

Confidential enquiry into maternal deaths in the Netherlands, 2006-2018: a retrospective cohort study

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Shortened running title: Confidential enquiry into maternal mortality in the Netherlands 2006-2018.

Abstract

Objective: To calculate maternal mortality ratio (MMR) for 2006-2018 in the Netherlands and compare with 1993-2005. Describe women's and obstetric characteristics, causes of death and improvable factors.

Design: Prospective cohort study.

Setting: Nationwide.

Population: 2,304,271 livebirths.

Methods: Analysis of all maternal deaths between January 1st, 2006, and December, 31st, 2018 as reported to and audited by the national Audit Committee Maternal Mortality and Morbidity.

Main outcome measures: MMR, causes of death, improvable factors.

Results: Overall MMR was 6.2 per 100,000 livebirths, a decrease from 12.1 in 1993-2005 (Odds Ratio (OR) 0.5, 95%CI 0.4-0.6). Women with non-Western ethnic background had a slightly increased MMR compared to Dutch women (MMR 6.5 vs 5.0, OR 1.3, 95%CI 0.9-1.9), and was particularly increased among women with a background from Surinam/Dutch Antilles (MMR 14.7 OR 2.9, 95%CI 1.6 – 5.3). Half of all women had an uncomplicated medical history (79/161, 49.1%). Of 172 pregnancy-related deaths within one year postpartum, 103 (60%) had a direct and 69 (40%) an indirect cause. Leading causes within 42 days postpartum were cardiac disease (n=21, 14.8%), hypertensive disorders (n=20, 14.1%) and thrombosis (n=19, 13.4%). For deaths up to one year postpartum, suicide was the third commonest cause (n=20, 11.6%). Improvable factors in care were identified in 76 (47.5%) of all deaths.

Conclusions: Maternal mortality halved in 2006-2018 compared to 1993-2005. Unlike before, cardiac disease outnumbered hypertensive disorders as main cause of death. Women with a background from Surinam/Dutch Antilles had a threefold higher risk of death compared to Dutch women.

Funding: No funding was received for this study.

Keywords: maternal mortality, maternal health, the Netherlands, confidential enquiry

Introduction

In 2017, 295,000 women worldwide died during pregnancy or postpartum, over 90% in low- and middle-income countries, the overwhelming majority potentially preventable.¹ However, also in high-income countries, reporting and reviewing maternal deaths remains important: from every death, lessons can be drawn to improve obstetric and perinatal care and prevent future deaths and morbidities of mothers and their children. The national maternal mortality ratio (MMR) is an important healthcare indicator, enabling identification of changes over time and international comparisons. In order to further unravel the reasons why women die, several countries, have established systems of confidential enquiry into maternal deaths.^{2, 3}

In the Netherlands, maternal deaths until one year after birth are reported to the Netherlands Audit Committee Maternal Mortality and Morbidity (ACMMM, *Auditcommissie Maternale Sterfte en Morbiditeit*, AMSM). While the global rate of maternal mortality dropped by 43% between 1990 and 2015, the MMR in the Netherlands previously increased from 9.7 in 1982-1992 to 12.1 per 100,000 livebirths in 1993-2005.⁴⁻⁶ This increase was attributed to demographic changes, upcoming risk factors such as obesity and chronic hypertension and reduced underreporting.⁴ This is the first report in the international literature, since the previous report in 2010.

In 1993-2005, the commonest cause of death was (pre-)eclampsia, accountable for almost one third of deaths. In 2013, the Netherlands Obstetric Surveillance System (NethOSS) was introduced, registering severe maternal morbidity. Results showed a reduction in rates of eclampsia by 70% comparing timeframes 2004-2006 and 2013-2016.⁷ This decrease was attributed to awareness of the relatively high number of deaths due to hypertensive disorders, followed by improved management, starting magnesium sulphate and antihypertensives earlier in the course of disease, combined with early term induction and obstetric emergency training for consultants and registrars.^{8, 9} It is not yet known whether this observed decline in eclampsia, is also reflected in the number of hypertension-related maternal deaths.

Primary aim of this study was to calculate the MMR for 2006-2018, and compare it to 1993-2005. Secondary aims were to describe women's and obstetric characteristics, causes of deaths and improvable factors identified in the confidential enquiry.

