Title: Monitoring severe acute maternal morbidity across Europe: a feasibility study

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Brief title: Severe maternal morbidity across Europe (39 characters including space

Ab**stract (250 words, max= 256words)**

Background: Given the current changes in obstetric practices and in mother profiles, monitoring severe acute maternal morbidity (SAMM) appears essential to optimize care and inform policies. International comparisons may provide useful information to identify national specificities and suggest areas for improvement. However, the comparability of indicators across countries should first be assessed.

Objective: To assess the feasibility of monitoring SAMM according to a common definition from hospital discharge databases across Europe.

Research design: We conducted a comparative study using hospital discharge data in eight European countries (3,000,000 deliveries). Women with SAMM were identified among all hospitalisations of women of reproductive age admitted for antenatal or delivery care. The rates of five SAMM indicators were calculated and variations were described across countries, and within countries by mode of delivery. The validity of results was assessed by comparisons with population-based studies.

Results: In a context of obstetric hemorrhage, the ratios across countries between the highest and lowest rates for hysterectomy and red blood cell (RBC) transfusion were respectively 1:2.1 and 1:3.5. Countries with high hysterectomy rates and low RBC transfusion rates also had the highest rates of maternal mortality from hemorrhage (France, Italy, Portugal). Ratios across countries were low for eclampsia (1:3.4) and high for septicaemia (1:22.5) with highest rates in the UK. Eclampsia was over-reported in hospital discharge databases whereas the two indicators of severe hemorrhage had good validity.

Conclusions: Monitoring some SAMM indicators from European hospital databases is feasible. In association with obstetric hemorrhage, hysterectomy and RBC transfusion appear to be good candidates for maternal morbidity surveillance.

Keywords: severe acute maternal morbidity, hospital discharge databases, Europe, maternal health surveillance, obstetric complications

Introduction

In recent decades, significant changes in maternal profiles and obstetric practices have justified the development of surveillance systems to assess their potential impact on maternal health and inform public health policies.[1-7] Maternal mortality is the traditional indicator of maternal health surveillance.[8] Nevertheless, given the scarcity and singularity of maternal deaths in high-resources countries, monitoring severe acute maternal morbidity (SAMM) increasingly appears as an important complementary activity. [9-14] However, implementation of SAMM monitoring presents several difficulties, including the lack of an international consensus on a definition and of evaluations of its availability and reliability in routine databases.[11, 14, 15] Indeed, routine hospital discharge databases have been extensively used for both surveillance and research purposes without prior assessment of the accuracy and reliability of their coding.

In Europe, the Euro-Peristat project attempted to collect indicators for surveillance of SAMM across countries [5, 6, 16]. In 2010, only 5 of the 29 member-states could provide all 5 proposed SAMM indicators, and the data collected showed questionably wide variations across countries.[5] These impediments contrasted with the consistency of indicators available for monitoring infant health and led participants to conclude that further development was needed before these indicators could serve as a comparable measure of SAMM.

Because international comparisons of health indicators are a preliminary step in identifying national specificities and thus generating research hypotheses to explain observed differences,[5, 6, 14, 16-18] the indicators must be measured consistently to avoid attributing to health differences between countries disparities that actually result from measurement differences.[14, 16, 19, 20] To date, there is no SAMM specific monitoring data at European level. Hospital discharge databases, available in most countries, offer the opportunity for such on-going monitoring since severe maternal complications, with rare exceptions, involve hospitalisation. Some countries already use this data source to study SAMM or some of its components, but each country uses its own criteria and codes, preventing rigorous

