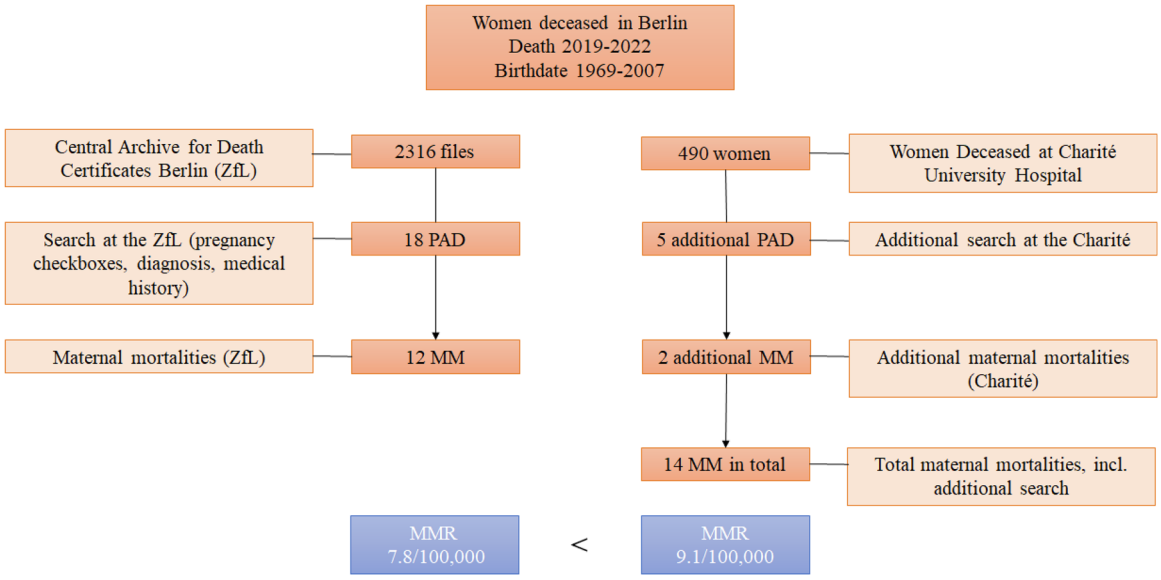

Figure 3: Case identification of maternal mortalities, Berlin 2019–2022, PAD, Pregnancy-associated deaths; MM, Maternal mortalities according to WHO definition (WHO definition); MMR, Maternal mortality rate per 100,000 live births; Zfl, Zentralarchiv für Leichenschauscheine.

operation was signalled, though the patient could not be found. Another institution was not able to provide information due to an ongoing criminal investigation.

Classification of cases

After obtaining further information about the potential maternal mortalities, the cases were classified into maternal deaths, late maternal deaths, and accidental/incidental deaths (Table 3). One case could not be classified due to an ongoing criminal investigation. The number of maternal mortalities fulfilling WHO criteria varied from two in 2020 and 2022 to seven in 2021.

Characteristics of maternal mortalities

Of the 14 maternal deaths, over half (n=8, 57.1 %) of patients were aged 30–39 at time of death. The remaining six patients consisted of four between the ages of 20–29 (28.6 %) and two aged 40–49 (14.3 %). Four deaths occurred during pregnancy (28.6 %), four were peripartum deaths (28.6 %) and six women died during the puerperium (42.9 %) (Figure 5).

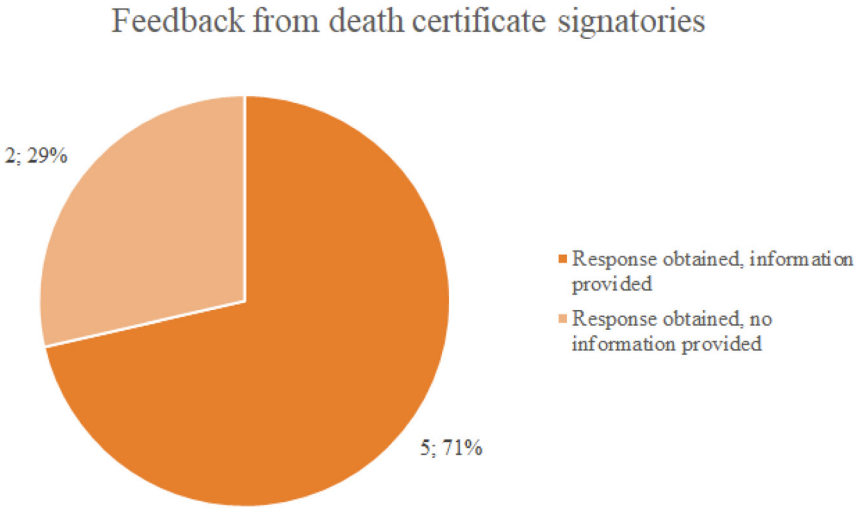

Figure 4: Feedback obtained from the signatories of the death certificates.