Methods

This was a prospective nationwide cohort study of maternal deaths reported to the AMSM between January 1st, 2006, and December 31st, 2018.¹⁰

According to the World Health Organization (WHO), maternal mortality is defined as the death of a woman during pregnancy, childbirth, or within 42 days postpartum or after termination of pregnancy. Death of a woman after 42 days up to one year postpartum is

defined as late maternal mortality.¹¹ In the Netherlands, ascertainment of maternal deaths is based on reporting of maternal deaths up to one year postpartum, to the AMSM, as stated in a national guideline by the Netherlands Society of Obstetrics and Gynaecology.¹² The AMSM consists of eight consultant obstetrician-gynaecologists, one obstetric anaesthesiologist and two registrars in obstetrics and gynaecology. Committee members are employed at academic and non-academic teaching hospitals. Deaths can be reported directly to the AMSM by medical specialists, midwives or general practitioners.¹²

Starting from 2016, electronic reporting was available through NethOSS, a nationwide population-based obstetric surveillance system for registration of severe maternal morbidity and mortality. A monthly email, for online registration, is sent out to assigned clinicians in every hospital with a maternity ward requesting to report cases meeting inclusion criteria or declare 'nothing to report' to ascertain validity of the system.⁷

To ensure completeness of reporting, a cross-check with Statistics Netherlands, the national authority collecting vital statistics, was performed annually until 31st of December 2011. A reminder to report to the AMSM was sent to each hospital by Statistics Netherlands. After 2011 Statistics Netherlands did not allow further cross-checking, since due to small numbers anonymity of data was considered to be potentially compromised. Statistics Netherlands publishes national reports on causes of death, including maternal and pregnancy-related deaths. These reports rely on information from death certificates, including only cause of death and age of the woman.¹³ Deaths identified from the cross-check, for which the timing of death was unknown, were included as non-late deaths.

Following the report of a death, the AMSM requests all medical records, including antenatal charts, laboratory and microbiology results, operation reports, autopsy reports and local audit results. Medical records are uploaded to a secured online platform, to which only members of the AMSM are allowed access. Through confidential enquiry, underlying causes of death are identified and care evaluated for possible improvable factors. Anonymised patient data are subsequently stored in a secured database that can only be accessed by the members of the AMSM.

Main outcome was the MMR for the years 2006-2018, which was compared with that of 1993-2005. The MMR was calculated for direct and indirect deaths separately and a sensitivity analysis was conducted for the absence of cross-checking after 2011, comparing total maternal deaths with and without additional deaths from Statistics Netherlands.

Maternal and obstetric characteristics are presented alongside those of the general population. Pregnancy-related characteristics of the general pregnant population such as antenatal care characteristics, referral, place and mode of birth were extracted from the Netherlands Perinatal Registry (Perined), in which approximately 95.5% of all births with gestational age ≥ 22 weeks were recorded before 2011, and more than 99% from 2012 onwards.¹⁴ For parity, age groups and ethnic background groups we calculated the MMR, with the number of livebirths obtained from Statistics Netherlands based on birth certificates.¹⁵

We analysed underlying causes of death, as described by the confidential enquiry. A cause-specific MMR was calculated and compared with 1993-2005. Underlying cause is defined as the disease or condition that initiated the morbid chain of events leading to death.¹ Causes are classified as 'direct', 'indirect', or 'non-pregnancy-related'. Direct obstetric deaths are those resulting from obstetric complications of pregnancy or their management. Indirect obstetric deaths are the result of pre-existing disease, or disease that developed during pregnancy not due to direct obstetric causes, but aggravated by physiological effects of pregnancy.¹ Non-pregnancy-related deaths, e.g. traffic accidents, non-pregnancy-related malignancies and violence, were excluded from further analysis. Late maternal deaths were excluded from calculations of the MMR, but included for all other analyses. According to the tenth revision of the International Classification of Diseases to deaths during pregnancy, childbirth, and the puerperium (ICD-MM), with regard to the classification of suicide as a direct cause of death, all suicide deaths were re-classified into that category, regardless of psychiatric history.¹⁶

Causes of death were categorised according to the classification applied by 'Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries in the UK' (MBRRACE-UK), which is based on the ICD-MM, but has more extensive subclassifications. In the previous Dutch report on maternal mortality, a different classification was chosen, which differed from international standards.⁴ To compare our results with those from 1993-2005, whilst still seeking international uniformity, the previous time period was also reclassified according to the MBRRACE-UK categories. (Appendix S1)