104 comparisons. [10, 21-23] Consistent with the CROWN Initiative, we support that maternal health
105 surveillance assessed in comparable permanent databases across countries should be based on a set of
106 common SAMM indicators. [24, 25]
107
108 Our general objective was to assess the feasibility of monitoring SAMM in Europe using hospital
109 discharge databases, according to a common definition. Our specific objectives were to: 1) describe
110 the available hospital discharge data for monitoring SAMM across countries, 2) develop a common
111 algorithm for monitoring SAMM, and 3) conduct a cross-country comparative study of SAMM on the
112 basis of the common algorithm and assess the accuracy of the results through an external validation.
113
114 **Methods**
115
116 ▪ ***Description of the hospital discharge data available for monitoring SAMM in each country***
117 The EURONET-SAMM group comprised researchers and public health professionals from 8 European
118 countries who had access to their national hospital discharge databases: Finland, France, Italy,
119 Portugal, Switzerland and three nations of the United Kingdom - England, Scotland and Wales.
120 Partners were asked to complete a questionnaire about the design and availability of hospital discharge
121 data in their country and more specifically on the classifications used for coding diagnoses and
122 procedures, the temporal and geographical coverage of the data collection and the possibility of linking
123 hospitalisations for the same patient.
124
125 ▪ ***Selection of SAMM indicators and development of a common algorithm***
126 The study partners selected SAMM indicators during a consensus meeting (Paris, April 2016). They
127 first agreed on the following principles: 1) selected SAMM indicators should focus on maternal
128 complications that are leading causes of maternal mortality and morbidity, 2) they should characterize
129 a severe complication and not a situation at risk of severe complication, 3) they should reflect the

health status of mothers rather than organization of care, 4) they should cover a morbidity occurring during a temporal window extending from pregnancy to the early postpartum period, 5) they should have a relatively uniform definition that was not conducive to various interpretations, 6) they could be translated into diagnostic or procedure codes, and finally 7) they should be monitored individually and not necessarily combined into one composite indicator.

Once the set of SAMM indicators was selected, the corresponding codes were sought in each country's specific diagnostic and procedure classifications. The meaning of each procedure code was examined to ensure only interventions characterising the selected SAMM indicator were chosen. A specific algorithm was designed for each country.

- ***Cross-country comparisons***

. *Data sources*

We used data from the hospital discharge databases that are national, permanent, considered exhaustive and provide anonymous and standardised information from the discharge abstracts of patient hospitalisations.

. *Study population and selection of abstracts*

For countries with at least 100 000 annual deliveries, we used data from the most recent year available. For countries with less than 100 000 annual deliveries, we used data from the three most recent years available. Data extraction was conducted in each country. From the national databases of each participant country, each country team extracted hospitalisations of reproductive aged women (12 to 55 years) that mentioned pregnancy or delivery. From this source population and using each country's diagnostic and procedure classifications (Table 1), hospitalisations including at least one code corresponding to the selected SAMM indicators were identified. To enable woman-based analyses, multiple abstracts from the same woman were linked. The linkage strategy was applied to each year separately for countries providing data for three consecutive years.

. *Statistical analyses*

Rates of SAMM indicators were calculated on linked datasets. For each SAMM indicator, the rate was calculated as the number of women who experienced the SAMM outcome divided by the total number of deliveries for the period. SAMM rates by mode of delivery (vaginal or cesarean delivery) were calculated among delivery stay abstracts separately for vaginal and cesarean deliveries. The eclampsia rate by mode of delivery was not included in this analysis since it cannot be considered a possible complication of mode of delivery.

To quantify variations across countries for each SAMM outcome, ratios between the lowest and highest rates were calculated by dividing the highest by the lowest rate (hereafter referred to as ratios across countries). To describe variations within countries according to the mode of delivery, ratios between SAMM rates by mode of delivery were calculated dividing the SAMM rate among cesarean deliveries by the SAMM rate among vaginal deliveries in each country (hereafter: ratios by mode of delivery). Aggregated results were sent by each partner and centralised for analysis.

