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Severe maternal morbidity during pregnancy, delivery and puerperium in the Netherlands: a nationwide population-based study of 371 000 pregnancies

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Objective To assess incidence, case fatality rate, risk factors and substandard care in severe maternal morbidity in the Netherlands.

Design Prospective population-based cohort study.

Setting All 98 maternity units in the Netherlands.

Population All pregnant women in the Netherlands.

Methods Cases of severe maternal morbidity were collected during a 2-year period. All pregnant women in the Netherlands in the same period acted as reference cohort (n = 371 021). As immigrant women are disproportionately represented in Dutch maternal mortality statistics, special attention was paid to the ethnic background. In a subset of 2.5% of women, substandard care was assessed through clinical audit.

Main outcome measures Incidence, case fatality rates, possible risk factors and substandard care.

Results Severe maternal morbidity was reported in 2552 women, giving an overall incidence of 7.1 per 1000 deliveries. Intensive care unit admission was reported in 847 women (incidence 2.4 per 1000), uterine rupture in 218 women (incidence 6.1/10 000), eclampsia in 222 women (incidence 6.2/10 000) and major obstetric haemorrhage in 1606 women (incidence 4.5 per 1000). Non-Western immigrant women had a 1.3-fold increased risk of severe maternal morbidity (95% CI 1.2–1.5) when compared with Western women. Overall case fatality rate was 1 in 53. Substandard care was found in 39 of a subset of 63 women (62%) through clinical audit.

Conclusions Severe maternal morbidity complicates at least 0.71% of all pregnancies in the Netherlands, immigrant women experiencing an increased risk. Since substandard care was found in the majority of assessed cases, reduction of severe maternal morbidity seems a mandatory challenge.

Keywords Ethnicity, incidence, maternal mortality, nationwide, risk factors, severe maternal morbidity, substandard care.

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Introduction

Severe maternal morbidity gains interest as a new quality indicator of obstetric care.[1–4] The most important reason is the extremely low maternal mortality rate in Western countries, so that it takes years to collect the numbers needed to be able to draw valid conclusions from analysing cases of maternal mortality. Maternal deaths also tend to be more and more the result of rare complications, whereas regular life-threatening complications such as major obstetric haemorrhage (MOH) are relatively underexposed as they less frequently lead to death nowadays.[2,3] The most important and difficult issue, however, is the definition of severe maternal morbidity. Different research groups have already addressed this issue, and the World Health Organization is in the process of integrating these efforts into internationally accepted criteria for severe maternal morbidity.[5–13] Recent studies demonstrate an increase in severe maternal morbidity in Western countries, possibly due to changes in management of obstetric complications and increasing age of pregnant women.[2,14,15]

A nationwide cohort study of severe maternal morbidity, called LEMMoN, was conducted in the Netherlands to assess incidence, case fatality rates, risk factors and substandard care overall for different subgroups. As ethnicity appeared to be a significant risk factor for pregnancy-related death[2,16,17] and seemed to be a risk factor for severe maternal morbidity, we are especially interested in the association of ethnicity with severe maternal morbidity.[18,19]

Methods

Women were included from 1 August 2004 until 1 August 2006. All 98 hospitals (100%) with a maternity unit in the Netherlands participated in the survey: 10 tertiary care centres, 33 non-university teaching hospitals and 55 other general hospitals. The annual number of deliveries per unit in 2005 ranged from 93 to 2655 (average: 1162). Women with high-risk pregnancies and those with low-risk pregnancies who develop complications deliver in hospital under the guidance of obstetricians (secondary or tertiary care, 59% of all births). Women with low-risk pregnancies without complications deliver under the guidance of midwives and family physicians (primary care) either at home (30% of all births) or in hospital under their responsibility (11% of all births).[20]

Final inclusion criteria were defined after searching the literature and after agreement with the National Maternal Mortality Committee of the Dutch Society of Obstetrics and Gynaecology. An expert panel of obstetricians advised about the design of the study. The main issues for setting our criteria were easy clinical applicability and univocality. Inclusion criteria are listed in Figure 1. The last group was meant to include rare conditions of severe maternal morbidity (e.g. acute fatty liver of pregnancy), as well as severe manifestations of generally less severe conditions (e.g. severe early pre-eclampsia that did not require admission to intensive care unit [ICU]). Proven cases of pulmonary embolism could also be reported in this group. All women during pregnancy, delivery and puerperium (limited to 6 weeks postpartum) were regarded as cases, including complications in early pregnancy. Cases were classified as 'early pregnancy' if one could not speak of a 'partus' and hence not of 'antepartum' or 'postpartum'. This by definition applies to cases in which pregnancy ends before 17 weeks of gestational age in the Netherlands and it also applies to cases of second-trimester instrumental abortion.

