



**HAL**  
open science

## Understanding regional differences in maternal mortality: a national case-control study in France.

Monica Saucedo, Catherine Deneux-Tharaux, Marie-Hélène Bouvier-Colle

### ► To cite this version:

Monica Saucedo, Catherine Deneux-Tharaux, Marie-Hélène Bouvier-Colle. Understanding regional differences in maternal mortality: a national case-control study in France.: Geographic disparities in maternal mortality. *BJOG: An International Journal of Obstetrics and Gynaecology*, 2012, 119 (5), pp.573-81. 10.1111/j.1471-0528.2011.03220.x . inserm-00661028

**HAL Id: inserm-00661028**

**<https://inserm.hal.science/inserm-00661028>**

Submitted on 13 Dec 2012

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1 **1.-Title page**

2 Understanding regional differences in maternal mortality: A national case-  
3 control study in France.

4

5 **Authors**

6 Monica Saucedo<sup>a</sup>, Catherine Deneux-Tharaux<sup>a</sup> and Marie-Hélène Bouvier-Colle<sup>a</sup>.

7

8 **Affiliations**

9 <sup>a</sup>INSERM, UMR S953, Epidemiological Research Unit on Perinatal Health and Women's  
10 and Children's Health, UPMC University Paris 06, Paris, France

11

12 **Corresponding author:**

13 Monica Saucedo, INSERM U953, Hôpital Saint Vincent de Paul, Bâtiment Lelong, porte 5.  
14 82, avenue Denfert-Rochereau. 75014 Paris, France.

15 Tél: +33 (0) 142345576

16 Email: Monica.saucedo@inserm.fr

17

18 Running title: Geographic disparities in maternal mortality

19 **2. Abstract**

20 Objectives: to assess the risk of postpartum maternal death associated with region, and to  
21 examine whether the quality of care received by the women who died differed by region.

22 Design: A national case-control study

23 Setting: France

24 Population: selected from recent nationwide surveys, 328 postpartum maternal deaths from  
25 2001 through 2006 as cases; and a representative sample (n=14,878) of women who gave  
26 birth in 2003 as controls.

27 Methods: Crude and adjusted odd ratios of maternal death associated with region were  
28 calculated with logistic regression, and the quality of care for cases was compared according  
29 to region with chi-square tests or Fisher's exact tests.

30 Main outcome measures: Risk of postpartum maternal death associated with region, and  
31 quality of care.

32 Results: After adjustment for maternal age and nationality, the risk of maternal death was  
33 higher in Ile-de-France region (aOR1.6; 95% CI: 1.2, 2.0) and the overseas districts (aOR3.5;  
34 95% CI: 2.4, 5.0) than in the rest of continental France group. In both regions, the excess risk  
35 of death from haemorrhage, amniotic fluid embolism and hypertensive disorders was  
36 significant. In continental France, after further controlling for women's obstetric  
37 characteristics, the risk of maternal death in Ile-de-France remained higher (aOR1.8; 95%CI:  
38 1.3, 2.6). The cases received suboptimal care more frequently in Ile-de-France than in the rest  
39 of continental regions (64% versus 43%, p=0.01).

40 Conclusions: These results suggest that quality of care and organization of health services  
41 may play a role in the differential risk of maternal mortality between regions in France.  
42 Research on severe maternal morbidity and its determinants is needed to clarify the  
43 mechanisms involved.

44 **Keywords:** case-control study, maternal mortality, regional disparities, substandard care.

45

### 46 **3. Main body of text**

#### 47 **Introduction**

48 Maternal mortality (MM) remains the principal indicator of maternal health, a simultaneous  
49 marker of the quality of and access to care [1-4]. The last report from the French National  
50 Confidential Enquiry into Maternal Deaths (ENCMM) covered the 2001-2006 period and  
51 showed a global maternal mortality ratio (MMR) of 9.6 deaths per 100,000 live births [5].  
52 Although similar to MMRs in other high-resource countries with an enhanced surveillance  
53 system [6, 7], this ratio can probably be reduced still further. One approach to this goal is to  
54 identify the subgroups of women at increased risk and develop preventive strategies for them.  
55 Results in several countries show an association between some individual characteristics, such  
56 as advanced age or foreign nationality or geographic origin, and a higher risk of maternal  
57 death [8-10]. The implications of these findings in terms of prevention nonetheless remain  
58 unclear.