Partners also provided rates of maternal mortality by obstetric hemorrhage for the closest time period as the group decided that these were to be presented concomitantly with the rates of hysterectomy for obstetric hemorrhage. For most partners, these rates came from enhanced surveillance systems for maternal mortality surveillance (France, Italy, United Kingdom).[26-29]

External validation was performed for countries where partners could provide data on SAMM from population-based studies. For France, data came from the PITHAGORE6 and EPIMOMS studies, two population-based studies conducted, in six regions covering one-fifth of French annual deliveries, on postpartum haemorrhage in 2005-06 and on SAMM in 2012-13 respectively [30-33] . Italy supplied results from the Italian Obstetric Surveillance System (ItOSS), a prospective population-based study on hemorrhagic SAMM conducted in 2014-16 in six regions covering half of Italian annual births.[34] Portugal provided results from a national survey of pregnancy-related hypertension conducted in public maternity hospitals in November 2005.[35] United Kingdom results came from the United Kingdom Obstetric Surveillance System (UKOSS), a national prospective rolling study of specific

obstetric disorders.[36, 37] Scotland supplied results from the Scottish confidential audit of severe maternal morbidity (SCASMM), a permanent system describing SAMM cases reported from all maternity units in Scotland between 2003 to 2012.[38]

Every partner had authorised access to their country's hospital discharge database and had appropriate permissions to send aggregated results to the group. Because we used aggregated data, this study was exempt from review by an ethics committee.

Results

The description of the available hospital discharge data for monitoring SAMM showed that most countries used the ICD-10 classification, with the exception or Italy and Portugal where ICD-9 was still used. On the contrary, the coding of procedures involved multiple specific classifications, one for each country (Table 1). The total number of deliveries included in the study was 2 826 868, varying from 91 431 over 3 years in Wales to 808 975 in 1 year in France. Years included were from 2012 to 2015.

The consensus meeting resulted in a list of 5 SAMM indicators: 2 diagnoses – eclampsia and septicaemia, and 3 procedures – hysterectomy, and two markers of severe obstetric hemorrhage – hysterectomy associated with obstetric hemorrhage, and red blood cell (RBC) transfusion associated with obstetric hemorrhage. To allow for appropriate interpretation, the indicator of hysterectomy associated with obstetric hemorrhage was provided concomitantly with the maternal mortality ratio from obstetric hemorrhage. Other indicators were discussed but not selected. An indicator of severe obstetric hemorrhage defined by conservative procedures such as embolization and/or surgery –vessel ligations and uterine compressive sutures- performed in a context of an obstetric hemorrhage was not selected because most country procedure classifications contained no available code for uterine

embolization or uterine compressive suture, and because the use of some of these procedures depends on the availability of technical resources. Venous thromboembolism was not selected as it was expected to often occur during the postpartum period and not only during the delivery stay, and its comprehensive study would then have required a linkage between delivery and re-hospitalizations abstracts, which was not possible in many partners' databases. The group also rejected ICU admission in the final list of SAMM indicators, on the grounds that cross-country comparisons would reflect differences in transfers and organization of care more than in maternal morbidity.

Diagnosis and procedure codes corresponding to SAMM indicators selected by the group were sought in each country's specific classifications resulting in the production of 5 different algorithms (Appendix lists the diagnosis and procedure codes for each SAMM indicator and each classification).

Cross-country comparisons showed variations in rates of all SAMM outcomes (Table 2). These variations were fairly small for hysterectomy associated with obstetric hemorrhage and for eclampsia (with ratios across countries of 1:2.1 and 1:3.4, respectively), whereas they were higher for septicaemia (ratio across countries 1:22.5). Switzerland and the UK nations had the highest rates for septicaemia. Finland and the UK nations reported the lowest rates of hysterectomy and of hysterectomy associated with an obstetric hemorrhage. Finland and Switzerland had the highest rates of RBC transfusion in that same context. Italy had the highest rates of both hysterectomy and hysterectomy associated with an obstetric hemorrhage. The countries reporting the highest rates of maternal deaths for obstetric hemorrhage were also those reporting the highest rates of hysterectomy for hemorrhage and the lowest rates of RBC transfusion (France, Italy, Portugal).