Group 1: ICU admission
- Admission to ICU or coronary care unit, other than for standard postoperative recovery

Group 2: Uterine rupture
- Clinical symptoms (pain, fetal distress, acute loss of contractions and haemorrhage) that led to an emergency caesarean section, at which the presumed diagnosis of uterine rupture was confirmed
- Peripartum hysterectomy or laparotomy for uterine rupture

Group 3: Eclampsia/HELLP syndrome
- Eclampsia
- HELLP syndrome only when accompanied by liver haematoma or rupture

Group 4: MOH
- Transfusion need of ≥ 4 units of packed cells
- Embolisation or hysterectomy for MOH

Group 5: Miscellaneous
- Other cases of severe maternal morbidity to the opinion of the treating obstetrician, not to be included in group 1–4

Figure 1. Inclusion criteria.

Ethnicity was defined by country of origin ('geographical ethnic origin'). We used the definitions of Statistics Netherlands, based on country of birth of the woman. When the woman was born in the Netherlands with at least one of her parents born abroad, she was considered to be from the same origin as her parent(s) from abroad. Women from other Western European countries and from North America, Japan and Indonesia were considered Western immigrants according to Statistics Netherlands because of their socio-economic and cultural position in the Netherlands. All other immigrant women were considered non-Western.

Maternal deaths were reported to the National Maternal Mortality Committee of the Dutch Society of Obstetrics and Gynaecology by the attending obstetrician as usual. These cases were added to our database. Women who had more than one condition were considered only once in the overall incidence figures, only the first group was counted. For example, a woman with MOH (group 4) who was admitted to the ICU (group 1) was only counted as an ICU admission. However, these women were counted for each condition in the subanalysis of the different groups.

In each hospital, a local coordinator reported all cases monthly using a standardised web-based form. Absence of cases in a particular month was also communicated to control for underreporting. Cases were identified in the respective hospitals using multiple strategies, including maternity computer databases, labour ward diaries, staff reports, intensive care admission registers, blood transfusion registers, discharge data and personal communication. At the central office, cases were collected using the national electronic surveillance system of the Netherlands Surveillance Centre for Obstetrics and Gynaecology, a newly established nonprofit organisation for scientific data collection, analogous to the Dutch Signaling Centre for Paediatrics (NSCK; TNO Quality of Life, Leiden, the Netherlands).[21] Cases were initially notified by reporting initials and date of birth to LEMMoN to minimise underreporting. Anonymised data were then obtained, consisting of a case record form with photocopies of relevant parts of the patient file. All cases were entered into an Access database by trained staff, and each case was finally checked for correctness by the first author. We recorded maternal characteristics (age, body mass index [BMI], parity, ethnicity, income, single household, language skills and smoking), all data on pregnancy and delivery and data on

the specific complication. A minimum of 87 items were entered into the database for each case, depending on the subgroup(s) of severe morbidity in which the case was included. We also recorded characteristics of each hospital (university or teaching hospital and annual number of deliveries). Socio-economic status was ascribed using the validated zip code/socio-economic status indicator of Statistics Netherlands based on home price and income, stratified into low, modest and high.[22]

Although 30% of women in the Netherlands deliver at home, all women with severe maternal morbidity as defined in our inclusion criteria will eventually have been referred to one of the maternity units. Therefore, this study represents all deliveries in the Netherlands during the study period. As a consequence, nationwide statistics could be used as reference values whenever appropriate. To control for underreporting, we cross-checked our data with different other databases: underreporting of uterine rupture and eclampsia was controlled for using the national perinatal database (LVR-2).[23] Underreporting of MOH was controlled for using data from a large representative sample of local blood transfusion laboratories in the Netherlands during a 20-month period. Cases that were found to be not reported to our study were only counted and were not added to the database.

Seven audit meetings were held throughout the country to assess substandard care in a selection of cases, using the audit criteria developed by the Dutch Maternal Mortality Committee.[24] Assessors were members of the LEMMoN expert panel as well as local staff. After individual assessment by each assessor, a plenary meeting was held to discuss all items found. At this meeting, complete patient files were present to optimise suitability for assessment. Substandard care was assumed if the majority of assessors judged this to be present.