Table 3: Classification of pregnancy-associated deaths, in accordance with WHO guidelines, ([a]) In relation to all cases, including additional search at the Charité University Hospital database, MMR, Maternal mortality rate per 100,000 live births.

	Cases identified through death certificates n=18	All cases incl. search at Charité database n=23	%[a]	MMR[a]
Maternal deaths 2019–2022	**12**	**14**	**60.9**	**9.1**
Direct causes	8	9	39.1	5.9
Indirect causes	4	5	21.7	3.3
Late maternal deaths	3	6	26.1	
Accidental/incidental deaths	2	2	8.7	
Non-classified cases	1	1	4.3	

In the case of peripartum/postpartum decease, four pregnancies resulted in live births, four in fetal death (termination/miscarriage/stillbirth), and one in a twin birth where both neonates died perinatally. In one case, live birth or stillbirth was not specified (Figure 5).

Causes of maternal deaths

The most common causes of direct obstetric death in women were death after a pregnancy with abortive outcome (33.3 %) and other obstetric complications (33.3 %) (Figure 6). Of the deaths categorized under group 1, one death followed a ruptured tubal pregnancy, another resulted from sepsis following pelvic infection after miscarriage, and in one instance, termination of pregnancy in a woman with an unknown cervical vascular anomaly resulted in decease due to internal haemorrhage. Other obstetric complications (group 5) included two cases of pulmonary embolism and one case of amniotic fluid embolism. The remaining direct obstetric deaths resulted from hypertensive disorders and obstetric haemorrhage.

Indirect causes of death included cancer, COVID-19, subarachnoid haemorrhage, haemorrhage from a previously undiagnosed thoracic aneurysm, and cardiac arrest following termination of pregnancy in a woman with a pre-existing heart condition.

Half of all late maternal deaths were due to non-obstetric complications including cancer and sepsis (Figure 7). Other reasons for late maternal death were pulmonary embolism after termination of pregnancy,