In all deaths available for enquiry, quality of care was assessed systematically with regard to possible improvable factors that might have contributed to the chain of events leading to death. These improvable factors could be patient-related, primary obstetric care-related (provided by general practitioner or midwife) or hospital care-related (concerning care provided by obstetricians and other medical specialists). Improvable factors were classified as presented previously.⁴ Additionally, lessons learnt were proposed by the AMSM, by translating improvable factors into generalised clinical recommendations, aiming to promote improvements in care at all levels. Lessons were categorised in a manner similar to that of the national perinatal mortality audit, with regard to guidelines, communication and training of health professionals.¹⁷

Improvable factors in care were evaluated by the AMSM for women with different ethnic backgrounds. Ethnic background was based on the description stated in medical records, without further information available on whether women were native or foreign-born. Categorisation into Western and non-Western, was based on nation-specific socioeconomic and social-cultural status, according to the definitions of Statistics Netherlands. Western women were those originating from Europe (excluding Turkey), North-America, Oceania, Indonesia and Japan, and non-Western women those from Africa, Latin-America, Turkey and Asia.¹⁸ Dutch women were natives without a migration background. Dutch women and Western women were grouped together for comparison with non-Western women, due to the very small proportion of non-Dutch women with a

Western ethnic background. This is in line with studies from the US, where the risk of maternal death was comparable for US-native white women and foreign-born white women, and significantly different from that of black women, either born in the US or elsewhere.¹⁹

The MMR is defined as the number of maternal deaths during pregnancy or within 42 days postpartum per 100,000 livebirths.¹ Livebirths are registered by Statistics Netherlands and defined as the birth of a child that showed any sign of life after birth, regardless of gestational age.¹⁵ Obesity was defined as a body mass index (BMI) of ≥ 30 kg/m², or when obesity was explicitly mentioned in the medical records in case BMI was missing. Caesarean sections were classified as 'planned' or 'unplanned'. In the Netherlands, "low risk" women receive maternity care and give birth in midwife-led primary care, or are referred to hospital obstetrician-led care if they are assessed as "high-risk" at booking or if complications arise according to national guidelines.²⁰

Odds ratios (OR) with 95% confidence intervals (95%CI) were calculated to compare the MMR between groups. Statistical analyses were performed using IBM SPSS for Mac, version 27 (SPSS Inc., Chicago, IL, USA).

Results

A total of 207 maternal deaths were reported to the AMSM during the thirteen-year period. After cross-checking with Statistics Netherlands for the years 2006-2011, 11 additional mortalities were identified, of whom only age and cause of death were known. In 46 women, death was classified as non-pregnancy-related and excluded from further analysis (Appendix S2). In 30 (17.4%) women, death occurred after 42 days postpartum. In 94.5% of registered mortalities (206/218), medical records were available for enquiry. Statistics Netherlands documented 83 deaths in 2006-2018, compared to 207 reported to the AMSM, amounting to an estimated underreporting of 60% in the Statistics Netherlands.

The MMR for the years 2006-2018 was 6.2 per 100,000 livebirths (142/2,304,271), significantly lower than the MMR of 12.1 for 1993-2005 (OR 0.5 95% CI 0.4-0.6). Excluding deaths identified after cross-checking with Statistics Netherlands did not substantially alter the reduction (MMR 10.4 vs 5.7 per 100,000 livebirths, OR 0.5, 95% CI 0.4-0.7). Considerable decreases were seen in both direct and indirect deaths (Table 1). When excluding numbers from Statistics Netherlands these decreases remained similar: 3.6 vs 7.2 per 100,000 livebirths for direct deaths, (OR 0.5, 95% CI 0.4-0.6) and 2.1 vs 3.2 per 100,000 livebirths for indirect deaths (OR 0.7, 95% CI 0.5-0.9).

