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SEVERE ACUTE MATERNAL MORBIDITY

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INTRODUCTION

For every woman who dies of postpartum hemorrhage, a host more suffer short- and long-term consequences from postpartum hemorrhages or their sequelae, even when well-managed. During the 1990s, the concept of severe adverse maternal morbidity (SAMM) emerged in response to the need for a more sensitive marker of quality of obstetric care[1,2]. This term has the advantage over maternal death of drawing attention to surviving women's reproductive health and lives and is equally applicable in developing as well as developed countries.

In developed countries, maternal death from postpartum hemorrhage has become too rare for adequate surveillance of services. For example, the United Kingdom (UK) triennial Confidential Enquiry into Maternal Deaths has revealed that, over the past 50 years, the number of maternal deaths from hemorrhage has fallen from 40 to 3 per annum[3]. Currently, the overall maternal mortality rate in the UK is around 7 per 100 000 maternities[4]. However, the same causes of death persist as in the 1950s, with hypertensive disorders and hemorrhage as the most common causes of direct obstetric deaths[5]. Seventeen out of a total of 106 direct obstetric deaths were attributed to hemorrhage during 2000–2002 (i.e. 16%). Of these, ten were due to postpartum hemorrhage[3]. Compared to the previous report (seven deaths in 1997–1999)[6], there was a slight rise in incidence. Although this is not statistically significant, it needs to be watched as a possible trend alongside a rising Cesarean section rate. A potentially far more worrying factor is that substandard care was implicated in 80% of the cases attributed to hemorrhage[3].

The UK remains one of the few developed countries in which every maternal death is investigated. This was also the case in the United States (US) after 1930, but the rapid decline in maternal mortality in the latter part of the 20th century diminished the vigor used to investigate each individual case. It is not clear how many developed countries have policies similar to that of the UK. As a result of perceived racial discrepancies in maternal mortality in the US, as well as evidence that not all maternal deaths were reported to the National Vital Statistics System (NVSS)[7], a parallel, voluntary system of reporting was introduced in 1983, termed the Pregnancy-related Mortality Surveillance System (PMSS)[8]. While the NVSS collects information from death certificates alone, the PMSS combines data from maternal death certificates with fetal death certificates, autopsy reports and reports produced by maternal mortality review committees[8]. This has led to better ascertainment of cause of death, and a more accurate maternal mortality rate of 11.8[8,9] rather than 7.7[7,8] per 100 000 live births for the period 1991–1999.

WHAT IS THE DIFFERENCE BETWEEN A 'NEAR-MISS' AND A SAMM?

A 'near-miss' used to be thought of as a case where a woman had a near brush with death; she would have died were good fortune and medical care not on her side. This characterization was also used for women with severe organ dysfunction or organ failure who survived[10,11], that is, with intensive medical intervention, a maternal death was avoided and turned into a survival[12]. However, the term

'near-miss' is no longer used, as the 'near-miss' concept was originally derived from the aviation industry and referred more to risk management than the effect on the woman. In contrast, SAMM refers to the morbidity a woman actually suffers. Essentially, we can think of a pyramid of disease in pregnancy (see Figure 1), the base being the numerically larger general pregnant population, the 'tip of the iceberg' being maternal death and much hidden morbidity beneath the surface[9–11]. A clinical insult may be followed by a systemic response and subsequent organ dysfunction, which leads to organ failure and eventual death[1,10]. Figure 1 illustrates both the severity continuum of morbidity as well as factors that move a woman up or down the pyramid. For example, a faulty ambulance or wrongly cross-matched blood might lead to an anemic woman dying of hemorrhage unnecessarily (arrow A). If she is well managed and treated promptly, there may be no residual morbidity at all (arrow B). A wrongly labelled blood bag that is spotted in time still constitutes a 'near-miss' requiring follow-up of the error, although the woman did not experience a transfusion reaction. 'Near-miss' now refers to avoidable risks whereas SAMM retains the concept of the harmed or damaged mother.

An agreed and accurate definition of SAMM is not available, as studies in different parts of the world use different criteria. The two main definitions of SAMM to date are as follows:

(1) An organ system approach[10,11,13], e.g. shock from hemorrhage, severe pre-eclampsia or specific organ failure; these are best identified as they occur;

(2) Management, or process, based[12,14], e.g. admission to a high-dependency unit (HDU) or intensive care unit (ICU) or transfer to another health-care facility (usually higher level); these are usually retrospective studies.

A diligent unit is more likely to pick up cases via the organ system approach and carefully record them; this will translate into a disproportionately higher rate of SAMM[11]. On the other hand, a poor-quality unit that does not recognize and treat hemorrhage promptly may have more severe sequelae as the natural history progresses. Use of the management-based approach relies on more easily agreed parameters, but also on the availability of HDU/ICU beds. Units have different policies and thresholds for transfer. There may be an underestimation of the true incidence of SAMM, especially