The analysis of SAMM indicators by mode of delivery showed higher rates for cesarean than vaginal deliveries for all SAMM indicators and for all countries. Variations across countries were wide in particular for septicaemia, with ratios across countries of 1:30.6 in vaginal deliveries and of 1:14.3 in

cesarean deliveries (Table 3). The low variation across countries in rates of hysterectomy associated with obstetric hemorrhage at cesarean delivery was an exception (ratio across countries of 1:2.0).

Finland and Italy had a particular position among the countries reporting high rates of septicaemia: their ratios for septicaemia rates in cesarean deliveries were more than 4 to 6 times greater than in vaginal deliveries, notably higher than in the other countries with ratios around 1:2 to 1:3. In France, similarly, the ratio by mode of delivery was around 1:3 for RBC transfusions and around 1:1.1 in the other countries.

The comparison with *ad hoc* population-based studies suggested an over-reporting for eclampsia in hospital discharge databases for most countries (ratios of up to 1:3.6) (Table 4). Conversely, rates of hysterectomies associated with obstetric hemorrhage differed little between hospital discharge databases and *ad hoc* population-based studies. External validation was not possible for sepsis because of the heterogeneity of definitions of severe sepsis used in the studies in each country.

Discussion

Main findings

This study in 8 European countries covered around three million deliveries and demonstrated that it is possible to monitor some SAMM indicators from European hospital discharge databases. Of the 5 indicators tested, two appear to be good candidates for international comparisons of SAMM: both hysterectomy and RBC transfusion, when associated with obstetric hemorrhage. Countries with high hysterectomy and low transfusion rates also had the highest rates of maternal mortality by hemorrhage (France, Italy and Portugal). The use of indicators of eclampsia and septicaemia from hospital discharge databases should be limited and interpreted with great prudence, in view of their questionable quality at this time.

Strengths and limitations

The EURONET-SAMM study is among the first to propose the use of indicators for SAMM surveillance covering several countries and yielding comparable measurements. Continuing the efforts of previous projects [5, 16], the group has succeeded in developing a 'core set of outcomes' to monitor maternal health. Thus, we have developed a common algorithm for SAMM, have applied it to the national databases of 8 countries, and then have constructed the linkages necessary to interpret the relevant health results based on women rather than hospitalisations. Finally, in comparison with most studies that use hospital discharge databases without prior assessment of the accuracy or reliability of their coding, external validation of the data is a valuable additional feature. This allows to determine which indicators can currently been considered valid for maternal health surveillance in Europe from hospital discharge databases, as well as those for which the quality of reporting in these databases requires improvement.

This work had several limitations. The utilization of hospital databases is complex and our choice, in particular, to work from linked data limited the participation of some countries that were interested in the project but either did not have access to these data or had not developed expertise in data linking. Although this methodological choice limited the number of participants, it appeared essential to ensure data comparability data between countries. Moreover, although the coding of the information contained in these databases is standardised, we could not really verify the quality of the reporting. Next, the choice to limit the study of SAMM to the period of the pregnancy and the delivery stay did not allow us to study all complications of the postpartum period (i.e., up to 42 days postnatal); this choice was, however, necessary because of the technical difficulties faced by some countries in selecting this 42-day period or in linking all the summaries of individual women readmitted after discharge from their delivery stay. Finally, the external validation stage was limited by the relatively

small number of population-based studies of maternal morbidity conducted in Europe and could not be used for septicaemia because definitions were not standardised in these studies.