For each group, incidence was calculated using the total number of births in the Netherlands during the study period as the denominator. Denominator data for the number of deliveries in the Netherlands were obtained from Statistics Netherlands (CBS).[25] They were based on birth registries during the exact study period, corrected for multiple births and stillbirths of 24 weeks or over. Denominator data for the number of women from the different ethnic groups were obtained from Statistics Netherlands. For the four large immigrant groups and for non-Western immigrants overall, numbers of mothers of newborns were available. For the smaller subgroups, we had to rely on numbers of women of fertile age (15–40 years) to calculate the denominator, thereby disregarding the difference in fertility rate among the different ethnic groups. Relative risks (RRs) were calculated when reference data were available. National reference values for possible risk factors for severe maternal morbidity were obtained from Statistics Netherlands and the LVR-2 database. Incidence figures in LVR-2 were multiplied by 59/100 to also represent all deliveries under primary care (41% in 2002).[23] Case fatality rates were calculated by dividing the number of deaths due to a specific condition by the number of severe maternal morbidities due to that condition. Possible risk factors were identified by calculating RRs and 95% CIs. Significance was assumed when the CI did not cross 1. Statistical analysis was performed using the SPSS statistical package 14.0 (SPSS Inc., Chicago, IL, USA).

Results

During the study period, there were 371 021 deliveries in the Netherlands. All 98 hospitals with an obstetric ward in the Netherlands agreed to participate. A maximum of 2352 (98×24) 'hospital-months' could be reported. Mainly due to later enrolment of some hospitals into the study, a total of 2275 'hospital months' were actually returned (97%). Regarding only those maternities occurring during the months each hospital actively participated in the study, the study represents 358 874 deliveries. A total of 2552 women were reported during the study period. We received detailed data of 2513 of 2552 women (98.5%). The overall incidence of severe maternal morbidity in the Netherlands was 7.1 per 1000 deliveries. Women were divided over the five groups as indicated in Table 1. Among the 2552 women included, 3143 complications were noted, 21.4 and 1.7% having two and three complications simultaneous, respectively. One woman had all four eligible complications. Two women were included twice during the study period in distinct pregnancies. Forty-eight women with pregnancy-related death were reported to the Maternal Mortality Committee during the study period, giving an overall case fatality rate of 1 in 53 (1.9%). Incidence varied largely between hospitals in the Netherlands ranging from 0 to 39.1 per 1000 deliveries. The mean hospital-incidence (regarding only the secondary and tertiary care deliveries in the respective hospitals) was 10.8 per 1000, 9.3 for non-university hospitals and 26.7 for university hospitals. In 2.8% of women, the (first) complication occurred in early pregnancy, in 26.5% antepartum and in 70.7% postpartum. Characteristics of women included are shown in Table 2.

Possible risk factors for severe maternal morbidity are shown in Table 3. Overall, 21.1% of women were non-Western immigrants. The RR for non-Western women to experience severe maternal morbidity was 1.3 (95% CI 1.2–1.5) compared with Western women. This elevated risk remained significant for each separate inclusion group (Table 4). Of the four largest immigrant groups in the Netherlands (Morocco, Turkey, Surinam and Netherlands Antilles), only Surinam women showed a significantly elevated risk compared with native Dutch women (RR 1.4, 95% CI 1.1–1.7). Sub-Saharan African women had the highest risk (RR 3.5, 95% CI 2.8–4.3). Overall RRs of women from the Middle East and South-East Asia were 1.5 (95% CI 1.1–2.1) and 2.2 (95% CI 1.7–2.8).

Table 1. Numbers, incidence and case fatality rate per inclusion group

	ICU admission	Uterine rupture	Eclampsia/HELLP	MOH	Miscellaneous	Total
Patients, *n* (%)	847 (33.2)	191 (7.5)	135 (5.3)	1146 (44.9)	233 (9.1)	2552 (100)
Complications*, *n* (%)	847 (26.9)	218 (6.9)	239 (7.6)	1606 (51.1)	233 (7.4)	3143 (100)
Data available, *n* (%)	837 (98.8)	218 (100)	230 (96.2)	1590 (99.0)	228 (97.9)	3102 (98.7)
Incidence (/1000 deliveries)	2.4	0.6	0.7	4.5	0.7	7.1
Case fatality rate	1:29 (3.4%)	— (0%)	1:55 (1.8%)	1:201 (0.5%)	1:14 (7.3%)	1:53 (1.9%)

*One patient can have more than one complication.