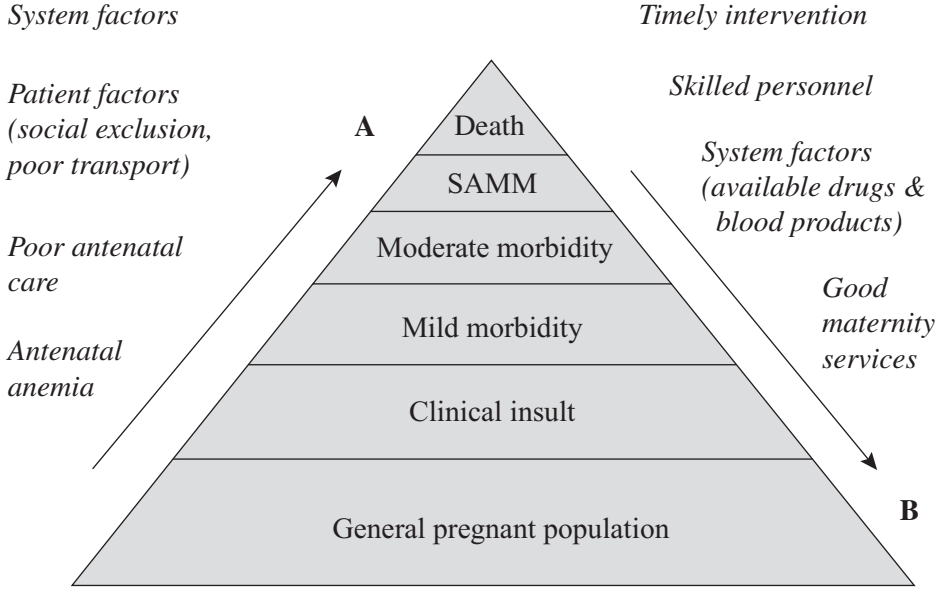

Figure 1 A representation of the morbidity–mortality continuum

in smaller, more isolated units and in developing countries.

INCIDENCE OF SAMM

Quantifying SAMM is problematic as there is no international definition and recording is haphazard at best. Thus, there is a wide variation in the estimate of incidence. Tables 1 and 2 summarize studies to date. Wide variations are present in study settings, definitions and main causes. Some studies use admission to ICU[14,15], others define the actual conditions responsible for the morbidity[10,11], and some list both[12]. Two methods have been described to address the relationship between severe morbidity and mortality. These are the *mortality-to-morbidity ratio*[1,13] and the *mortality index*[11,16]. The mortality-to-morbidity ratio simply describes the number of severe morbidity cases for each maternal death[1,13]. The mortality index, on the other hand, is defined as the number of maternal deaths divided by the sum of women with SAMM and maternal deaths, and is expressed as a percentage[11,16]. Both can be expressed as totals (all-cause) or by condition. They both reflect the impact of a condition on severe morbidity and mortality and identify those conditions that are more or less amenable to intervention. In general, the risk of mortality depends on the prior health of the mother, the severity of the particular condition, the access to skilled help and the availability and quality of medical intervention. Postpartum hemorrhage is common, and has a very favorable morbidity-to-mortality ratio (or low mortality index)[1,11,13,16]. Stated another way, the condition, at least in developed countries, is very amenable to treatment. More women's lives can be saved with medical interventions than for a comparable number of cases of infection or cardiac disease. Many lives can be, and indeed are being, saved daily by the provision of adequate maternity services world-wide. As hemorrhage is so obviously both avoidable and treatable, and because all parturients are at risk, it is tragic that so many women die unnecessarily. Unfortunately, complacency in developed countries about the daily marvels achieved in childbirth[4] has made any sudden unexpected threat to life almost unbelievable and unbearable.

CAUSES OF SAMM

Most cases of SAMM fall into three major categories:

(1) Hemorrhage;

(2) Hypertensive disorders of pregnancy (including eclampsia and HELLP syndrome);

(3) Sepsis.

Table 1 summarizes both the all-cause incidence of SAMM as well as the three major causes. Rates in European countries are similar for the three major causes of severe morbidity despite the use of different definitions. Regardless of geographical factors, hemorrhage is the largest contributor, accounting for one-fifth[17] to one-half[10,18,19] of cases. Hypertensive disease and its consequences account for 10%[18] to 45%[20] of cases of SAMM, whereas morbidity secondary to sepsis is much lower (1.5%[18] to 20%[10]). Other rarer causes of severe morbidity include uterine rupture, thromboembolic disease and psychiatric illness[5,21]. The Mothers' Mortality and Severe Morbidity Survey was conducted during the 1990s by an international team which spanned 11 European countries. There are two parts to the survey: MOMS-A and MOMS-B[20]. MOMS-A collected and compared data on maternal deaths, while MOMS-B identified cases of severe morbidity[20]. The survey established that, in European countries with the highest SAMM rates, i.e. Belgium, Finland and the UK, most of the difference was due to higher incidence of hemorrhage. However, maternal mortality was no higher than in other European countries. This suggests either that ascertainment of cases in these three countries is more complete or that hemorrhage is not a major cause of death; therefore the higher incidence of SAMM does not affect overall mortality data. Alternatively, it may be that mortality rates are associated more closely to the quality of care than the prevalence of morbidity[20]. The geographical areas chosen in different countries had very different demographics, and this also may have affected the rates of morbidity; Belgium and the UK were represented by Brussels and the South-East Thames region, areas with significant inner-city and migrant