Interpretation

The choice of the indicators selected for appropriate monitoring of SAMM was fully debated in the group. Obstetric hemorrhages account for a major portion of SAMM and must therefore be monitored by indicators that enable identification of all cases. Several composite indicators combining a diagnosis of obstetric hemorrhage with conservative procedures (embolization, and/or surgery –vessel ligations and uterine compressive sutures) were proposed but not retained, because codes for them were unavailable in the classifications of several countries. Likewise, venous thromboembolism (as a complication of the post-partum period) could not be retained because linkage between delivery and re-hospitalizations abstracts was not possible in many partners' databases. Two indicators were finally chosen: hysterectomy associated with an obstetric hemorrhage to characterize the most severe hemorrhages and RBC transfusion associated with an obstetric hemorrhage to characterize those slightly less severe. As an ultimate maternal rescue procedure, the hysterectomy indicator is particularly interesting because it represents the procedure least dependent on practices and their heterogeneity.

Results of these indicators showed that countries seem to have relatively harmonious practices for hysterectomies for obstetric hemorrhage during cesareans (ratio across countries 1:1.9), but not for those associated with vaginal deliveries (ratio 1:8.0). Other results showed that countries with high hysterectomy and low RBC transfusion rates (France, Italy, Portugal) also had the highest rates of maternal mortality attributable to hemorrhage. Although the aim of this study was not to determine causality or to judge the good or bad practices of each country, this finding raises the hypothesis to be confirmed of a possible excess of surgical procedures and a lack of medical resuscitation support. Our result finds on a large scale similar conclusions as Kayem *et al.*, who showed a higher hysterectomy rate for PPH in France than in the Netherlands, and those of Bonnet *et al.*, who showed inadequate

311 recourse to transfusion in PPH management in France.[31, 32, 39, 40] Several hypotheses may explain these
312 results: i) hemorrhages may be more severe from the outset in these countries, ii) women in these
313 countries may have more individual risk factors (BMI, age, etc.), iii) a more frequent use of some
314 interventions for labour and delivery management at potentially greater risk of PPH (induction or
315 augmentation of labour, episiotomy, cesarean)[41] iv) a less effective management of early PPH before
316 it becomes severe or, v) non-optimal second line strategies (for example, an excessive recourse to
317 embolization, which may delay management and aggravate the PPH),[32, 41] and a relatively rare use of
318 intrauterine tamponade. While the causes associated with higher rates of maternal mortality from
319 hemorrhage in some countries are probably multifactorial, comparisons between countries can help to
320 guide investigations of each of the above hypotheses.[18]
321
322 Our external study validation enabled us to conclude that two indicators are reliable and could be
323 continuously monitored: the severe hemorrhages characterized by a diagnosis of obstetric hemorrhage
324 and a hysterectomy, and the hemorrhages characterized by a diagnosis of obstetric hemorrhage
325 associated with a RBC transfusion. The reported rates of hysterectomy for obstetric hemorrhage in
326 hospital data are close to those reported in *ad hoc* population-based studies. Although this observation
327 covers only a small proportion of European countries, the conclusions of the external validation are
328 consistent with the literature, suggesting that our findings could be generalised. Indeed, procedures are
329 generally better coded than diagnoses and the more severe the complications are, the more reliable is
330 their coding.[42-45] Moreover, very encouraging results for the validation of individual data on
331 hysterectomies and transfusions have been reported.[21, 46, 47] In the future, and assuming the creation
332 of standardised and homogeneous coding across countries, other procedures used for the treatment of
333 severe obstetric hemorrhage, such as intrauterine tamponade or uterine compression sutures, may
334 constitute additional indicators of maternal morbidity in Europe.
335

Comparisons for the other indicators showed high rates of septicaemia for the UK nations and Switzerland. The study of the ratios by mode of delivery within countries revealed particularly specific results for Finland and Italy, which had septicaemia rates around 5 to 7 times higher after cesarean than vaginal deliveries, whereas this ratio was lower for the UK nations. Although the database did not allow us to determine if sepsis was the cause or consequence of these cesarean deliveries, these results nonetheless suggest an avenue for research to improve maternal health. External validation for the septicaemia indicator was not possible because definitions used in the population-based studies are much more severe and restrictive than in hospital databases. Indeed, the ICD codes used to code for maternal sepsis (O85 in ICD-10, for example) cannot distinguish infections from sepsis, since it is used simultaneously to code for a symptom as general as fever but also endometritis and peritonitis. Moreover, unlike for hemorrhage, there are no identified criteria for severity that can be measured in hospital databases to ensure only severe cases of sepsis are captured.