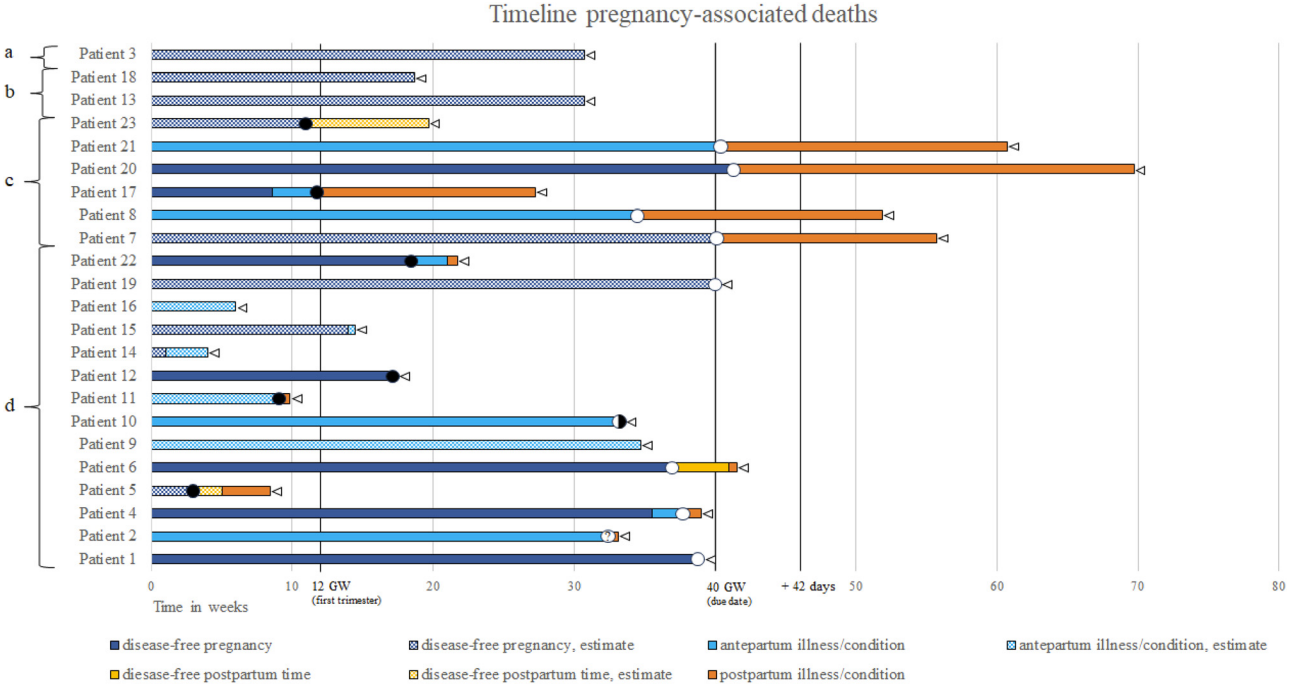

Figure 5: Timelines of pregnancy-associated deaths in weeks. Each line represents a maternal mortality case. Shown are times of disease-free pregnancy, duration of antepartum illness/condition, time between end of pregnancy and onset of illness/condition and time between onset of illness/condition and death. Where no exact pregnancy timeline is known, but can be estimated based on information given, the line is checkered. Thicker vertical lines symbolize 12 gestational weeks (GW), 40 GW, and 6 weeks (42 days) postpartum (relating to normal length of pregnancy). ○ Live birth, ● abortion/miscarriage/stillbirth, (?) delivery, live birth or stillbirth not specified, ◑ twin birth, perinatal death of both, ◁ maternal death (a) non-classified case; (b) accidental/incidental deaths; (c) late maternal deaths; (d) maternal deaths.

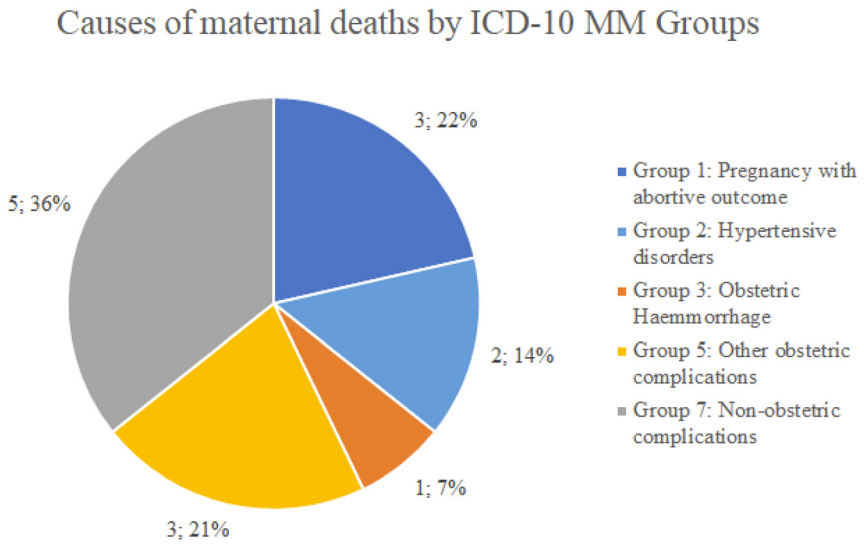

Figure 6: Causes of maternal deaths by ICD-10 MM groups.