Of the 131 maternal deaths within 42 days postpartum (excluding numbers from Statistics Netherlands), 62 (47.3%) were in nulliparous women. Nulliparous women and women of higher parity had a higher risk of death compared to women with a second ongoing pregnancy, who had the lowest MMR (OR 1.5 (1.0-2.2) and 2.2 (1.1-4.4) respectively). (Table 2) Mean age was 31.8 years (range 17 - 53). Women aged 25-29 years had the lowest MMR (3.9 per 100,000 livebirths), compared with 20.4/100,000 (OR 5.3 95%CI 1.8-15.1) in teenage women and 21.6/100,000 (OR 5.6 95%CI 0.8-41.0) and women

≥45 years. Compared to Dutch women, women with non-Western ethnic background had a statistically non-significant increase in MMR (6.5 vs 5.0 per 100,000 , OR 1.3, 95%CI 0.9-1.9). Compared to Dutch and Western women, women with a non-Western ethnic background more often had pre-existing medical conditions (OR 3.3, 95%CI 1.6-7.0), obesity (OR 2.4, 95%CI 1.1-5.6) and teenage pregnancies (OR 28.7, 95%CI 1.5 - 545). (Appendix S3) Women with a background from Surinam and the Dutch Antilles (n=13) had a considerably increased MMR (14.7 per 100,000). In four out of these 13, cause of death was unascertained, three died of pre-eclampsia, two of suicide and one due to progressive cardiac disease. Four were obese, three smoked during pregnancy and four had pre-existing medical problems.

Of 161 women who died up to one year postpartum, 60 (37.3%) were booked as “high-risk” at booking, and received antenatal care exclusively in secondary or tertiary obstetrician-led care. Eighty-seven women (54.0%) started antenatal care in primary care, ten (6.2%) received no antenatal care at all. Sixty-five women (40.4%) were referred from primary care to secondary or tertiary care during pregnancy (n=52, 80%), childbirth (n=5, 7.7%) or postpartum (n=5, 7.7%). A total of 119 women (73.7%) died postpartum, of whom 13 had given birth at home (10.9%). Caesarean section was performed in 60 (50.4%) women: 40 were unplanned (66.7%) and 14 (2.3%) were perimortem caesarean sections during resuscitation of the woman. Most women (n=119, 73.9%) died in hospital, but in 43 women (36.1%), the lethal event had taken place out of hospital. (Table 3)

Medical history was uncomplicated in 79/161 (49.1%) women before conception. Thirteen (8.1%) women had a previous thromboembolic event, 20 (12.5%) were known to have a cardiovascular condition and 12 (7.5%) a mental health condition. (Appendix S4)

Following confidential enquiry of all 172 deaths within one year postpartum, 103 (59.9%) were categorised as direct and 69 (40.1%) as indirect. For the 142 maternal deaths within 42 days postpartum, leading causes were cardiac disease (n=21, 14.8%), hypertensive disorders of pregnancy (n=20, 14.1%) and thrombosis (n=19, 13.4%). Up to one year postpartum, cardiac disease and hypertensive disorders remained the commonest causes , with suicide rising to third place (n=20, 11.6%). (Table 1)

Assessment of the quality of care for all cases available for enquiry up to one year postpartum (n=160) identified improvable factors in 76 women (47.5%). (Table 4) The majority of improvable factors were identified in care received in secondary or tertiary care (n=46, 28.8%), mostly due to inadequate management (n=27, 16.9%) and delay in diagnosis (n=18, 11.3%), followed by delay in diagnosis in primary obstetric care (n=14, 8.8%). Communication difficulties hampered optimal care in 5 (12.2%) of non-Western women compared to 1 of Dutch and Western women (0.8%). Communication difficulties are unlikely to play a role in women from Surinam/Dutch Antilles, who speak Dutch. Lessons learnt during audit of maternal deaths are presented in Box 1.

<u>Guidelines and obstetric care</u>

- Generate awareness among pregnant women for alarm symptoms in pregnancy especially for hypertensive disorder and cardiac symptoms. Every woman should be encouraged to seek medical advice in case of new symptoms without experiencing any barriers in terms of communication or other. Maternity care givers should invest time and effort in overcoming language barriers with women of non-native ethnic background.
- Manage hypertensive diseases timely and appropriately with administration of magnesium sulphate and antihypertensive medication. Plan adequate or more frequent antenatal visits for woman at risk of hypertensive disorders or monitor more intensively at home or in hospital.
- Implement screening methods at booking, to identify women at risk of developing perinatal depression, such as the Edinburgh Postnatal Depression Scale. For women with estimated high risk of mental problems, organize a multidisciplinary care pathway in pregnancy and postpartum.
- Implement obstetric early warning scores for monitoring and early detection of critically ill or deteriorating women, especially post-operatively.
- Stabilise critically ill women, before proceeding to birth or transportation to another facility/department. Maximize the use of multidisciplinary expertise when caring for critically ill pregnant women.
- Consider timely postpartum hysterectomy in the management of major haemorrhage, especially in women refusing blood transfusion. Delay due to applying serial conservative options might lead to adverse outcome.