For eclampsia, the external validation study was possible and concluded that the over reporting of eclampsia is generalised and prevents its use as a valid SAMM indicator. Its Europe-wide surveillance thus does not currently appear useful. The over-reporting phenomenon of diagnoses has already been reported in the literature, in studies seeking to validate individual data in small samples;[47-52] this finding is reinforced here.

Finally, the group consensus was not to use the maternal ICU admissions indicator, agreeing that it reflects the organization of care and bed availability within each country more than the health status of mothers. In their Delphi consensus process, the International Network of Obstetric Surveillance Systems (INOSS, including 103 experts from 13 countries) also chose not to consider ICU as an indicator of maternal morbidity, in a research context.[14]

Our results suggest that new indicators can be considered for monitoring severe maternal morbidity in Europe from hospital discharge databases. Two indicators for severe obstetric hemorrhage –

362 hysterectomy and RBC transfusion associated with an obstetric hemorrhage – appear to be
363 immediately usable for comparisons between countries. Moreover, improvements to enlarge the set of
364 reliable indicators of severe maternal morbidity might concern: 1) the creation of procedure codes for
365 intrauterine tamponade or uterine compression sutures in classifications to characterize severe
366 hemorrhages more completely, 2) the proposal of a new ICD code for severe sepsis, and 3) the training
367 of staff involved in coding hospital discharge data to improve their accuracy and reliability.
368

Legend of figures and tables:

- Table 1: Classification used by each partner for coding diagnoses and procedures in hospital discharge databases and details on data used for the comparative study of SAMM in Europe.

- Table 2: Selected SAMM indicators, rates per 1,000 deliveries and ratios across countries

- Table 3: Selected SAMM indicators, rates per 1,000 deliveries by mode of delivery and ratios across countries and within countries

- Table 4: External validation – comparison between results from hospital discharge databases and available population-based studies for some partners.

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TABLE 1 Classification used in each country for coding diagnoses and procedures in national hospital discharge databases and details on data used for the comparative study of SAMM in Europe

			Data used for the comparative study of SAMM in Europe			
Partner	Classification used for diagnoses	Classification used for procedures	Number of years considered	Years considered	Coverage	Total of deliveries in the considered period
Finland	ICD-10	NCSP	3	2012-2014	National	173 786
France	ICD-10	CCAM	1	2014	National	808 975
Italy	ICD-9	ICD-9-CM (2007 version)	1	2015	National	478 936
Portugal	ICD-9	ICD-9-CM	3	2013-2015	National (public hospitals only)	196 974
Switzerland	ICD-10	CHOP	3	2012-2014	National	247 329
England	ICD-10	OPCS-IV	1	2013	National	664 517
Scotland	ICD-10	OPCS-IV	3	2012-2014	National	164 920
Wales	ICD-10	OPCS-IV	3	2013-2015	National	91 431
Total						2 826 868

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TABLE 2 Selected SAMM indicators [a], rates per 1000 deliveries and ratios across countries [b]