59 Geographic disparities in MM within the same country are potentially informative but have  
60 been studied less [11, 12]. Of the 27 administrative French regions, risk of MM is reported to  
61 be highest in the Ile-de-France region (Paris and its suburbs) and in the overseas districts  
62 (DOM: French Guyana, Reunion, Guadeloupe and Martinique) than in the rest of continental  
63 France, and this excess risk persists after standardization for maternal age [11]. These 2  
64 regions account for 42% of the maternal deaths in France (28% in Ile-de-France and 14% in  
65 the DOM), although they account for only 26% of live births (22% in Ile-de-France and 4% in  
66 the DOM) [Figure 1]. The reasons for this excess MM remain controversial. Such disparities  
67 can result from differences in the women's characteristics but also from heterogeneity in the  
68 organization and quality of care.

69 Although policies governing the organization of health care and clinical guidelines are  
70 defined at a national level in France, they are implemented regionally. Understanding the

71 mechanisms of geographic disparities may help to design customized regional policies  
72 focused on specific subgroups and/or modes of health-service organization.

73 Our objectives were to test the hypothesis that the risk of postpartum maternal death in France  
74 remains significantly higher in the Ile-de-France region and the DOM, taking the individual  
75 characteristics of women into account and to determine if the quality of care received by the  
76 women who died differed according to their region of delivery.

77

## 78 **Methods**

79 This study used a case-control design, with both cases and controls selected from recent  
80 nationwide surveys.

81

### 82 **Population**

83 **Cases:** Women who died were selected from the ENCMM [5], conducted in France since  
84 1996 and specifically from those who died during the 2001-2006 period. This permanent  
85 survey system follows the International Classification of Diseases in defining maternal death  
86 (ICD-10th revision) [13] as “the death of a woman while pregnant or within 42 days of  
87 termination of pregnancy, irrespective of the duration and site of the pregnancy, from any  
88 cause related to or aggravated by pregnancy or its management but not from accidental or  
89 incidental causes.” Deaths with any mention of pregnancy or birth or puerperium, or for  
90 which the pregnancy tick box is marked, on review of the death certificate’s content are  
91 selected by the national center of statistics for medical causes of death (CépiDc) and reported  
92 to the ENCMM. A team of assessors (an obstetrician and an anaesthetist) conducts a  
93 confidential enquiry of each death that occurred in the context of a current or recent  
94 pregnancy. The assessors use a standardized detailed medical questionnaire to collect the  
95 relevant clinical information related to the woman and her death through interviews and a  
96 review of hospital records and autopsy reports. Given the non-participation of some local

97 clinicians, the confidential enquiry is completed and deaths fully documented in only three  
98 quarters of maternal deaths identified by the ENCMM. Deaths are then anonymously  
99 reviewed by the National Committee of Experts [5], who make a unanimous determination  
100 about the underlying cause of death (whether the death is a maternal death, either direct or  
101 indirect, according to the ICD definition), its avoidability (certainly, perhaps, or cannot be  
102 determined) and the reasons for avoidability (one or more of these reasons: delay in treatment,  
103 missed diagnosis, inadequate or insufficient treatment, medical error or patient negligence),  
104 and the global quality of medical and obstetric care (not optimal, optimal or cannot be  
105 determined) [5]. The surveillance system identified 463 maternal deaths for the 6-year study  
106 period considered here. Specifically, this study included the postpartum maternal deaths from  
107 that period associated with birth at a gestational age of 22 weeks or more (still- or live births),  
108 for consistency with the definition of the controls (*see below*). To avoid possible referral bias,  
109 we excluded women who died outside their region of residence. The study population of  
110 women who died during the postpartum period therefore included 328 cases [figure 2].