Table 1 The incidence of each major cause of morbidity per 1000 deliveries

Study, country and year of publication	*Incidence of SAMM (all causes)*	*Incidence of hemorrhage (% of total)*	*Incidence of hypertension (% of total)*	*Incidence of severe sepsis (% of total)*	*Additional comments*
Stones[2], UK, 1991	8.8	3.23 (36.8%)	2.77 (31.5%)	not available	SAMM defined as 'potentially life-threatening episodes'. Incidence for total morbidity 267/1000. Incidence of all sepsis 30.5/1000 (severe sepsis not separated out). Hemorrhage includes antepartum and postpartum if over 2000 ml and also 1 case of secondary PPH due to sepsis which required hysterectomy
Bouvier-Colle[17], France, 1996	3.1	0.62 (20%)	0.81 (26.2%)	0.14 (4.36%)	3rd highest cause of morbidity is embolic events at 0.38/1000. Hemorrhage includes uterine rupture. Hypertensive disease includes cerebral hemorrhage
Bewley & Creighton[12], UK, 1997	4.97	2.3 (46.7%)	1.98 (40%)	0.49 (10%)	SAMM = ITU admission. Total 30 cases of SAMM. 14 cases classed as hemorrhage (blood loss > 2000 ml but a further 2 cases DIC/HELLP so proportion due to hemorrhage could be > 50%)
Baskett & Sternadel[22], USA, 1998	0.72	0.16 (22%)	0.18 (25%)	0.1 (14.5%)	SAMM = ITU admission
Mantel[10], South Africa, 1998	10.9	6.1 (55.8%)	2.82 (25.8%)	2.16 (19.7%)	Sepsis incorporates septic abortion, chorioamnionitis and puerperal sepsis. Hemorrhage incorporates antepartum and postpartum hemorrhage and emergency hysterectomy; PPH alone is 1.8/1000
Prual[18], West Africa, 2000	59.8	29.6 (49.5%)	6.15 (10.3%)	0.9 (1.5%)	Obstructed labor is significant cause for severe morbidity (20.5/1000 of which 1.2/1000 uterine rupture)
Waterstone[13] (COSMO), UK, 2001	12.0	6.7 (55.7%)	4.6 (38%)	0.35 (2.89%)	Clinically based definitions, not including management processes. Estimated blood loss > 1500 ml picked up 55% of cases of SAMM due to hemorrhage
Brace[19], Scotland, 2004	3.8	1.9 (50%)	1.15 (30%)	0.09 (3%)	Septic shock is the only category for sepsis. Number of SAMM due to hypertensive disease derived by adding the number of cases with eclampsia, renal dysfunction and pulmonary edema. Only one-third of patients with SAMM were admitted to ITU
Zhang[20] (MOMS-B), Europe, 2005	9.48	4.6 (48.8%)	4.33 (45.7%)	0.8 (8.2%)	Multinational study, rates differing widely between countries. Range of SAMM 6–14.7%, highest in Finland, Belgium and UK; lowest rates in Italy, Ireland, France

DIC, disseminated intravascular coagulation; SAMM, severe adverse maternal morbidity; ITU = intensive therapy unit; HELLP, hemolysis, elevated liver enzymes, low platelets; PPH, postpartum hemorrhage

Table 2 The incidence of SAMM and hemorrhage and definitions used to ascertain cases

Author, country, year of publication	*Type of study, type of unit*	*Number of deliveries, cases of SAMM, cases of hemorrhage*	*Incidence of SAMM or ITU (/1000 deliveries)*	*Incidence of hemorrhage (/1000 deliveries)*	*% of SAMM due to hemorrhage*	*Definition of severe hemorrhage (additional comments)*	*Perinatal outcome*	*Number of maternal deaths, MMR for SAMM overall, mortality per 100 000*
Graham & Luxton[41], UK, 1989	retrospective, general ITU	21 983 23 (ITU) 1 (5)*	1.04	0.05 (0.23)*	4.35% (21.7%)*	1 case of hemorrhage counted but 5 cases in total (3 abruptions: 1 was the hemorrhage and 2 cases of DIC). 9 patients showed some coagulopathy, 5 received > 4 units transfusion	1 intrauterine death	2 11.5 : 1 9.1
Mabie & Sibai[23], US, 1990	retrospective, 3-bed dedicated obstetric ITU	22 651 200 (ITU) 21	8.82	0.93	10.5%	massive hemorrhage not defined	not collected	not collected
Stones[2], UK, 1991	retrospective, single unit	2164 19 7	8.8	3.23	36.8%	hemorrhage > 2000 ml or DIC or hysterectomy	not collected	0 0
Killpatrick & Matthay[14], US, 1992	retrospective, general ITU	8000 32 (ITU) 4	4	0.5	12.5%	hemorrhage/hemodynamic instability. 52% of postpartum admissions were for hemodynamic instability	2 stillbirths delivered on ITU. No neonatal/ fetal deaths after admission to ITU	4 8 : 1 50
Monaco[15], US, 1993	retrospective, ITU admissions	15 323 38 (ITU) 4	2.47	0.26	10.5%	2 cases following PPH and 2 cases of hematologic dysfunction (local policy is to admit only for ventilatory support or pulmonary artery catheterization)	perinatal mortality rate 12% (4 of 33 pregnancies followed up)	7 5.4 : 1 45.7
Bouvier-Colle[17], France, 1996	retrospective, 2 French regions	140 323 435 (ITU) 87	3.1	0.62	20%	hemorrhage not defined but includes uterine rupture	stillbirth rate collected only 24.6% in hypertension, 17.3% in hemorrhage, 33.3% in sepsis	22 19.8 : 1 15.7
Bewley & Creighton[12], UK, 1997	retrospective, general ITU	6039 30 (ITU) 14	4.97	2.3	46.7%	transfer to ITU for blood loss > 2000 ml	not collected	not collected

Continued

Table 2 *Continued*

Author, country, year of publication	*Type of study, type of unit*	*Number of deliveries, cases of SAMM, cases of hemorrhage*	*Incidence of SAMM or ITU (/1000 deliveries)*	*Incidence of hemorrhage (/1000 deliveries)*	*% of SAMM due to hemorrhage*	*Definition of severe hemorrhage (additional comments)*	*Perinatal outcome*	*Number of maternal deaths, MMR for SAMM overall, mortality per 100 000*
Lapinsky[27], Canada, 1997	retrospective, ITU admissions in tertiary hospital	25 000 65 (ITU) 11	2.6	0.44	17%	hemorrhage requiring ITU admission, not defined. 52% of admissions involved hemodynamic instability; 4 hysterectomies	perinatal mortality rate 11%	0 0
Tang[25], Hong Kong, 1997	retrospective, single center	39 354 49 (ITU) 26	1.24	0.66	53%	blood loss 1000–8500, mean 3500 ml. Received blood transfusion (mean 12 units), platelet transfusion or FFP. DIC in 34% and mild coagulopathy in 27% of hemorrhage cases. Hysterectomy in 22 cases (84.6% of all hemorrhage)	perinatal mortality rate 10.2%	2 24.5 : 1 5.1
Mantel[10], South Africa, 1998	prospective, multicenter	13 429 147 82	10.9	6.1	55.8%	severe hemorrhage = hypovolemia requiring 5 or more units of blood for resuscitation or emergency hysterectomy	not collected	30 4.9 : 1 223.4
Mahutte[28], Canada, 1999	retrospective, 2 tertiary care units with general ITU	44 340 131 (ITU) 34	2.95	0.77	26%	hemorrhage causing admission due to abnormal placentation, atony, lacerations, RPOC, severe coagulopathy. 27 (79%) received blood products and 12 (35%) admitted after Cesarean hysterectomy	not collected	3 43.7 : 1 6.8
Waterstone[13,21], UK, 2001	prospective, case–control, multicenter	48 865 588 327	12.0	6.7	55.7%	blood loss > 1500 ml/peripartum hemoglobin drop ≥ 4 g/dl or acute transfusion ≥ 4 units	perinatal mortality rate 7.5%	5 118 : 1 10.2
Prual[18], West Africa, 2000	prospective, 6 countries	20 326 1215 601	59.8	29.6	49.5%	hemorrhage requiring transfusion, hospitalization > 4 days or hysterectomy (only 2.8% of deaths were due to severe hemorrhage)	not collected	38 32 : 1 187
Hazelgrove[24], UK, 2001	retrospective, multi-unit	122 850 210 (ITU) 70	1.7	0.6	33.3%	major hemorrhage not specified; 35% were short admissions (< 2/7) and no specific interventions. 7 patients required transfer to specialist ITUs	fetal mortality rate 20% (includes fetal losses < 24 weeks gestation)	7 30 : 1 5.7