ICU admission

A total of 847 cases of ICU admission were reported, giving an incidence of 2.4 per 1000 deliveries. Of all women with pregnancy-related death, 29 were admitted to ICU before death, giving a case fatality rate of 1 in 29. The mean duration of ICU stay was 3.6 days (range 1–74 days). The main reasons for admission were MOH (47%), hypertensive disorders of pregnancy (33%), respiratory complications (8%) and cardiac

Table 2. Characteristics of women in the study

	n	%
Age (years) (mean 31.6)		
<20	31	1.2
20–35	1770	70.4
35–40	590	23.5
≥40	122	4.9
Socio-economic status indicator		
Low	701	31.6
Middle	994	44.9
High	520	23.5
Unknown	298	
Smoking during pregnancy		
Yes	175	12.0
No	1290	88.0
Unknown	1048	
BMI (kg/m²)		
<18.5	48	2.8
18.5–24.9	1018	60.2
25.0—29.9 (overweight)	404	23.9
30.0—34.9 (obese)	125	7.4
≥35.0 (morbidly obese)	95	5.6
Unknown	823	
Geographical ethnic origin		
Netherlands	1864	74.4
Morocco	116	4.6
Turkey	87	3.5
Surinam/Dutch Antilles	111	4.4
Sub-Saharan Africa	90	3.6
Other non-Western	146	5.8
Other Western	92	3.7
Unknown	7	

Table 3. Risk factors for severe maternal morbidity

Risk factor	LEMMoN (%)	Netherlands (%)	RR (95% CI)
Patient			
Age ≥ 35 years	29.3	24.7**	1.2 (1.1–1.3)
Age ≥ 40 years	4.8	3.4**	1.4 (1.2–1.7)
Low income	31.6	n/a	
Single household	3.0	n/a	
Smoking during pregnancy	12.0	n/a	
BMI ≥ 25 kg/m² (overweight)	36.9	31.7**	1.3 (1.1–1.4)
BMI ≥ 30 kg/m² (obese)	13.0	9.1**	1.5 (1.3–1.7)
Non-Western immigrants	21.1	16.8**	1.3 (1.2–1.5)
Chronic disease in general history*	9.7	n/a	
Pregnancy			
Initial antenatal care by obstetrician	35.8	14.3***	3.3 (3.1–3.6)
Prior caesarean section	19.3	6.0[26]	3.7 (3.4–4.1)
Parity 0	49.9	45.2**	1.2 (1.1–1.3)
Parity ≥3	5.1	5.0**	1.0 (0.9–1.2)
Parity ≥6	0.4	0.4***	1.2 (0.7–2.2)
Multiple pregnancy	8.0	1.7**	4.9 (4.3–5.7)
Artificial reproduction techniques: IVF/ICSI	4.7	1.9[27]	2.5 (2.1–3.0)
Delivery			
Home delivery	6.3	31.6**	0.1 (0.1–0.2)
Induction of labour	26.5	12.5***	3.1 (2.8–3.4)
Caesarean section without labour	22.3	5.9***	4.6 (4.2–5.0)
Ventouse/forceps	12.7	8.6***	1.6 (1.4–1.7)
Caesarean section overall	43.6	13.0***	5.2 (4.8–5.6)
Breech presentation	7.9	4.9***	1.7 (1.4–1.9)
Preterm birth (<37 weeks)	28.8	5.8***	6.6 (6.0–7.2)
Postterm birth (≥42 weeks)	5.3	4.3***	1.3 (1.0–1.5)

n/a, data not available; IVF, *in vitro* fertilisation; ICSI, intracytoplasmatic sperm injection.
*Includes hypertension, diabetes, cardiac disease and coagulation disorders.
**National reference values from Statistics Netherlands (exact study period).
***National reference values from the Netherlands Perinatal Registry (LVR-2, 2005).