Total of deliveries in the year(s)considered	[min-max] rates	Finland		France		Italy		Portugal		Switzerland		England		Scotland		Wales	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
		173 786		808 975		478 936		196 974		247 329		664 517		164 920		91 431	
Eclampsia	[0.29-0.98] ratio 1:3.4	57	(0.3)	553	(0.7)	269	(0.6)	57	(0.3)	132	(0.5)	393	(0.6)	155	(0.9)	90	(1.0)
Septicaemia	[0.48-10.81] ratio 1:22.5	379	(2.2)	1976	(2.4)	230	(0.5)	430	(2.2)	1236	(5.0)	3386	(5.1)	1126	(6.8)	988	(10.8)
Hysterectomy	[0.36-1.12] ratio 1:3.1	77	(0.4)	543	(0.7)	535	(1.1)	175	(0.9)	210	(0.8)	238	(0.4)	90	(0.5)	39	(0.4)
Hysterectomy associated with obstetric haemorrhage	[0.28-0.59] ratio 1:2.1	53	(0.3)	381	(0.5)	284	(0.6)	101	(0.5)	144	(0.6)	187	(0.3)	64	(0.4)	27	(0.3)
RBC transfusion associated with obstetric haemorrhage	[3.74-13.13] ratio 1:3.5	2.282	(13.1)	3550	(4.4)	1791	(3.7)	921	(4.7)	2406	(9.7)	NA	NA	NA	NA	NA	NA
Maternal death due to obstetric haemorrhage [/100,000 deliveries]		0	[0.0]	29	[1.2]	57	[2.0]	13	[1.7]	6	[0.8]	13[c]	[0.6]				
Time period covered		2012	2014	2010	2012	2006	2012	2006	2015	2005	2014	2012	2014				
Number of deliveries for the period considered		173 786		2 477 240		2 852 674		766 016		775 365		2 341 745					

Abbreviation: NA, if not available.

[a]Among pregnancy and delivery stays in hospital discharge databases.

[b]Ratio across countries was calculated for each SAMM indicator as the highest rate divided by the lowest rate among all countries.

[c]Total of maternal deaths for obstetric haemorrhage for United Kingdom including: England, Northern Ireland, Scotland and Wales.

TABLE 3 Selected SAMM indicators [a], rates per 1,000 deliveries by mode of delivery and ratios across [b] and within countries [c]

Total of deliveries in the year(s)considered			Finland[d]		France[e]		Italy		Portugal		Switzerland		England		Scotland		Wales	
Vaginal			145 550		645 311		307 617		140 198		164 576		493 271		116 958		67 004	
Caesarean	[min-max] rates	Ratios across countries	28 236		160 300		173 319		56 776		82 753		171 246		47 962		24 425	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Septicaemia																		
Vaginal delivery	[0.18-5.51]	1:30.6	165	(1.1)	726	(1.1)	56	(0.2)	241	(1.7)	288	(1.7)	802	(1.6)	315	(2.7)	369	(5.5)
Cesarean delivery	[0.87-12.45]	1:14.3	213	(7.5)	420	(2.6)	151	(0.9)	173	(3.0)	367	(4.4)	891	(5.2)	371	(7.7)	304	(12.4)
Ratio			1:6.7		1:2.3		1:4.8		1:1.8		1:2.5		1:3.2		1:2.9		1:2.3	
Hysterectomy																		
Vaginal delivery	[0.03-0.31]	1:10.3	29	(0.2)	103	(0.2)	74	(0.2)	44	(0.3)	27	(0.2)	36	(0.07)	10	(0.1)	2	(0.0)
Cesarean delivery	[0.93-2.19]	1:2.4	48	(1.7)	295	(1.8)	380	(2.2)	93	(1.6)	120	(1.4)	159	(0.9)	47	(0.1)	26	(1.1)
Ratio			1:8.5		1:11.5		1:9.1		1:5.3		1:9.1		1:13.3		1:10.9		1:35.3	
Hysterectomy associated with obstetric haemorrhage																		
Vaginal delivery	[0.03-0.26]	1:8.7	20	(0.1)	97	(0.1)	55	(0.2)	36	(0.3)	26	(0.2)	25	(0.0)	8	(0.1)	2	(0.0)
Cesarean delivery	[0.78-1.54]	1:2.0	33	(1.2)	247	(1.5)	234	(1.3)	61	(1.1)	98	(1.2)	150	(0.9)	44	(0.9)	19	(0.8)
Ratio			1:8.4		1:10.3		1:7.5		1:4.1		1:7.4		1:17.6		1:13.1		1:26.0	
RBC transfusion associated with obstetric haemorrhage																		
Vaginal delivery	[3.04-12.55]	1:4.1	1826	(12.5)	1962	(3.0)	1193	(3.9)	554	(3.9)	1420	(8.6)	NA	NA	NA	NA	NA	NA
Cesarean delivery	[3.44-13.81]	1:4.0	390	(13.8)	1426	(8.9)	597	(3.4)	336	(5.9)	760	(9.2)	NA	NA	NA	NA	NA	NA
Ratio			1:1.1		1:2.9		1:0.9		1:1.5		1:1.1							