Murphy & Charlett[29], US, 2002	retrospective cohort, general ITU in teaching hospital	51 576 50 (ITU) 12	0.97	0.23	24%	no definition/information on transfusion given but cause of hemorrhage given; 7 hysterectomies	perinatal mortality rate 14%.	3 16.7 : 1 5.8
Vandecruys[16], South Africa, 1997–1999	prospective, tertiary center, phase 1	26 152 305 44	11.7	1.68	14.4%	definitions not given. Data on hemorrhage refer to PPH	not collected	59 5.2 : 1 225.6
Vandecruys[16], South Africa, 2002	prospective tertiary center, phase 2 (re-audit)	13 854 121 23	8.7	1.66	19%	as above. SAMM and mortality declined compared to the first audit due mainly to reduction in abortion complications	not collected	26 4.7 : 1 188
Pattinson[11], South Africa, 2003	prospective, 3 geographic areas (urban and rural)	NA 423 130	NA	NA	30.7%	condition-based definitions same as Mantel10. Calculates mortality index but cannot define incidence as number of deliveries not given. Hemorrhage includes antepartum and postpartum; PPH alone is 18%. PPH is second most common cause of SAMM but 7th cause of death	not collected	128 3.3 : 1 NA
Brace[19], Scotland, 2004	prospective observational, (22 consultant-led units in Scotland)	51 165 196 98	3.8	1.9	50%	major hemorrhage = cases transfused at least 5 units during the acute episode of hypovolemia (13 categories of morbidity leading to ITU admission)	not collected	4 49 : 1 7.8
Gandhi[26], South Africa, 2004	prospective, 4 rural primary hospitals	5728 31 10	5.41	1.75	32%	Mantel's definitions adapted for use in primary hospital with limited resources. Includes antepartum and postpartum hemorrhage, DIC and hysterectomy	not collected	not disclosed
Zhang[20] (MOMS-B), Europe, 2005	Population based questionnaire, multi-unit, multi-national	182 734 1734 847	9.48	4.6	48.8%	blood loss > 1500 ml/blood loss requiring plasma expanders and/or blood loss > 2500 ml in 24 h/blood loss resulting in maternal death. Incidence range 0.7–8.8 according to country	fetal death rate 4.8%	4 433.5 : 1 2.2

SAMM, severe adverse maternal morbidity; ITU, admissions to intensive therapy unit; (ITU), SAMM cases defined as ITU admissions; MMR, morbidity to mortality ratio (calculated from rate of SAMM to mortality); PPH, postpartum hemorrhage; DIC, disseminated intravascular coagulation; HD, high-dependency unit; RPOC, retained products of conception; NA, not available

*Data in parentheses are calculations as applied for five cases

populations, whilst the three regions in France did not include major cities[20].

In general, severe hemorrhage and hypertension have much higher incidence (range 0.6[17]–29.6[18] and 0.18[22]–6.15[18] per 1000 deliveries, respectively) than severe sepsis (0.09[19]–2.16[10] per 1000). The same low rate for sepsis is observed in West Africa, where the second greatest cause of SAMM after hemorrhage is obstructed labor[18]. Uterine rupture has been combined with data for obstructed labor in one study[18] and with hemorrhage in another[17]. Waterstone and colleagues (2001)[13] considered uterine rupture as a separate entity; this is a more accurate way of using the data unless we have clear evidence of the blood loss associated with each case[13]. Few studies have looked at immediate moderate morbidity, although a number of studies of the puerperium examine moderate to minor morbidity[2,13]. For example, Stones and colleagues (1991) included less severe cases of morbidity in their analysis: anesthetic complications (usually post-spinal headache) 0.46%; urinary retention/incontinence 1.2%; late perineal complications 0.65%[2].

HEMORRHAGE AS A CAUSE FOR SAMM: THE EVIDENCE

Most studies of SAMM to date report severe hemorrhage as the largest single contributing factor. Severe hemorrhage was defined by one or a combination of factors:

(1) Estimated blood loss ≥ 1500 ml (or ≥ 2000 ml);

(2) Hemoglobin drop ≥ 40 g/dl;

(3) Transfusion of ≥ 4 units of blood.