Table 4. Relative risk of severe maternal morbidity for non-Western immigrants

Geographical ethnic origin	Non-Western immigrants	Western women	Unknown	RR (95% CI)
ICU admission (n = 837)	189	645	3	1.5 (1.2–1.7)
Uterine rupture (n = 218)	48	170	0	1.4 (1.0–1.9)
Eclampsia/HELLP (n = 230)	59	170	1	1.7 (1.3–2.3)
MOH (n = 1590)	318	1268	4	1.3 (1.1–1.4)
Total (n = 2513)	529	1977	7	1.3 (1.2–1.5)

complications (7%). Assisted ventilation, inotropic support and renal dialysis were necessary in 34.2, 8.6 and 1.9% of women, respectively.

Uterine rupture

A total of 218 women with uterine rupture were reported, giving an incidence of 6.1 per 10 000 deliveries. No cases of pregnancy-related death due to uterine rupture occurred. Admission to ICU occurred in 12% of women and 21% experienced MOH. In 87% of women, obstetric history revealed at least one caesarean section. Of the other 28 women, 3 had a history of a known uterine scar due to myomectomy, tubectomy for isthmic pregnancy or dilatation and curettage. In 25 women, there was no known uterine scar, 12 of whom did not have any possible known risk factor in general or obstetric history. In two women, rupture occurred as a complication of second-trimester dilatation and curettage for unwanted pregnancy. In six women, uterine rupture complicated medically induced termination of pregnancy after 16 weeks of gestation.

Eclampsia and HELLP syndrome accompanied by liver haematoma or rupture

A total of 222 women with eclampsia were reported, giving an incidence in the Netherlands of 6.2 per 10 000 deliveries. In addition, 19 women with HELLP (haemolysis, elevated liver enzymes and low platelets) syndrome accompanied by liver haematoma (n = 12) and/or liver rupture (n = 7) were included. Two women had both eclampsia and HELLP syndrome accompanied by liver haematoma. There were four women with pregnancy-related death due to eclampsia/HELLP, case fatality rate being 1 in 55. Admission to ICU occurred in 42% of women.

Major obstetric haemorrhage

A total of 1606 women were reported, giving an incidence of MOH in our study of 4.5 per 1000 deliveries. There were eight women with pregnancy-related death due to MOH, case fatality rate being 1 in 201. Admission to ICU occurred in 27% of women. Three percent of cases occurred in early pregnancy, 9% antepartum and 88% postpartum. Primary diagnoses are shown in Table 5. In 107 and 114 women (6.7 and 7.2%), respectively, hysterectomy and arterial embolisation were performed. In 14 women (13%), hysterectomy was necessary after arterial embolisation failed to stop haemorrhage. Vice versa, in two women, embolisation was performed after hysterectomy. Intrauterine balloon catheters were used in 154 (9.7%) women, (re)laparotomy was performed in 202 (12.5%) with B-Lynch suture in 12 (0.7%) and ligation of arterial vessels in 21 (1.3%). The average amount of estimated blood loss was 3150 cc (maximum 20 000 cc). An average of

Table 5. Major obstetric haemorrhage, primary diagnoses

Timing	Diagnosis*	n	%
Early pregnancy (n = 51)	Ectopic pregnancy	29	56.9
	Miscarriage	10	19.6
	Termination of pregnancy	10	19.6
	Miscellaneous**	2	3.9
Antepartum (n = 135)***	Placental abruption	61	45.5
	Placenta praevia	54	40.3
	Miscellaneous****	7	5.2
	Unknown diagnosis	12	9.0
Postpartum (n = 1480)***	Retained placenta or placental rests	703	47.8
	Uterine atonia	567	38.5
	Haemorrhage following caesarean section	183	12.4
	Perineal tears/episiotomy	148	10.1
	Clotting disorders	116	7.9
	Placenta accreta/increta/percreta	109	7.4
	Rupture of cervix	58	3.9
	Uterine rupture	44	3.0
	Uterine inversion	13	0.9
	Miscellaneous	65	4.4
	Unknown diagnosis	10	0.7

*Up to three diagnoses could be coded postpartum.
**Molar pregnancy and placenta percreta.
***In 76 cases, both antepartum and postpartum diagnoses were coded.
****Rupture of uterine/ovarian artery, rupture of ovarian cyst, placenta percreta, vasa praevia, retro placental haematoma, rupture of uterine vein.

6.6 units of blood were transfused (range 0–50). Fresh-frozen plasma and pooled thrombocyte suspension were given in 48.3 and 16.2% of women, respectively. Recombinant factor seven (Novo-seven®) was administered in 64 women (4.0%). In 178 women (11.2%), MOH was accompanied by pre-eclampsia. Five women with Jehovah's witnesses with MOH were included on the basis of hysterectomy or arterial embolisation without transfusion (n = 4) or final acceptance of blood products (n = 1). Six others were reported because of ICU admission or as 'other severe maternal morbidity'.