Communication

- Women with severe pre-existing medical conditions require a timely multidisciplinary approach and preferably even pre-conceptual counselling.
- Improve communication, collaboration and comprehension between obstetricians and anaesthesiologists by joint team training sessions in obstetric emergencies.

Training

- Be aware of non-specific complaints in the postpartum period. Shortness of breath should not be attributed to hyperventilation without further analysis, but prompt medical evaluation including vital parameters, especially oxygen saturation.

Box 1. Lessons learnt as deduced from the improvable factors formulated by the AMSM during audit of maternal deaths in the Netherlands, 2006-2018.

Discussion

Main Findings

Maternal mortality decreased by 50% in the Netherlands during the period 2006-2018 compared to 1993-2005, and resulted in the lowest frequency ever described since the inception of the confidential enquiry. This trend was contrary to the previous increase in maternal deaths. Women with a background from Surinam and the Dutch Antilles had an almost threefold higher maternal mortality ratio, whilst other women with a non-Western background did not have a statistically significantly increased MMR. Commonest causes of death were cardiac disease, hypertensive disorders and thromboembolism. Improvable factors in care were identified in nearly half of all deaths.

Interpretation

Compared with other high-income countries, the Netherlands has one of the lowest MMRs. In the UK, the MMR was 9.8 in 2015-2017, which has remained stable in the last decade. In contrast with the Netherlands, indirect causes of death have been more prevalent than direct causes ever since 2003.²¹ In France, the MMR was 10.3 in 2010-2012, the commonest cause being obstetric haemorrhage with double the haemorrhage-related MMR compared to the Netherlands (1.6 vs 0.6 per 100,000 livebirths).²² In Italy, where maternal mortality is identified after record-linkage of hospital and death registries without confidential enquiry, the MMR was 9.2 per 100,000 livebirths in 2006-2012 with obstetric haemorrhage being the leading cause (1.9 per 100,000 livebirths).²³ Differences in the rates of deaths caused by obstetric haemorrhage and hypertensive disorders might partly be explained by classification differences, which were previously demonstrated between the UK and the Netherlands.²⁴ However, such differences are unlikely to substantially impact on these comparisons.

Leading cause of death has become cardiac disease, in line with the UK and the US.²¹ ²⁵ However, in the UK rates of mortality due to cardiac disease, are more than twice as high compared to the Netherlands (MMR 2.1 vs 0.9 per 100,000 livebirths), accounting for 23.0% of all deaths. In the US, cardiovascular diseases and cardiomyopathy account for 15.5% and 11.0% of deaths respectively. Possible explanations for the growing contribution of cardiac disease are changes in risk profiles of Dutch women with more pregnant women smoking, being older, more frequently obese and having pre-existing cardiac conditions, posing them at increased risk of adverse outcome.^{26, 27}

We recommend that women with severe pre-existing conditions including cardiac disease access pre-conception counselling and multidisciplinary approach by a dedicated

team of obstetricians with other specialist expertise. In-depth analysis of cardiac deaths may help identify additional lessons for obstetricians and cardiologists. Our findings stress the importance of efforts to stop smoking and reduce obesity.

In 1993-2005, hypertensive disorders accounted for one third of maternal deaths, compared to 14% in 2006-2018 and a dramatic decrease in MMR from 3.5 to 0.9.^{4,5} This is in line with the demonstrated decline in the incidence of eclampsia by NethOSS, related to more timely management of hypertensive disorders with magnesium sulphate and earlier labour induction following an updated national guideline.^{7,9} Nevertheless, the proportion of hypertensive disorders-related deaths remains considerable, with improvable factors still present with regard to frequency of antenatal monitoring (which may be under pressure in the present COVID-19 era), and timely treatment of severe hypertensive disorders.