Table 2 outlines the incidence of severe hemorrhage in a variety of studies to date. The problem of varied definitions is highlighted, making comparisons between studies difficult. The proportion of SAMM due to hemorrhage is also shown. This varies widely but tends to be lower in studies that are management-based, as not all cases require admissions to ICU. Local policies and availability of obstetric HDU beds on labor wards has a great influence on the management of massive postpartum hemorrhage as it avoids delays in treatment secondary to transfers and also ensures continuity of obstetric care[23]. Obstetric HDU beds are becoming more commonplace in tertiary centers in the UK[12,13,24] and US[14,15,23]. Comparisons are more valid between studies that have used agreed or similar definitions for hemorrhage[10,12,18,19,25]. Many of them are prospective[10,11,13,19,26] rather than retrospective[14,17,27–29], and they tend to find higher proportions of hemorrhage: 30–50% rather than 10–30%, although there is some overlap[12,18].The higher rate from prospective studies is likely to be due to better case ascertainment. Rates appear to be very similar in developed[13,19,20] and developing[10,18] countries when comparable definitions are used.

Emergency obstetric hysterectomy provides another means of examining SAMM caused by postpartum hemorrhage. It has the advantage of being relatively clearly defined, and is rare enough to be easy to collect data. The traditional advice is to perform hysterectomy early to avoid mortality[6]. The threshold for performing hysterectomy clearly varies with operator and unit, but evidence exists that early hysterectomy decreases morbidity[30]. The new United Kingdom Obstetric Surveillance System (UKOSS) requires units to report cases of specified rare conditions on a monthly basis. Hysterectomy has been chosen as the exemplar obstetric morbidity, and this large national surveillance should provide further information about best practice in the future.

RISK FACTORS FOR SAMM AS APPLIED TO HEMORRHAGE

Although it is challenging to define the size of the problem (i.e. the incidence of SAMM as a result of hemorrhage), it is necessary to understand the factors that increase the risk of severe hemorrhage. Table 3 has been adapted from the findings of a multicenter case–control study in the South East Thames region of the UK (COSMO)[13] and outlines the odds ratios of having a severe hemorrhage (as defined by blood loss ≥ 1500 ml, hemoglobin drop ≥ 40 g/dl, or blood transfusion ≥ 4 units), depending on a wide range of risk factors. The main predictors are:

Table 3 Risk factors for having a severe adverse maternal morbidity, or severe hemorrhage (from Waterstone *et al.*, 2001)[8]. Figures are odds ratios (95% confidence interval)

Risk factors	*Odds ratios for SAMM (all causes)*	*Odds ratios for SAMM due to hemorrhage*
Age > 35 years	1.46 (1.11–1.92)	1.41 (1.03–1.95)
Blood pressure at booking	1.23 (1.12–1.34)	1.18 (1.06–1.31)
Black	1.16 (0.85–1.58)	0.97 (0.66–1.42)
Other race	1.93 (1.24–2.99)	1.82 (1.09–3.03)
Social exclusion	2.64 (1.69–4.11)	2.91 (1.76–4.82)
Smoker	0.68 (0.49–0.93)	0.65 (0.44–0.96)
Previous postpartum hemorrhage	2.41 (1.53–3.77)	2.74 (1.69–4.44)
Hypertension	1.10 (0.63–1.95)	0.82 (0.37–1.80)
Diabetes	1.76 (0.43–7.20)	1.85 (0.38–9.14)
Multiple pregnancy	2.21 (1.24–3.96)	2.29 (1.2–4.37)
Antenatal admission	1.75 (1.37–2.23)	1.85 (1.39–2.47)
Taking iron at booking	5.53 (2.28–13.41)	5.98 (2.28–15.65)
Taking antidepressants at booking	4.3 (0.91–1.88)	10.55 (2.19–50.71)
Taking antiepileptics at booking	5.31 (1.4–20.13)	5.75 (1.28–25.72)
IOL because overdue	1.36 (0.99–1.88)	1.38 (0.95–1.99)
IOL on medical grounds	2.45 (1.68–3.57)	1.33 (0.87–1.07)
Oxytocin augmentation	0.99 (0.76–1.28)	1.61 (1.2–2.15)
Manual removal of placenta	9.60 (5.67–16.28)	13.12 (7.72–22.30)
Emergency Cesarean	4.31 (3.39–5.49)	3.09 (2.29–4.17)

SAMM, severe adverse maternal mortality; IOL, induction of labor

(1) *Demographic*: age ≥ 35 years, non-white race, social exclusion (this was a composite measure of a woman's social deprivation beyond the use of her marital or partner's employment status. It included concealed pregnancy, age < 16 years, poor housing, 'on income support' in the notes, previous minor or child in local authority or state care (currently or in the past), in trouble with the law (currently or previously), living alone, unbooked, unwanted pregnancy, currently or previously in foster care, care order being considered on potential child, social worker involved, or drug or alcohol dependency[21]);

(2) *General medical factors*: anemia, depression, diabetes, hypertension, epilepsy;

(3) *Obstetric factors*: previous postpartum hemorrhage, multiple pregnancy, antenatal admissions, obstetric interventions (augmentation with oxytocin, manual removal of placenta, emergency Cesarean section).

Other studies[31,32] find the same trend, with death and severe morbidity being more common in black women, multiparae and women of 'low status'[32] as defined by poor education, poverty, low antenatal care attendance, low contraceptive ever-use and little power to make decisions regarding access to health care. In Geller's study (2004)[31], the peak of mortality and SAMM occurred in the 20–34-year age group, with three times fewer women aged > 35 years in all categories of the morbidity-to-mortality continuum[31]. This is more likely to reflect the age distribution of the study population rather than a true difference between the USA and the UK, and emphasizes the need for the use of multiple logistic regression to tease out risk factors. Manual removal of placenta had the biggest impact[13], in keeping with abnormally adherent placentas being a major cause of postpartum hemorrhage. Antenatal anemia, Cesarean section, and the use of antidepressants or antiepileptics at booking also appear to have significant impacts, though their relative importance is difficult

to ascertain as the confidence intervals were wide. Induction of labor increases the risk of postpartum hemorrhage regardless of the indication[13].