Other severe maternal morbidity

A total of 233 cases were reported as other severe maternal morbidity (Table 6). Divided over all inclusion groups, 69 women with thromboembolism were included: pulmonary embolism (n = 44), amniotic fluid embolism (n = 9) and thrombosis of pelvic, ovarian, mesenteric, portal vein, sagittal sinus, mesenteric vein, portal vein and vena cava (n = 16). In addition to the 239 women with eclampsia/severe HELLP included in group 3, 360 women with pre-eclampsia were included in the other groups. Thus, 23.9% of all women had pre-eclampsia. Sepsis was reported in 84 women (estimated incidence 2.3 per 10 000).

Underreporting

During the first 5 months of the study, we found only one woman with uterine rupture and two women with eclampsia who were not reported to LEMMoN, underreporting being estimated at 2 and 3%, respectively. Underreporting of MOH to the LEMMoN study appeared to be 29% (range 0–83%) in a large representative sample. Cases not reported to our survey appeared to be mainly the relatively less severe cases of MOH, with 68% of unreported cases being transfused only 4 units of blood. Taking into account this degree of underreporting, the overall incidence of MOH in the Netherlands would be 5.8 per 1000 deliveries. Controlling for underreporting of ICU admission on a national level appeared unfeasible.

Audit

During seven audit sessions throughout the country, substandard care was judged to be present by the majority of assessors in 39 (62%) of 63 women (Table 7).

Discussion

This study represents the first nationwide survey of severe maternal morbidity in the Netherlands and to date, by far the largest study in the literature. All aspects of severe maternal morbidity in the Netherlands have been mapped. The incidence in our study was 7.1 per 1000 deliveries, indicating that the average obstetric ward in the Netherlands encounters one case every month. We realise that incidence figures largely depend on the denominator chosen. We deliberately chose to express the incidence as the total pregnancy-related risk of severe maternal morbidity per delivery. That means, we included complications of early pregnancy while we did only include deliveries from 24 weeks onward in the denominator. Therefore, the incidence is expressed as a ratio, not a rate. Leaving out all cases in early pregnancy and before 24 weeks of gestation would have resulted in a slightly lower incidence of 6.8 per 1000.

Table 6. Cases reported as 'other severe maternal morbidity' (n = 233)

	n	%	Examples
Obstetric	100	43	
Pre-eclampsia/HELLP	70	30	Early severe HELLP necessitating termination of pregnancy or with retinal detachment
Genital tract sepsis	8	3	Group A streptococcal sepsis
AFLP	5	2	
MOH in Jehovah's witnesses	3	1	
Miscellaneous obstetric	14	6	Maternal hydrops syndrome, abdominal bleeding after laser therapy for TTTS
Nonobstetric	128	55	
Cardio respiratory	20	9	Myocardial infarction after caesarean section, cardiomyopathy, pleural empyema
Cerebral/neurological	19	8	Viral meningoencephalitis, sagittal sinus thrombosis, cerebrovascular accident
Thromboembolism	30	13	Pulmonary embolism, portal vein thrombosis, vena cava thrombosis
Sepsis	4	2	Urosepsis, sepsis from cholangitis
Surgical	21	9	Splenectomy after trauma, colectomy due to Crohn's disease, appendicectomy
Oncological	12	5	Kaposi sarcoma with AIDS, vulval cancer, acute lymphatic leukaemia
Anaesthetic complication	2	1	Acute life-threatening danger during intubation due to extreme obesity
Miscellaneous nonobstetric	20	9	Acute pancreatitis, sickle cell crises, severe immune thrombocytopenic purpura
Unknown	5	2	

AFLP, acute fatty liver of pregnancy; TTTS, twin-to-twin-transfusion syndrome.