111 Controls: The control women came from the 2003 French National Perinatal Survey (NPS), a  
112 national representative sample of births in France (n=15,108). NPS are repeated cross-  
113 sectional studies intended to monitor trends in perinatal health indicators and medical  
114 practices. They cover all births (live births and stillbirths) occurring during 1 week in France  
115 if they are at a gestational age of 22 weeks or more or weighing at least 500 g. The precise  
116 methodology of the 2003 survey has been described elsewhere [14, 15]. Data were collected  
117 through interviews with the mother and from medical records. The comparison group for our  
118 case-control study thus included women who participated in the 2003 National Perinatal  
119 Survey (because it fell in the middle of the 2001–2006 time window for case inclusion) who  
120 delivered in their region of residence, for consistency with the definition of the cases. The  
121 control sample therefore included 14,878 women [figure 2].

122 Study variables

123 The primary predictor variable of interest was the region — the region of delivery for the  
124 controls and the region of death for the cases. Regions were classified in three groups: the  
125 DOM, Ile-de-France, and other continental regions as the reference group. The following  
126 socio-demographic variables examined as potential confounders were the mother's age,  
127 nationality, work status and marital status. These data were collected from the interviews of  
128 control subjects and from the death certificates for the cases.

129 We collected the following obstetric characteristics for cases and controls: parity, mode of  
130 delivery, multiple birth, and variables considered as markers of preexisting morbidity, i.e.,  
131 hypertensive disorders during pregnancy, hospitalization during pregnancy, induction of  
132 labor, emergency cesarean delivery, and preterm delivery. These data came from the medical  
133 records for the controls and from the confidential enquiry for the cases reviewed by the  
134 National Committee of Experts. Because the proportion of missing data for these clinical  
135 variables was so high in the maternal deaths from the DOM (50%, n=21), they were only  
136 analyzed for women from continental France.

137

138 Analyses

139 To test the hypothesis of an excess risk of postpartum maternal death among women from Ile-  
140 de-France and the DOM, we used different multivariate logistic regression models. A first  
141 model was adjusted for the relevant socio-demographic characteristics in all women and crude  
142 and adjusted odds ratios associated with region were assessed, overall and for cause-specific  
143 postpartum MM. A second logistic regression analysis included socio-demographic and  
144 relevant obstetric characteristics and was conducted only in women from IDF and the rest of  
145 continental France; among obstetrics characteristics, hypertension during pregnancy and  
146 induced labor were not included in the multivariate model because of significantly different

147 missing-value rates for cases between regions. The same analysis was conducted in the  
148 subgroup of women from continental France with a singleton term delivery (gestational age  
149  $\geq 37$  weeks), to eliminate possible residual confounding related to pre-existing morbidity  
150 The last part of the analysis was restricted to the women who died. In this group, we  
151 compared quality of care received, avoidability of death and reasons for avoidability,  
152 according to geographic region. Again, because of the proportion of missing data for women  
153 who died in the DOM, this analysis was limited to the cases from continental France.  
154 Proportions were compared with chi-square tests or, when appropriate, Fisher's exact tests.  
155 The level of statistical significance was .05. Statistical analysis was performed with STATA  
156 10 software (StataCorp., LP, College Station, TX, USA).

157

## 158 **Results**

159 Characteristics of cases and controls are shown in Table 1. They differed significantly for the  
160 distribution of geographic region: there were more women in the DOM among the cases than  
161 controls (12.8% compared with 4.1%). Women in Ile-de-France were also overrepresented  
162 among the women who died (29.9% compared with 21.3%,  $p < 0.001$ ). Compared with  
163 controls, cases were significantly older and more often of foreign nationality. Among cases  
164 from continental France, clinical information obtained through the enquiry was available for  
165 74.8% (N=214). Compared with controls, cases were more likely to be multiparous, to have  
166 been hospitalized during pregnancy and to have had a hypertensive disorder during  
167 pregnancy. The proportions of induced labor, emergency cesarean deliveries, and preterm  
168 deliveries were all significantly higher among cases than controls (Table 1).

169 The risk of postpartum maternal death was 4 times higher for women from the DOM and 1.8  
170 times higher for those from Ile-de-France, compared with the rest of continental France. After

171 taking age and nationality into account, the adjusted odds ratio (aOR) was 3.5 (95% CI: 2.4,  
172 5.0) for the DOM and 1.6 (95% CI: 1.2, 2.0) for Ile-de-France (Table 2).