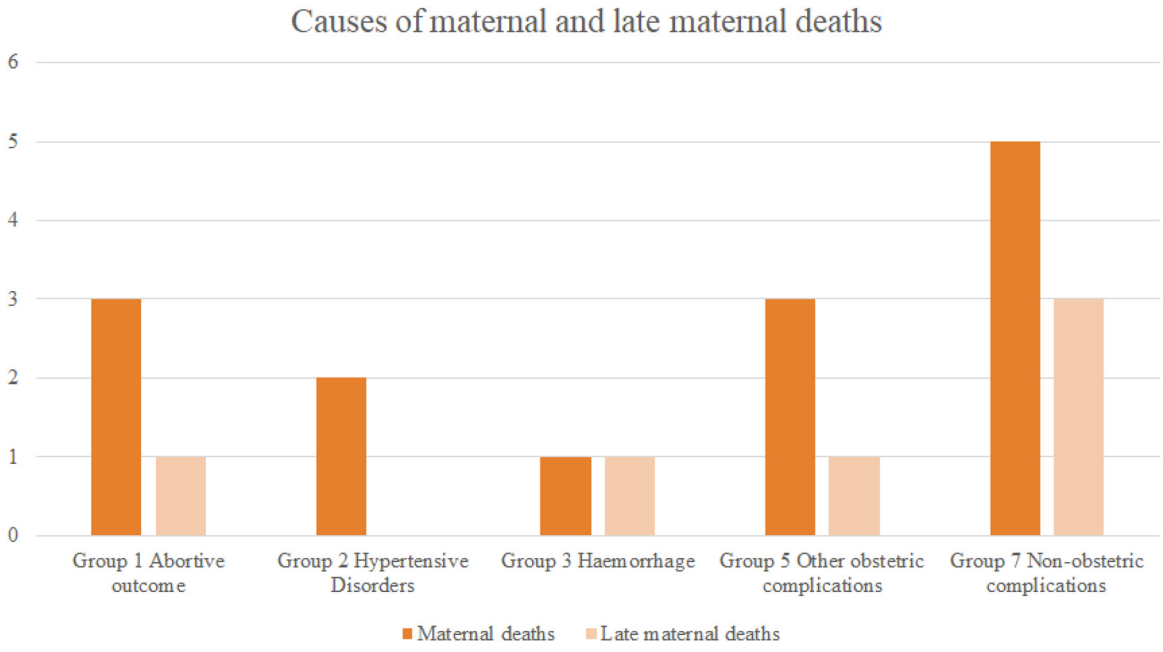

Figure 7: Causes of maternal and late maternal deaths, grouped by ICD-MM guidelines, comparing maternal deaths (<42 days p.p.) and late maternal deaths (>42–365 days p.p.).

sepsis following uterine rupture and multi organ failure, and peripartum cardiomyopathy.

Quality of data and underreporting

Of all 2,316 death certificates studied, information on the status of an underlying pregnancy in this person under the section 'additional information in women' was given in 26.8 % of women, including cases marked 'unknown'. This means the death certificates of women were not fully completed in 73.2 % of cases.

Focusing on the maternal mortality cases, our research revealed a similar level of death certificate completion (Table 4). A relevant ICD-10 diagnosis was documented on less than a third of death certificates of maternal mortality cases (Table 4).

In total, 12 maternal mortality cases fitting WHO criteria were found at the ZfL Berlin, amounting to a MMR of 7.8/

Table 4: Levels of reporting of pregnancy-association on death certificates, grouped by maternal deaths, late maternal deaths, accidental/incidental deaths, and non-classified cases.

	Maternal deaths n=14	Late maternal deaths n=6	Accidental/ incidental deaths n=2	Non-classified cases n=1
Relevant diagnosis present on death certificate	4 (28.6 %)	1 (16.7 %)	0 (0.0 %)	0 (0.0 %)
Checked box under section 'additional information in women'	4 (28.6 %)	1 (16.7 %)	2 (100.0 %)	1 (100.0 %)

100,000 live births (Figure 8), excluding one non-classifiable case.

With the additional search at the Charité University database, we were able to identify two further, unreported maternal mortality cases. These women were not found in our manual search of death certificates due to insufficient information given on file.

Discussion

The level of maternal mortality found in this study is much higher than previously estimated. The main reason for this seems to be the method of recording maternal deaths in Germany, which is currently based on relevant ICD-10 diagnoses on death certificates, reported by the Federal Statistical Office. In our study, less than a third of death certificates of maternal mortalities included a relevant diagnosis (Table 4). This explain the high discrepancy that can already be seen when comparing the number of maternal deaths identified through the search at the ZfL Berlin and the official OECD estimate with an MMR of 7.8 (Berlin, 2019–2022) compared to 3.4 (Germany, 2019–2021 average) [9].

On top of this comes the issue of underreporting of any pregnancy-association on the death certificate, as could be seen in the two maternal deaths identified in the additional search at the Charité University Hospital database. At 153,093 live births in Berlin between 2019 and 2022 [16], 21,871 (14.3 %) of which were born at the Charité [19–22], this translates to an additional MMR of 1.3/100,00 live births. Presumably, this could be representative of a larger issue of underreporting.

The Institute for Quality and Transparency in the Healthcare Sector (IQTIG), another instrument of assessing perinatal healthcare, found one maternal mortality in Berlin in 2019 and none in 2020 and 2022 [18, 23]. For 2021, at least one but a maximum of three cases were reported, though the exact number is not available [18]. This incongruity in numbers can be explained by the fact that the IQTIG only reports on maternal deaths when they occur surrounding a hospital delivery, missing out on patients who die during pregnancy, women who deliver outside of hospitals, as well as women deceasing during the puerperium. It also matches previous findings in the Berlin study by Hellmeyer et al., where for 2016, three underreported deaths were found in addition to the two identified through numbers given by the IQTIG [14].