Table 7. Substandard care items and their contribution*

	n	%**
Patient	55	6.6
Delay in consulting doctor	30	3.6
Refusal of medical help or advise	15	1.8
Language barrier	10	1.2
GP/midwife	164	19.9
Inadequate antenatal care	44	5.3
Delay in recognition of symptoms/signs	58	7.0
Delay in referral to obstetrician	62	7.5
Obstetrician	441	53.4
Inadequate antenatal care	70	8.5
Delay in recognition of symptoms/signs	146	17.7
Delay in treatment after diagnosis	200	24.2
Delay in referral to tertiary care centre	25	3.0
Other consultant	5	0.6
Delay in consulting obstetrician	5	0.6
Healthcare system	84	10.2
Home birth influenced outcome	19	2.3
Birth in general hospital influenced outcome	40	4.8
Quality of transport influenced outcome	25	3.0

*After individual assessment of 59/63 cases by on average 14 assessors.
**Each item could maximally be scored 826 times (59 cases times 14 assessors).

There have been only two other large surveys addressing the overall incidence of severe maternal morbidity in Western countries.[7,9] Their reported incidences were 12.0/1000 in South-West England (n = 48 865) and 3.8/1000 in Scotland (n = 51 165). Our incidence is well within the range of the other two studies. However, the incidence figures are strikingly different, bearing in mind the relatively comparable healthcare systems and populations. These differences can be mainly explained by the differences in inclusion criteria. The inclusion criteria for MOH, which affect the overall incidence to a great extent as it concerns about half of all inclusions, was more liberal in the English study (blood loss of more than 1500 cc) compared with the Scottish study (transfusion of 5 or more units of blood). Our definition of MOH was in between those two (transfusion of 4 or more units of blood) and so was our overall incidence. The large differences in reported incidences due to different inclusion criteria clearly reflect the need for internationally accepted definitions of severe maternal morbidity.

The high incidence of eclampsia in the Netherlands is worrying and should be subject of further research, especially seen in the light of the also high maternal mortality due to hypertensive disorders of pregnancy in the Netherlands.[3]

Case fatality rates for the different types of severe maternal morbidity ranged from 0% for uterine rupture to 3.4% for ICU admission, indicating the severity of cases included. Despite the difference in inclusion criteria, our overall case fatality rate is comparable with that in Scotland.[9]

Several risk factors were identified in this study. Due to the nationwide design of the study, we were able to reliably calculate RRs based on available national reference data. However, for some of them, it is important to realise that the condition could be the cause of severe maternal morbidity, but it could also represent the result of it. This is especially true for caesarean section and induction of labour, which were often performed because of the compromised maternal condition. Preterm birth is also closely related. With respect to artificial reproductive techniques, the trend towards single embryo transfer might well lead to reduction of severe maternal morbidity because women with multiple pregnancies were at higher risk.[28] We found BMI to be an important risk factor for severe maternal morbidity. As the incidence of overweight and obesity is increasing rapidly in Western countries, we expect severe maternal morbidity to increase in the future. Home delivery appeared to be a strong protective factor for severe maternal morbidity in the Netherlands with a RR of 0.1 (95% CI 0.1–0.2). This again demonstrates the proper functioning of the Dutch risk selection system, in which low-risk pregnancies are cared for by midwives in private practices or family physicians outside the scope of the obstetrician.[29]

As was already expected from maternal mortality statistics, non-Western ethnic background appeared to be an independent risk factor for experiencing severe maternal morbidity. Three of the four large immigrant groups in the Netherlands—Moroccan, Turkish and Dutch Caribbean—however, were not overrepresented in our study. Surinam women were slightly overrepresented, especially due to a high incidence of eclampsia. Members of the smaller ethnic minority groups were disproportionately more often represented in our study. Preliminary findings of the qualitative study that complemented the present registration study reveal several issues that may play an important role in their increased risk. Namely, women's relative short stay in the Netherlands, their lack of a social support network, their lack of knowledge of our healthcare system, communication problems with care providers and health illiteracy. More qualitative in-depth research into the nonmedical backgrounds of these women and the course of events preceding their complication are currently carried out and will shed light on patient-related backgrounds of the increased risk.

The main limitation of this study is that we did not record the individual characteristics of all maternities without severe maternal morbidity during the study period. Therefore, we could not adjust RRs for confounding variables. Furthermore, despite our efforts, we cannot guarantee the completeness of data. Therefore, our reported incidence figures only represent a minimum level of severe maternal morbidity. Due to the nationwide nature of the study, we depended on the active participation of local coordinating obstetricians for completeness of data. We tried to meet this by keeping coordinators actively involved and providing help in collecting the data.