OUTCOMES OF WOMEN WHO SUFFER SAMM

Few studies look at outcomes beyond survival or immediate morbidity. Studies of postnatal morbidity in general (low- and high-risk women analyzed together) found that the prevalence of problems is high (87%) and lasts up to 18 months[33]. A case–control study of outcome 6–12 months postpartum compared women who had suffered SAMM and women who had not[21]. Women who had suffered SAMM were twice as likely as controls to attend general practitioner services and three times as likely to attend Accident and Emergency departments. This may have been due in part to some underlying morbidity and its follow-up but clearly points to a continuing burden on health services with its personal, family and economic cost. Cases also suffered slightly more postnatal depression than controls (who were not entirely 'normal' women and included women with operative deliveries and smaller hemorrhages). Although this difference was not statistically significant, cases also scored higher on the Edinburgh Postnatal Depression Scale. Significantly more cases (50%) than controls (29%) were reluctant to re-establish sexual relations with their partners for fear of becoming pregnant, suggesting that a negative experience in one pregnancy may prevent a woman from achieving the family she initially intended[21]. Women with stillbirths are almost always excluded from postnatal studies[33], although a higher proportion of them also suffer SAMM by the nature of underlying conditions (e.g. abruptions, diabetes). Only half of the studies of SAMM quoted give data about perinatal loss. The figures quoted above are very likely underestimates of the true spectrum of postnatal morbidity.

DECREASING SAMM: MOVING FORWARD

Before designing studies into effective interventions for reducing SAMM, it will be necessary to develop standardized definitions for severe morbidity and its main causes. Intuitively, a condition-based approach will be better, as it would allow clinical comparisons to be made. Recommendations could be more easily applied to settings where ICU facilities are scarce. Two groups[10,31] have refined this clinical approach by classifying SAMM according to the initial obstetric cause (e.g. hypertensive disorders, hemorrhage or sepsis) as well as the organ dysfunction which led to the severe illness. Hemorrhage could be further classified by cause (atony, surgical, adherent placenta, disseminated intravascular coagulopathy (DIC), inverted uterus, etc.).

In the context of severe hemorrhage, possible components of an international definition might include:

- Measured blood loss ≥ 1500 ml at the time of pregnancy outcome (including abortion, ectopic, vaginal delivery or Cesarean)
- Peripartum hemoglobin drop ≥ 4 g/dl
- Acute transfusion ≥ 4 units of blood
- Presence of DIC or shock
- Use of additional, non-obstetric procedures, e.g. hysterectomy/ laparotomy/interventional radiology
- Blood loss resulting in vital organ dysfunction/ICU admission
- Blood loss resulting in maternal death

The first three components are imprecise and early indicators of morbidity. Moreover, the amount of blood loss is notoriously inaccurate, blood transfusion is practitioner- and protocol-dependent and hemoglobin decreases are not measured world-wide. The severity of the impact on the woman's health will depend on her prior hemoglobin level and further management of her condition. Blood loss in excess of 1500 ml is a sensitive predictor of SAMM. Some of the studies discussed so far[12,13] identified 50% of their cases of hemorrhage by using this measure. The latter categories are clear but late markers of severity. Potentially, a scoring system could be devised to increase the accuracy of assessment of severity. A woman who loses a large quantity of blood, is adequately

transfused with blood and blood products, and managed in an obstetric HDU is likely to suffer less long-term morbidity than a woman with the same blood loss, but also with a hysterectomy and ICU admission for ventilation and renal failure.

Based on the risk factors already identified and presently available treatments, interventions can be tested at different levels to reduce the rate of SAMM or to convert high-scoring cases to lower-scoring ones. One American group has devised a scoring system[31] which contains five categories, including organ system failure, ICU admission, extended intubation, transfusion > 3 units and surgical intervention. The maximum score is 15; women who scored more than 8 were classified as near-misses whereas those who scored less than 8 were classified as severe morbidity. The aim was to refine classification at the most extreme end of the morbidity-to-mortality continuum, thus enabling identification of the key factors responsible for moving women along the continuum and targeting interventions that shift women more towards morbidity rather than mortality[9,31].

To effectively improve outcome, change has to be implemented at various levels, from primary-care providers, through secondary and tertiary centers to health-care systems.

Basic antenatal care

This cannot be overemphasized, as ample evidence shows that antenatal follow-up decreases a woman's risk when it comes to labor and delivery[26,34]. Screening for complications antenatally, treatment and prevention of anemia, cleanliness during delivery, the presence of a skilled birth attendant and active management of the third stage of labor are all basic requirements advocated by the World Health Organization[35]. Staff attending deliveries in the primary-care sector need to be trained to recognize postpartum hemorrhage early and have access to simple drugs to treat it (e.g. misoprostol, ergometrine)[36], as well as recognize when to refer to a more specialized center[26]. In rural South Africa, health-worker problems were identified as causing substandard care in 35–49% of cases[26] out of a total of 65% where substandard care was an issue. Factors identified were delay in diagnosis, treatment, referral and monitoring. In the UK, substandard care was apparent in between 50%[12] and 80%[3] of cases of hemorrhage. Regular skills drills to train staff in estimating blood loss more accurately and recognize signs of compromise are beneficial[3,37]. Blood transfusion, although possible in rural South Africa, often fails because of depleted stocks[26], even if the need for transfusion is recognized[26]. When misoprostol is used at home births in Africa, it significantly reduces rates of postpartum hemorrhage and does not require a medically trained attendant[36,38]. New data[39,40] suggest that sublingual administration may be most effective, and the women can self-administer easily[38], further reducing the cost of an already cheap intervention.