Suicide was the third commonest cause of death up to one year postpartum, more than twice as many as reported in 1993-2005. This rise is in line with other high-income countries. In Austria and Italy, suicides represented 11% and 12% of maternal deaths up to one year postpartum respectively.^{28,29} The increased suicide rate in the Netherlands may also be partly explained by better reporting of suicides and late maternal mortality. In 1993-2005, 23/333 (12%) of pregnancy-related deaths were late, compared to 30/172 (17%) in this cohort. According to Statistics Netherlands, a similar trend was observed in the general Dutch population with suicide rates dropping from 1991 to 2007, but then showing a steady increase until 2017.³⁰ We endorse recommendations of implementing methods to identify women at risk of developing depression during pregnancy or postpartum, promote joint efforts between obstetric care and mental health professionals for pregnancy-related mental health matters and increase awareness among women and their families to timely recognise symptoms and seek care. Also, the number of suicide-related maternal deaths, most of which occur after 42 days postpartum, underlines the importance of addressing and reviewing late maternal deaths.

Although outcomes of women with a non-Western ethnic background appear to have improved in the Netherlands, women from Surinam and the Dutch Antilles continue to lag behind. In this group of second or third generation migrants risk factors of adverse outcome appear to be more common, with almost double the rate of obesity during pregnancy, around 40%.³¹ Previously this group was also found to have higher rates of severe acute maternal morbidity in a nationwide study.³² They remain a group requiring particular vigilance from health professionals and efforts should be undertaken to increase health literacy in this community in line with previous findings.³³

Strengths and Limitations

Major strength of this study is its nationwide character, prospective collection of data, covering a thirteen year period. Based on the systematic confidential enquiry performed in all reported deaths, we were able to distil lessons for care based on access to the actual medical records. We adjusted the categorisation of deaths to that used by the

MMBRACE-UK, which is based on the ICD-MM, to conform with international literature, enabling future comparisons.²¹

Given the fact that maternal deaths have become infrequent, robust comparisons are only possible over relatively long time frames. Over the course of the thirteen year study period changes in practice and demographics have been considerable. Since the possibility of cross-matching with vital statistics ceased in 2012, we can be less certain about underreporting thereafter. However, data quality was generally adequate for enquiry, in all but the twelve deaths. Complete ascertainment of all maternal deaths was hampered by the inability to perform a cross-check with Statistics Netherlands for the years 2012-2018. We hope to re-establish such a process of cross-checking with vital statistics information from Statistics Netherlands.⁴

Although our findings with regard to improvable care factors are derived from audit by an external committee at the national level, we applaud efforts to implement local audit of maternal deaths and feel that external findings should always be complemented by such internal, local audit in order to arrive at more substantiated and context-specific lessons.

Conclusion

MMR in the Netherlands is among the lowest of the world and the decline of maternal mortality implies improvements in quality of obstetric care, particularly with regard to the management of hypertensive disorders. The decrease, however, should not be taken for granted, as prevalence of risk factors for developing pregnancy-related complications increase nationally and globally. Effort should be made to optimize care for women at higher risk of mortality such as women from Surinam and the Dutch Antilles and women with pre-existing conditions. Maternal mortality should not be seen as a mere obstetric care problem given the latest trends in causes of mortality with increases in cardiac and mental health related deaths.

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Disclosure of Interests

None.

Contribution to Authorship

AK, a member of the AMSM and JMS, a former member of the AMSM, are shared lead author, contributed equally in collecting data, conducting data analysis and drafted the manuscript together with LS and TA. LS contributed in collecting data and analysis. IB, KB, BB, JC, SK, SL, AR, TS, JS, JZ and TA, all members of the AMSM, all contributed substantially to confidential enquiry of maternal mortalities, revised the manuscript and contributed to conceptualization of the study.

Details of Ethics Approval

In the Netherlands, ethical approval is not required for confidential enquiry, which is considered an essential element to improve birth care. Data collected in the database are strictly de-identified and none of our published outcomes can be traced back to individual patients or health workers. Therefore, approval of the Ethics Committee was previously waived.