European comparison

When comparing our Berlin findings to European countries with enhanced surveillance systems for recording maternal mortality [13], it becomes evident that Berlin's international standing with regards to maternal health also measures up much lower than previously assumed of Germany (Figure 9).

When taking a closer look at the UK, which has a long-standing reporting system for maternal deaths, we see that underreporting of maternal mortalities on death certificates is not just a German issue. There, the MMR for 2018–2020 based on death certificates alone was found to be 6.04, compared to 10.9 based on all study findings, an underreporting rate of 43.6 % [24]. However, since those otherwise

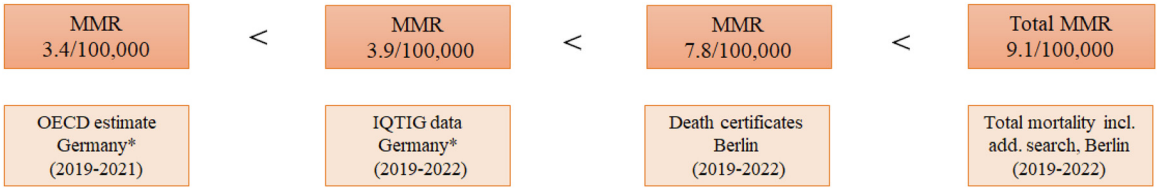

Figure 8: Maternal mortality rate Berlin 2019–2022, total mortality identified in this study including additional search at Charité University Hospital compared with initial analysis at Berlin Central Archive of Death Certificates, and [9] and IQTIG data [17, 18]. OECD, Organisation for Economic Co-operation and Development; IQTIG, Institute for Quality and Transparency in the Healthcare Sector, ([a]) Average of data for the given years.