Secondary and tertiary care

Some of the best data come comes from studies where cases were identified from daily audit meetings[10,11,16]. Results of audits and research should be fed back promptly to staff so that improvements can be implemented. In a two-phase study, a reduction in incidence of SAMM and maternal mortality was demonstrated over 4 years, when recommendations from the first audit were implemented[16]. However, in the same study, the incidence of hemorrhage was virtually unchanged: the main factor responsible for decreasing SAMM and mortality was improved care relating to abortion[16]. Clear management protocols and regular skills drills may both contribute to the maintenance of high standards in units[3,22]. Non-adherence to guidelines has been identified as a risk factor for increased maternal morbidity[3,37], whereas dissemination of guidelines and skills drills are associated with improved adherence to the agreed protocols and significant reduction in postpartum hemorrhage[37].

Access, transport, institutional or organizational change

Twenty percent of avoidable SAMM in rural South Africa is due to organizational or administrative causes such as the shortage of essential drugs, ambulances and lack of recruitment and

retaining of experienced staff[26]. These factors are less prominent in the developed world. However, implementation of guidelines and issues such as staff training and effective audit usually occur at organizational levels. Geller and colleagues (2004) analyzed the 'preventability' of events along the continuum of severe morbidity to near-miss to death and concluded that the same factors contributed to the outcome in all categories[31]. These were patient-factors (13–20%), system factors (33–47%) and provider-related factors (90%), mainly incomplete or inappropriate management[31]. Patient factors are potentially the hardest to rectify, especially in developing countries where access to education is limited. System factors figure higher in the US (33–47%)[31] than in South Africa (20%)[26], possibly because failures of well-established systems (as in the US) are likely to have a greater impact than in settings where transport or administrative systems are not established in the first place as, for example, in rural Africa[26]. Provider-related factors were more prominent as a cause of substandard care in the US (90%)[31] than in primary-care settings in South Africa (35–49%)[26]. This is more likely due to non-availability of specialist staff in the latter, with staff performing to the best of their ability in light of the skills they possess. US and European doctors working in obstetrics are specialists, who work to agreed protocols and participate in audit and research to maintain high standards[31].

Health systems

Wider factors relating to health systems can move a woman both up and down the risk pyramid for severity of morbidity. Social exclusion and inequity can be tackled at governmental level in both developing and developed countries[1,34]. Access to contraception, safe legal abortion and antenatal care can also be addressed. Special antenatal services for travellers, teenagers or the mentally ill may be set up by health-service planners[1]. The health insurance system in the US may play a role, as women most at risk are often not insured[31]. In the current era of increased migration, especially from deprived areas or as a result of war and conflict, the population in major cities is changing. Access to 24-h interpreters should become standard and might lead to significant reductions in severe morbidity[1].

CONCLUSION

The triennial UK Confidential Enquiry into Maternal Deaths started in the first half of the 20th century and witnessed a gradual decline in maternal mortality. The numbers of maternal deaths in the developed world are now relatively few, although still prevalent in developing countries. Severe maternal morbidity (SAMM) is prevalent throughout the world, mostly due to treatable conditions. It is often poor, socially excluded women that suffer most. For meaningful comparisons to be made, standardized, simple definitions need to be designed and agreed on as the benchmark for future research. Condition-based definitions are better than management-based ones[9,10,13,31], as the former can be used in poorly resourced areas[26]. Hemorrhage accounts for the largest proportion of SAMM, but it is not one of the major causes of maternal mortality, at least in developed countries[11]. This suggests that registering SAMM would be a valuable way to monitor and improve the quality of maternity services. The Scottish population survey[19] shows such a register is feasible at national level. As the causes of maternal deaths can be very different from the causes of SAMM[11], it would be most useful to have the two enquiries running in parallel. The last triennial report in the UK[5], published in 2004, has already incorporated a chapter on morbidity, thus acknowledging the need for SAMM to be taken into consideration. World-wide, avoidable maternal deaths remain a paramount issue of basic women's rights. Nevertheless, severe hemorrhages that women survive are much commoner. Understanding the relationship between morbidity and mortality should lead to reductions in substandard care and the global burden of both death and long-term morbidity from hemorrhage.

References

1. Bewley S, Wolfe C, Waterstone M. Severe maternal morbidity in the UK. In Maclean AB, Neilson J, eds. *Maternal Morbidity and Mortality*. London: RCOG Press, 2002:132–46