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	2006-2018			1993-2005			
	Livebirths: 2,304,271			Livebirths: 2,557,208			
	≤ 1 year (n)	≤ 42 days (n)	MMR	≤ 1 year (n)	≤ 42 days (n)	MMR	OR (95% CI)
All maternal deaths	172	142	6.2	333	309	12.1	0.5 (0.4-0.6)
Direct deaths	103	91	3.9	236	224	8.8	0.5 (0.4-0.6)
Indirect deaths	69	51	2.2	97	85	3.3	0.7 (0.5-0.9)
Underlying cause of death	n (%)^a	n (%)	MMR	n (%)^a	n (%)	MMR	OR (95% CI)
Cardiac disease	32 (18.6)	21 (14.8)	0.9	45 (13.5)	40 (12.9)	1.6	0.6 (0.3-1.0)
Hypertensive disorders of pregnancy	21 (12.2)	20 (14.1)	0.9	93 (27.9)	89 (28.9)	3.5	0.2 (0.2-0.4)
Thrombosis	19 (11.0)	19 (13.4)	0.8	44 (13.2)	42 (13.6)	1.6	0.5 (0.3-0.9)
Neurological - indirect	19 (11.0)	15 (10.6)	0.7	17 (5.1)	17 (5.5)	0.7	1.0 (0.5-2.0)
Unascertained - direct	14 (8.1)	14 (9.9)	0.6	22 (6.6)	21 (6.8)	0.9	0.7 (0.3-1.5)
Haemorrhage	13 (7.6)	13 (9.2)	0.6	25 (7.5)	25 (8.1)	1.0	0.6 (0.3-1.1)
Suicide	20 (11.6)	9 (6.3)	0.4	7 (2.1)	4 (1.3)	0.3	2.5 (0.8-8.1)
Amniotic fluid embolism	8 (4.7)	8 (5.6)	0.3	11 (3.3)	11 (3.6)	0.4	0.8 (0.3-2.0)
Sepsis - non obstetric	9 (5.2)	8 (5.6)	0.3	9 (2.7)	9 (2.9)	0.4	1.0 (0.4-2.6)
Pregnancy-related infection	6 (3.5)	6 (4.2)	0.3	20 (6.0)	19 (6.1)	0.7	0.4 (0.1-0.9)
Other indirect	6 ^b (3.5)	5 ^b (3.5)	0.2	16 (4.8)	14 (4.5)	0.5	0.4 (0.1-1.1)
Early pregnancy death	2 (1.2)	2 (2.2)	0.1	7 (2.1)	7 (2.3)	0.3	0.3 (0.1-1.5)
Indirect malignancy	3 (1.7)	2 (2.2)	0.1	3 (0.9)	1 (0.3)	0.0	2.2 (0.2-24.5)
Anaesthesia	0	0	0	2 (0.6)	2 (0.6)	0.1	0.2 (0.0-4.6)
Other direct	0	0	0	12 (3.6)	8 (2.6)	0.3	0.1 (0.0-1.1)

Table 1. Maternal mortality ratio and underlying causes of death in the Netherlands, 2006-2018 vs 1993-2005. Classified according to MBRRACE-UK classification. Numbers after cross-matching with Statistics Netherlands included. Odds Ratio comparing MMR for 2006-2018 (ref) and 1993-2005.

^a Late deaths, up to 1 year postpartum, included

^b Other indirect within 42 days: systemic lupus erythematosus (1), antiphospholipid syndrome (1), upper gastrointestinal bleeding (1), relapsing polychondritis (1), pheochromocytoma (1). After 42 days: aplastic anaemia (1)

OR= Odds Ratio, CI= Confidence Interval, MMR= Maternal Mortality Ratio (≤42 days postpartum).

	N	Livebirths	MMR	OR (95% CI)
Parity				
0	62	1052002	5.9	1.5 (1.0-2.2)
1	34	844224	4.0	Ref
2	23	293585	7.8	1.9 (1.1-3.3)
3+	10	114460	8.7	2.2 (1.1-4.4)
Missing	2			
Age ^a (years)				
15-19	4	19562	20.4	5.3 (1.8-15.1)
20-24	13	190412	6.8	1.8 (0.9-3.4)
25-29	25	642711	3.9	Ref
30-34	50	886680	5.6	1.4 (0.9-2.3)
35-39	36	469620	7.7	2.0 (1.2-3.3)
40-44	9	90656	9.9	2.6 (1.2-5.5)
≥45	1	4630	21.6	5.6 (0.8-41.0)
Missing	4			
Ethnic background				
Dutch native	83	1644594	5.0	Ref
Western ^b	9	231180	3.9	0.8 (0.4-1.6)
Non-western ^c	38	588888	6.5	1.3 (0.9-1.9)
Surinam/Dutch Antilles	13	88581	14.7	2.9 (1.6-5.3)
African	11	156741	7.0	1.4 (0.8-2.6)
Turkey	5	79453	6.3	1.3 (0.5-3.1)
Morocco	4	99750	4.0	0.8 (0.3-2.2)
Asian	3	133116	2.3	0.6 (0.2-1.9)
Missing	1			

Table 2. Maternal mortality ratio for parity, age and ethnic background. Numbers from Statistics Netherlands excluded for age and ethnic background.