173 Figure 3 shows the distribution of causes of death among the cases, according to region.  
174 Haemorrhage was the most important cause of MM in both the DOM (40.5%) and Ile-de-  
175 France (34.7%), whereas indirect causes were the leading cause in rest of continental France  
176 (34.0%). Further analysis of the risk for cause-specific MM associated with region showed,  
177 after adjustment for age and nationality, that the risk of mortality from all main causes of  
178 direct maternal death was significantly higher in Ile-de-France and the DOM (Table 2). The  
179 risk of death from hypertensive disorders and haemorrhage was 5.6 and 6.5 times higher,  
180 respectively, in the DOM and 2.7 and 2.3 times higher in Ile-de-France, compared with  
181 women in the rest of continental France (Table 2). The risk of maternal death from indirect  
182 obstetric causes did not differ significantly by regions.

183 After adjustment for socio-demographic and obstetric factors (parity, hospitalization during  
184 pregnancy and emergency cesarean), women in Ile-de-France had a higher risk of postpartum  
185 maternal death (aOR 1.8; 95% CI: 1.3, 2.6) than women in other continental regions (Table  
186 3). The analysis by specific cause of death showed that the risk of postpartum death from  
187 haemorrhage was higher in Ile-de-France than in the rest of continental France (aOR 2.2, 95%  
188 CI: 1.2, 4.0). After excluding multiple and preterm deliveries, we repeated this analysis and  
189 obtained similar results (Table 3).

190 The National Expert Committee concluded that among the women who died (all causes  
191 included) women in the Ile-de-France received non-optimal care (64.8%) more often than  
192 those from the rest of continental France (43.4%,  $p = .01$ ). Similarly, maternal deaths were  
193 avoidable more often in Ile-de-France (45.1%) than elsewhere in continental France (35.0%),  
194 although this difference was not statistically significant (Table 4).

195 Moreover, among the avoidable deaths, the reasons differed between Ile-de-France and the  
196 rest of continental France. Avoidability was related to “delay in treatment” more often in Ile-  
197 de-France (37.5%) than in the other continental regions (26.5%). “Inadequate or insufficient  
198 treatment” was the least frequent reason for avoidable maternal deaths in Ile-de-France (6.3%)  
199 and the leading reason (28.6%) elsewhere (Table 4). However, these differences were not  
200 statistically significant.

201

## 202 **Discussion**

203 The risk of postpartum maternal death is clearly higher for women in Ile-de-France and in the  
204 DOM (French Guyana, Guadeloupe, Martinique and Ile de la Reunion) than in the other  
205 regions of continental France. The excess MM in these regions was especially high for direct  
206 obstetric causes, that is, haemorrhages, pregnancy-related hypertension and amniotic fluid  
207 embolisms, and, for the DOM, thromboembolisms as well. In addition, we observed  
208 differences in the quality of care for the women who died between Ile-de-France and the rest  
209 of continental France; unfortunately this analysis could not be performed in the DOM.

210 These results, suggesting mechanisms of MM that have not been explored until now, must  
211 nonetheless be considered cautiously in view of the study's limitations.

212 The number of maternal deaths is small and generally limits our statistical power. This is one  
213 of the reasons that we chose a geographic division into three broad areas. These areas are not  
214 homogeneous in terms of demographic, geographic and economic characteristics. Ile de  
215 France, the highly urbanized region around the capital, and the DOM located in tropical and  
216 subtropical areas, each have a specific profile. The other regions of continental France are  
217 diverse, to the point that combining them creates a sort of national average. Nonetheless, the  
218 legislation and regulations, especially related to health and health care, are common to the  
219 entire country. Clinical information could not be collected for 25% of the potentially

220 postpartum maternal deaths identified by the ENCMM, because the local clinicians did not  
221 participate. The only available data were thus those on the death certificate. These deaths  
222 therefore could not be included in the analyses involving either the women's obstetric  
223 characteristics or the quality of their care. Nonetheless, this would induce bias only if the  
224 deaths that could not be investigated differed in nature from the deaths for which information  
225 could be collected, or if they were distributed differently between Ile-de-France and the rest of  
226 continental France. The distribution by region of uninvestigated cases did not differ from that  
227 of the cases that were studied. Moreover, the women's age, and nationality did not differ  
228 between the 2 groups, nor did the distribution of the causes of death (results not shown).  
229 Accordingly, the cases studied provide an acceptable sample that accurately reflects all the  
230 maternal deaths.