2. Stones W, Lim W, Al-Azzawi F. An investigation of maternal morbidity with identification of life-threatening 'near-miss' episodes. *Health Trends* 1991;23:13–15
3. Hall M. Haemorrhage. In Department of Health, Welsh Office, Scottish Office Department of Health, Department of Health and Social Services, Northern Ireland, *Why Mothers Die. Report on Confidential Enquiries into Maternal Deaths in the United Kingdom 2000–2002*. London: Her Majesty's Stationery Office, 2004
4. Drife JO. Maternal 'near-miss' reports? *Br Med J* 1993;307:1087–8
5. Department of Health, Welsh Office, Scottish Office Department of Health, Department of Health and Social Services, Northern Ireland. *Why Mothers Die. Report on Confidential Enquiries into Maternal Deaths in the United Kingdom, 2000–2002*. London: Her Majesty's Stationery Office, 2004
6. Department of Health, Welsh Office, Scottish Office Department of Health, Department of Health and Social Services, Northern Ireland. *Why Mothers Die. Report on Confidential Enquiries into Maternal Deaths in the United Kingdom, 1994–1996*. London: Her Majesty's Stationery Office, 1998
7. Smith JC, Hughes JM, Pekow PS. An assessment of the incidence of maternal mortality in the United States. *Am J Public Health* 1984;74:780–3
8. Chang J, Elam-Evans LD, Berg CJ, *et al*. Pregnancy-related mortality surveillance in the United States, 1991–1999. *Morbidity and Mortality Weekly Report Surveillance Summary* 2003;52 (SS02):1–8 (http://www.cdc.gov/mmwr)
9. Geller SE, Rosenberg D, Cox S, *et al*. Defining a conceptual framework for near-miss maternal morbidity. *J Am Med Women's Assoc* 2002;57: 135–9
10. Mantel GD, Buchmann E, Rees H, *et al*. Severe acute maternal morbidity: a pilot study of a definition for a near-miss. *Br J Obstet Gynaecol* 1998;105:985–90
11. Pattinson RC, Buchmann E, Mantel G, *et al*. Can enquiries into severe acute maternal morbidity act as a surrogate for maternal death enquiries? *Br J Obstet Gynaecol* 2003;110:889–93
12. Bewley S, Creighton S. 'Near-miss' obstetric enquiry. *J Obstet Gynaecol* 1997;17:26–9
13. Waterstone M, Bewley S, Wolfe C. Incidence and predictors of severe obstetric morbidity: case-control study. *Br Med J* 2001;322:1089–93
14. Kilpatrick SJ, Matthay MA. Obstetric patients requiring critical care. A five year review. *Chest* 2002:101:1407–12
15. Monaco TJ, Spielman FJ, Katz VL. Pregnant patients in the intensive care unit: a descriptive analysis. *South Med J* 1993;86:414–17
16. Vandecruys H, Pattinson RC, Macdonald A, *et al*. Severe acute maternal morbidity and mortality in the Pretoria Academic Complex: changing patterns over 4 years. *Eur J Obstet Gynaecol Reprod Biol* 2002;102:6–10
17. Bouvier-Colle MH, Salanave B, Ancel PY, *et al*. Obstetric patients treated in intensive care units and maternal mortality. Regional teams for the survey. *Eur J Obstet Gynaecol Reprod Biol* 1996; 65:121–5
18. Prual A, Bouvier-Colle MH, de Bernis L, *et al*. Severe maternal morbidity from direct obstetric causes in West Africa: incidence and case fatality rates. *Bull WHO* 2000;78:593–603
19. Brace V, Penney G, Hall M. Quantifying severe maternal morbidity: a Scottish population study. *Br J Obstet Gynaecol* 2004;111:481–4
20. Zhang WH, Alexander S, Bouvier-Colle MH, *et al*. Incidence of severe pre-eclampsia, post-partum haemorrhage and sepsis as a surrogate marker for severe maternal morbidity in a European population-based study: the MOMS-B survey. *Br J Obstet Gynaecol* 2005;112:89–96
21. Waterstone M, Wolfe C, Hooper R, *et al*. Postnatal morbidity after childbirth and severe obstetric morbidity. *Br J Obstet Gynaecol* 2003; 110:128–33
22. Baskett TF, Sternadel J. Maternal intensive care and near-miss mortality in obstetrics. *Br J Obstet Gynaecol* 1998;105:981–4
23. Mabie WC, Sibai BM. Treatment in an obstetric intensive care unit. *Am J Obstet Gynecol* 1990; 162:1–4
24. Hazelgrove JF, Price C, Pappachan VJ, *et al*. Multicenter study of obstetric admissions to 14 intensive care units in southern England. *Crit Care Med* 2001;29:770–5
25. Tang LC, Kwok AC, Wong AY, *et al*. Critical care in obstetrical patients: an eight year review. *China Med J* 1997:110:936–41
26. Gandhi MN, Welz T, Ronsmans C. Severe acute maternal morbidity in rural South Africa. *Int J Gynaecol Obstet* 2004;87:180–7
27. Lapinsky SE, Kruczynski K, Seaward GR, *et al*. Critical care management of the obstetric patient. *Can J Anaesthesia* 1997;4:325–9
28. Mahutte NG, Murphy-Kaulbeck L, Le Q, *et al*. Obstetric admissions to the intensive care unit. *Obstet Gynecol* 1999;94:263–6
29. Murphy D, Charlett P. Cohort study of near-miss maternal mortality and subsequent

reproductive outcome. *Eur J Obstet Gynaecol Reprod Biol* 2002;102:173–8
30. Al-Nuaim LA, Mustafa MS, Abdel Gader AG. Disseminated intravascular coagulation and obstetric haemorrhage. Management dilemma. *Saudi Med J* 2002;23;658–62
31. Geller SE, Rosenberg D, Cox SM, *et al*. The continuum of maternal morbidity and mortality: factors associated with severity. *Am J Obstet Gynecol* 2004;191:939–44
32. Kaye D, Mirembe F, Aziga F, *et al*. Maternal mortality and associated near-misses among emergency intrapartum referrals in Mulago Hospital, Kampala, Uganda. *East Afr Med J* 2003;80:144–9
33. Glazener CMA, Abdalla M, Stroud P, *et al*. Postnatal maternal morbidity: extent, causes, prevention and treatment. *Br J Obstet Gynaecol* 1995;102:282–7
34. The mother-baby package: WHO's guide to saving women's and infant's lives. *Safe Mother* 1994;15:4–7
35. Lazarus JV, Lalonde A. Reducing post-partum haemorrhage in Africa. *Int J Gynaecol Obstet* 2005;88:89–90
36. Prata N, Mbaruku G, Campbell M, *et al*. Controlling post-partum haemorrhage after home births in Tanzania. *Int J Gynaecol Obstet* 2005;90:51–5
37. Rizvi F, Mackey R, Barett T, *et al*. Successful reduction of massive postpartum haemorrhage by use of guidelines and staff education. *Br J Obstet Gynaecol* 2004;111:495–8
38. Potts M, Campbell M. Three meetings and fewer funerals – misoprostol in postpartum haemorrhage. *Lancet* 2004;364:1110–11
39. Vimala N, Mittal S, Kumar S, *et al*. Sublingual misoprostol versus methylergometrine for active management of the third stage of labour. *Int J Gynaecol Obstet* 2004;87:1–5
40. Hofmeyr GJ, Walraven G, Gulmezoglu AM, *et al*. Misoprostol to treat postpartum haemorrhage: a systematic review. *Br J Obstet Gynaecol* 2005;112:547–53
41. Graham SG, Luxton MC. The requirement for intensive care support for the pregnant population. *Anaesthesia* 1989;44:581–4