^a Numbers from Statistics Netherlands included

^b Western: European (5), Indonesian (3), Japanese (1)

^c Non-western: additionally Syrian (1), South American (1)

MMR= Maternal Mortality Ratio, OR = Odds Ratio, CI= Confidence Interval

	Maternal deaths n (%)	General population ^a (%)
Initial antenatal care	N=161	
Primary maternity care	87 (54.0)	84.6
Obstetrician	60 (37.3)	15.4
Not (yet) under obstetric care	10 (6.2)	
Unknown	4 (4.2)	
Referral by primary care giver	N=65	
During pregnancy	52 (80.0)	61.8
During birth	5 (7.7)	35.9
Postpartum	5 (7.7)	2.2
Unknown	3 (4.6)	
Time of death	N=161	
During pregnancy	39 (24.2)	
Postpartum	119 (73.9)	
Within 1 day	27 (22.7 ^b)	
Between 1-7 days	28 (23.5 ^b)	
Between 8-42 days	33 (27.7 ^b)	
Late death (>42 days)	30 (25.2 ^b)	
Unknown	1 (0.8 ^b)	
1 st trimester pathology ^c	3 (1.9)	
Place of death	N=161	
At home	38 (23.6)	
In hospital	119 (73.9)	
Start lethal event out of hospital	43 (36.1 ^b)	
Unknown	4 (2.5)	
Twin pregnancy	3 (1.9)	1.6
Birth	N=119	
At home	13 (10.9)	15.9
In hospital	97 (81.5)	82.7
During transport	1 (0.8)	
Unknown	8 (6.7)	
Mode of birth	N=119	
Vaginal	51 (42.9)	80.6
Instrumental	8 (6.7)	6.9
Caesarean section	60 (50.4)	14.9
- Planned	6 (10.0 ^b)	
- Unplanned	40 (66.7 ^b)	
- Perimortem	14 (2.3 ^b)	
Autopsy performed	N=161	
Yes	68 (42.2)	
Unknown	3 (1.8)	
Intrauterine foetal death	N=161	
< 24 weeks	28 (17.4)	
≥ 24 weeks	6 (3.7)	
Perinatal death ^d	24 (14.9)	0.4 ^e
Smoking	N=161	
Yes	38 (23.6)	24.9
Unknown	37 (23.0)	
Obesity	37 (23.0)	12.0

Table 3.

Pregnancy, birth and obstetric care characteristics of all deaths up to one year postpartum.

^a National reference values from Perinatal Registry the Netherlands (Perined), 2006-2018

^b Percentages of their subheading

^c Women who died shortly after miscarriage (2) or abortion (1)

^d Perinatal death defined as stillbirth with birthweight ≥ 1000g or ≥28 weeks of gestation, or neonatal death in the first 7 days postpartum.

^e Only numbers until 2016 available.

	Dutch and Western women (N= 119)	Non-Western women (N= 41)	Total (N=160)
Delaying factors in care	55 (46.2)	21 (51.2)	76 (47.5)
Patient			
Delay consulting doctor	7 (5.9)	2 (4.9)	9 (5.6)
Refusing medical advice	9 (7.6)	2 (4.9)	11 (6.9)
Communication difficulties	1 (0.8)	5 (12.2)	6 (3.8)
Primary obstetric care*			
Delay in diagnosis	12 (10.1)	2 (4.9)	14 (8.8)
Delay in referral to hospital	2 (1.7)	2 (4.9)	4 (2.5)
Inadequate referral to perinatal centre	0	1 (2.4)	1 (0.6)
Secondary or tertiary care **			
Inadequate antenatal visits	0	1 (2.4)	1 (0.6)
Delay in diagnosis	15 (12.6)	3 (7.3)	18 (11.3)
Inadequate management	19 (16.0)	8 (19.5)	27 (16.9)

Table 4. Improvable factors in care, compared between women with different ethnic background, Late deaths included. Values denoted as n (%).

*Primary midwifery care and/or general practitioner, ** Obstetricians and/or other medical specialists.