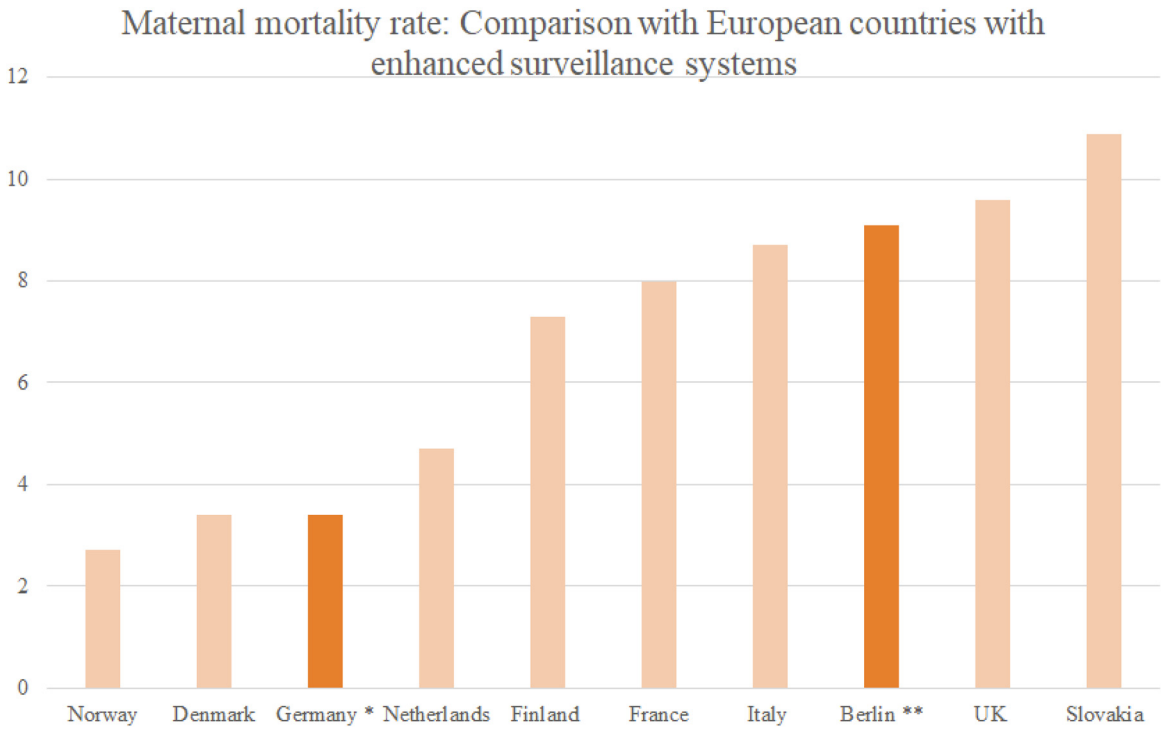

Figure 9: Maternal mortality ratio: comparison with European countries with enhanced surveillance systems [13]. [a]German OECD estimate, 2019–2021 average (OECD). [b]Berlin 2019–2022 average, based on all maternal deaths identified in this study time periods for calculation of MMR in other European countries (4): 2008–2012 (Finland), 2013–2015 (France, Italy), 2013–2017 (Denmark), 2014–2018 (Netherlands, Norway, Slovakia), 2016–2018 (UK).

underreported numbers are identified through the enhanced reporting system in the UK and regularly published, the realistic numbers can serve as a much better base for discussions surrounding funding and healthcare needs of pregnant women.

Global comparison

Even if the MMR of 9.1/100,000 is to be assumed for all of Germany, this would still be lower than the WHO estimate for the region of Europe and Northern America (Table 1) and place highly in comparison to other regions of the world and the worldwide average of 223/100,000 live births (2020) [4].

COVID-19 pandemic

The COVID-19 pandemic, spanning three of four years examined in this study, has previously been linked to worse maternal outcomes [25–27]. While the year 2021, the year with the highest number of COVID-19 related deaths in Germany [28], also showed the highest number of maternal mortalities in our study, only one death was caused by COVID-19. One further woman was infected with SARS-COV-2 at time of death, though there was likely no causal link. Due to the rare occurrence of maternal death in Berlin, there is not enough information to state whether there is a significant link of the COVID-19 pandemic to worse maternal outcomes in this study.

Limitations of this study

Since the official data/estimates based on numbers by the Federal Statistical Office do not discriminate findings by region, the MMR found in this study must be compared to German-wide estimates. Numbers found in Berlin may not be representative of the whole of Germany, especially since difficult obstetric cases in areas surrounding Berlin are routinely referred to the tertiary perinatal centres within the city.

In comparing the findings in Berlin to other studies, the MMR was averaged over the four-year study period in order to obtain more stable figures for this rare event. Differences to the German MMR estimates are possible since 2022 numbers have not been released yet. However, with the official OECD figures remaining relatively consistent over the timeframe studied, this issue is assumed to be minor.

It is unsure whether the same level of underreporting as found at the Charité University Hospital can be applied to the whole of Berlin. However, an analysis of all 2,316 deaths occurring in the studied timeframe would not have been feasible due to accessibility of data, time restraints, as well as data protection concerns.

Due to lack of information provided by the signatories of the death certificates, it was not always possible to obtain detailed information on the timeline as well as causality of the deaths.

Outlook

A manual review of all death certificates, as was carried out in this study, is too work- and cost-intensive to provide a realistic solution to lessen the extent of underreporting in Germany.

The pregnancy checkboxes on death certificates are currently too sparsely filled out regardless of pregnancy-association. If the completion of these checkboxes was to be made mandatory, this could provide a means of identifying further pregnancy-associated deaths in the future. To this end, the timeframe of the checkbox asking for previous pregnancy should be altered to adhere to the WHO definition of maternal mortality (pregnant within 42 days before death) and late maternal mortality (pregnant between 43 days and a year before death). To prevent overreporting of maternal deaths, as identified in previous studies on pregnancy checkboxes [11, 29], it would be advised to review the death certificates for pregnancy-related ICD-10 diagnosis and to obtain further information from the signatory where such a diagnosis is not present.

In general, the establishment of a perinatal death registry seems the most realistic option in improving the accurate portrayal of maternal mortality. Such a registry, including regular interdisciplinary reporting, is in the process of being created by an independent task force and will be implemented in coming years.

Going forward, analysing the factors leading to the deaths of mothers and learning from the results needs to stay a top priority for Berlin and Germany as a whole. In addition, more emotional and psychological support needs to be given to everybody affected by these tragedies, the family of the deceased as well as the healthcare team. In an environment where maternal mortality is not treated as taboo, one can best implement change.

Research ethics: Ethical approval was received from the ethics committee of Charité university hospital (EA1/156/23).
Informed consent: Not applicable.

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Competing interests: Authors state no conflict of interest.
Research funding: None declared.
Data availability: The raw data can be obtained on request from the corresponding author.

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