Abbreviation: NA, if not available.

[a]Among delivery stays

[b]Ratio across countries was calculated for each SAMM indicator as the highest rate divided by the lowest rate among all countries.

[c]Ratio by mode of delivery was calculated for each country and each SAMM indicator as the rate among caesarean deliveries divided by the rate among vaginal deliveries.

[d]For Finland, information was not available for 41 women (women without valid ID number for linkage with the medical birth register).

[e]For France, information about the route of delivery is missing for 3364 deliveries (0.4%).

TABLE 4 External validation of SAMM rates—comparison of results from hospital discharge databases and available population studies

	France			Italy		Portugal		England		Scotland			Wales	
	Hospital data (2014)	Epimoms study[a] (2012-2013)	Pithagore6 study[b] (2005-2006)	Hospital data (2015)	ItOSS survey (2014-2016)[c]	Hospital data (2013-2015)	National study (1 month in 2005)[d]	Hospital data (2013)	UKOSS survey[e]	Hospital data (2012-2014)	SCASMM audit (2003-2012)[f]	UKOSS survey[e]	Hospital data (2013-2015)	UKOSS survey[e]
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Total of deliveries in the year(s) considered	808 975	182 309	146 781	478 936	474 562	196 974	6726	664 517	≈780 000/ year	164 920	571 083	≈780 000/ year	91 431	≈780 000/ year
Eclampsia	(0.7)	(0.3)	/	(0.6)	/	(0.3)	(0.7)	(0.6)	(0.3)§	(0.9)	(0.3)	(0.3)§	(1.0)	(0.3)§
Septicaemia	(2.4)	/	/	(0.5)	/	(2.2)	/	(5.1)	/	(6.8)		/	(10.8)	/
Hysterectomy	(0.7)	/	/	(1.1)	(1.1)[g]	(0.9)	/	(0.4)	(0.4)	(0.5)		(0.4)	(0.4)	(0.4)
Hysterectomy associated with obstetric haemorrhage	(0.5)	(0.5)	(0.5)[h]	(0.6)	/	(0.5)	/	(0.3)	(0.4)[h]	(0.4)	(0.4)	(0.4)[h]	(0.3)	(0.4)[h]
RBC transfusion associated with obstetric haemorrhage	(4.4)	/	(4.4)[h]	(3.7)	/	(4.7)	/		/			/	/	/

[a]Epimoms study = prospective population-based study on SAMM in 2012-13, conducted in six regions and covering a fifth of French annual deliveries.
[b]Pithagore6 study = population-based study on postpartum haemorrhage conducted in 2005-2006 in six regions and covering one-fifth of French annual deliveries.
[c]ItOSS=Italian Obstetric Surveillance System, a prospective population-based study on hemorrhagic SAMM conducted in 2014-16 in six regions covering half of Italian annual births.
[d]National survey of pregnancy-related hypertension conducted in all public maternity hospitals in November 2005.
[e]UKOSS= United Kingdom Obstetric Surveillance System, a national prospective rolling study of specific rare obstetric disorders.
[f]SCASMM= Scottish confidential audit of severe maternal morbidity, a permanent system describing SAMM cases reported from all maternity units in Scotland between 2003 and 2012.
[g]corresponds to peripartum hysterectomy.
[h]data from 2005 to 2006

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