Local coordinators not responding to our monthly request for cases where reminded repeatedly by e-mail and phone. And finally, we thoroughly controlled for underreporting. Underreporting of eclampsia and uterine rupture appeared to be very low during the first 5 months of the study, and we therefore decided not to control for it in the remainder of the study period. Underreporting of MOH was estimated at 29% but appeared to be mainly due to relatively less severe complications requiring 'only' 4 units of blood. We expect underreporting to be relatively low for the most severe conditions such as acute fatty liver of pregnancy or amniotic fluid embolism as these are very impressive clinical events that draw the attention of many clinicians involved and will not likely be missed.

The institution of obstetric high care (OHC) facilities in university hospitals posed a methodological challenge. Women, who would without any doubt have been treated at an ICU in a non-university hospital, were not admitted to ICU in university hospitals. Inclusion of all admissions to OHC facilities was not merely possible as most of these admissions were for fetal rather than for maternal indication. Coordinators in university hospitals were instructed to report OHC admissions for strict maternal indications as 'other severe maternal morbidity'. More than half of all inclusions in this group came from university hospitals.

The incidence of severe maternal morbidity in the different hospitals varied largely. Although this could be caused by differences in local case management, other possible explanations are bias due to the management-based criteria, the degree of underreporting per hospital and chance. Hospitals, of which we knew that the local coordinator was dedicated and the local system of recognition and reporting of cases was supported by all clinicians, appeared to have higher incidence figures. Furthermore, incidence was by definition influenced by the management-based criteria 'admission to ICU' and 'MOH requiring 4 or more units of blood'. We noticed substantial variations in local policy for admission to ICU and transfusion of blood products.

The next step in the process of improving maternal care is to critically assess the course of events that led to the severe condition as substandard care analysis serves as a basis to improve guidelines and clinical protocols. Substandard care was judged to be present in the majority of assessed cases, mainly at the level of the care providers, indicating that further analysis of cases and improvement of guidelines could reduce severe maternal morbidity.[24] Several local initiatives for auditing of severe maternal morbidity came to our knowledge since this study.

To confirm the apparent increase in severe maternal morbidity in Western countries, and to evaluate our own clinical practice in the Netherlands, we would need to establish a continuing registration of severe maternal morbidity in the Netherlands. This should be incorporated in the Dutch Perinatal Database and be very comprehensive to assure cooperation of each maternity unit. Furthermore, the implementation of national registration of rare obstetric conditions, like UKOSS in the UK,[30] would be valuable, and the infrastructure is already in place in the Netherlands.[21]

This survey appears to be a valuable addition to the maternal mortality statistics that have already been registered for decades in the Netherlands. It gives a clear new insight in the problems encountered in obstetric practice nowadays and can serve as a reference work for severe maternal morbidity in the Netherlands and other Western countries. Improvement of the quality of obstetric care through auditing of cases of severe maternal morbidity seems a mandatory challenge.

Conclusions

Severe maternal morbidity complicates at least 0.71% of all pregnancies in the Netherlands, immigrant women experiencing an increased risk. Severe maternal morbidity should be considered internationally as a new indicator of the quality of obstetric care next to maternal mortality statistics. Because substandard care was found in the majority of assessed cases, reduction of severe maternal morbidity seems a mandatory challenge. Therefore, auditing of severe maternal morbidity at local or regional level should be encouraged to improve the quality of obstetric care and decrease the incidence of severe maternal morbidity and maternal mortality. Audit should be incorporated in our national public health policy as an instrument of quality control.

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Ethics approval

The study was centrally approved by the medical ethics committee of Leiden University Medical Centre (P04-020; 8 March 2004).

Contribution to authorship

J.J.Z. conducted the project, helped supervise enrolment, analysed and interpreted the data and wrote the manuscript. J.M.R. and F.Ö. conceived the project, provided background knowledge to the data analysis and interpretation and provided feedback on earlier drafts of the manuscript. J.I.P.d.V.

and K.W.M.B. were involved in the design of the study as members of the expert panel and provided feedback on earlier drafts of the manuscript. J.v.R. conceived the project, was project leader, provided background knowledge to the data analysis and interpretation and provided feedback on earlier drafts of the manuscript. J.v.R. will act as study guarantor.

Supplementary material

The following supplementary material is available for this article:

Appendix S1. Acknowledgements.

This material is available as part of the online article from: http://www.blackwell-synergy.com/doi/abs/10.1111/j.1471-0528.2008.01713.x

(This link will take you to the article abstract).

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