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2

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4 Monitoring severe acute maternal morbidity across Europe: a feasibility study.

5

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50

51

52

53 **Abstract (250 words, max= 256words)**

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

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

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

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

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

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

78 **Introduction**

79

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

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

96 Because international comparisons of health indicators are a preliminary step in identifying national
97 specificities and thus generating research hypotheses to explain observed differences,^(5, 6, 14, 16-18) the
98 indicators must be measured consistently to avoid attributing to health differences between countries
99 disparities that actually result from measurement differences.^(14, 16, 19, 20) To date, there is no SAMM
100 specific monitoring data at European level. Hospital discharge databases, available in most countries,
101 offer the opportunity for such on-going monitoring since severe maternal complications, with rare
102 exceptions, involve hospitalisation. Some countries already use this data source to study SAMM or
103 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

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

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

139

140 ▪ *Cross-country comparisons*

141 . *Data sources*

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

145 . *Study population and selection of abstracts*

146 For countries with at least 100 000 annual deliveries, we used data from the most recent year available.
147 For countries with less than 100 000 annual deliveries, we used data from the three most recent years
148 available. Data extraction was conducted in each country. From the national databases of each
149 participant country, each country team extracted hospitalisations of reproductive aged women (12 to
150 55 years) that mentioned pregnancy or delivery. From this source population and using each country's
151 diagnostic and procedure classifications (Table 1), hospitalisations including at least one code
152 corresponding to the selected SAMM indicators were identified. To enable woman-based analyses,
153 multiple abstracts from the same woman were linked. The linkage strategy was applied to each year
154 separately for countries providing data for three consecutive years.

155 . *Statistical analyses*

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

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

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

172

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

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

185

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

189

190 **Results**

191

192 The description of the available hospital discharge data for monitoring SAMM showed that most
193 countries used the ICD-10 classification, with the exception of Italy and Portugal where ICD-9 was
194 still used. On the contrary, the coding of procedures involved multiple specific classifications, one for
195 each country (Table 1). The total number of deliveries included in the study was 2 826 868, varying
196 from 91 431 over 3 years in Wales to 808 975 in 1 year in France. Years included were from 2012 to
197 2015.

198

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

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

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

218

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

229

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

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

235

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

241

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

247

248

249 **Discussion**

250 ***Main findings***

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

259

260 *Strengths and limitations*

261

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

273

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

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

287

288 ***Interpretation***

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

302 Results of these indicators showed that countries seem to have relatively harmonious practices for
303 hysterectomies for obstetric hemorrhage during cesareans (ratio across countries 1:1.9), but not for
304 those associated with vaginal deliveries (ratio 1:8.0). Other results showed that countries with high
305 hysterectomy and low RBC transfusion rates (France, Italy, Portugal) also had the highest rates of
306 maternal mortality attributable to hemorrhage. Although the aim of this study was not to determine
307 causality or to judge the good or bad practices of each country, this finding raises the hypothesis to be
308 confirmed of a possible excess of surgical procedures and a lack of medical resuscitation support. Our
309 result finds on a large scale similar conclusions as Kayem *et al.*, who showed a higher hysterectomy
310 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

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

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

353

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

359

360 Our results suggest that new indicators can be considered for monitoring severe maternal morbidity in
361 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

369 **Legend of figures and tables:**

370

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

373

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

375

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

378

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

381

382

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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

Partner	Classification used for diagnoses	Classification used for procedures	Data used for the comparative study of SAMM in Europe			
			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

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.

^aAmong pregnancy and delivery stays in hospital discharge databases.

^bRatio across countries was calculated for each SAMM indicator as the highest rate divided by the lowest rate among all countries.

^cTotal 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	
			28 236		160 300		173 319		56 776		82 753		171 246		47 962		24 425	
Caesarean	[min-max] rates	Ratios across countries	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.

^aAmong delivery stays^bRatio across countries was calculated for each SAMM indicator as the highest rate divided by the lowest rate among all countries.^cRatio 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.^dFor Finland, information was not available for 41 women (women without valid ID number for linkage with the medical birth register).^eFor France, information about the route of delivery is missing for 3364 deliveries (0.4%).

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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) ^h	(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)	/	/	/			/	/	/

^aEpimoms study = prospective population-based study on SAMM in 2012-13, conducted in six regions and covering a fifth of French annual deliveries.

^bPithagore6 study = population-based study on postpartum haemorrhage conducted in 2005-2006 in six regions and covering one-fifth of French annual deliveries.

^cItOSS=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.

^dNational survey of pregnancy-related hypertension conducted in all public maternity hospitals in November 2005.

^eUKOSS= United Kingdom Obstetric Surveillance System, a national prospective rolling study of specific rare obstetric disorders.

^fSCASMM= Scottish confidential audit of severe maternal morbidity, a permanent system describing SAMM cases reported from all maternity units in Scotland between 2003 and 2012.

^gcorresponds to peripartum hysterectomy.

^hdata from 2005 to 2006