231 The limited number of individual covariables, in particular socio-economic characteristics,  
232 included in the analysis is also a limitation. Nonetheless two important known risk factors —  
233 age, which is a primordial factor in terms of risk of death, and nationality — could be  
234 considered for all the women [8-10, 16].

235 The clinical characteristics (parity, hospitalization during pregnancy, and emergency  
236 cesarean) are not especially refined, but they can be considered as a proxy for the mother's  
237 health status, during pregnancy and, to some extent, at delivery. Residual confounding cannot  
238 be excluded, in particular educational level, income [17], obesity [18], or inadequacy of  
239 prenatal care [19]. The regional environment, in particular the socio-economic context, such  
240 as the *deprivation index* [20], working and commuting conditions, especially transportation to  
241 the different health-care facilities where women might be seen according to their health status,  
242 have not been studied because this type of information was not available. A different study  
243 protocol would be required to take them into account.

244 We will discuss Ile-de-France and the DOM separately.

245 The maternal age in Ile-de-France, higher on average than in the rest of France did not explain  
246 the excess MM - older women being at higher risk of dying [10, 16, 21]- nor did the higher  
247 proportion of women from foreign countries, principally sub-Saharan Africa [8, 22], in this  
248 region. The persistence of excess postpartum mortality, after adjustment for relevant clinical  
249 characteristics, suggests that this is not explained by the prevalence of obstetrical  
250 complications; in addition, though the attractive effect of Ile-de-France medicalization does  
251 exist, our study population included only women who gave birth in their region of residence  
252 to exclude *referral bias*.

253 The heterogeneity between regions in the quality of care provided by the healthcare system is  
254 another explanation of the regional variations in MM. This hypothesis is especially interesting  
255 in that the causes of death for which there is a significant excess risk in Ile de France are  
256 direct obstetric causes, in particular postpartum haemorrhages and complications of  
257 pregnancy-related hypertension.

258 The experts' judgment about the quality of care, based on a meticulous reconstruction of each  
259 maternal death, shows that suboptimal care was more frequent in Ile-de-France than in the  
260 other regions of continental France. This result might seem paradoxical, given the high  
261 density in this region of specialized centers offering a very high level of care and especially  
262 the significantly higher proportion of level 3 maternity units [14]. It appears to contradict the  
263 results of a US study that showed that the density of such specialized centers was significantly  
264 and inversely associated with the MM rate [12]. This result must not be immediately  
265 interpreted as a demonstration of poor performance by the obstetric care system, it must be  
266 considered only as a warning signal of possibly inadequate care.

267 For a more complete judgment, we would need to know how all severe complications were  
268 handled by the system. Only a prospective population-based study of severe maternal  
269 morbidity can provide such a judgment. The data from our study about the reasons for

270 suboptimal care provide markers extremely useful in designing such a study. The fact that  
271 "delay in intervention" and "missed diagnosis" were more frequent among the maternal deaths  
272 considered avoidable in Ile-de-France, where the highest excess risk is for death from  
273 complications of hypertension and then from postpartum haemorrhages suggests that a  
274 detailed study of the following factors would be useful: the role of interhospital transfers,  
275 flaws in the continuity of care, potential work overloads or inadequate staffing, or both, as  
276 well as the possibility that patients may be negligent in seeking care or complying with  
277 prescriptions or other doctors' orders. Delays in care may be especially important for these  
278 causes, for which serious complications could be either prevented or treated more rapidly  
279 [23].

280 Insufficient data from the DOM prevented us from advancing far in the analysis of excess  
281 maternal deaths, whether related to the women's clinical characteristics or the quality of care.  
282 It is still more regrettable that we were unable to study these aspects for the DOM, for the  
283 women in these districts are more often multiparous, have fewer prenatal visits and are  
284 hospitalized more often during pregnancy [14]. Nonetheless, this first result that maternal  
285 mortality excess in the DOM is not explained by maternal age or nationality attracts attention  
286 to this population and will help to develop studies focused more directly on the local  
287 determinants. Such studies are all the more necessary in that our results are consistent with the  
288 results of other studies of reproductive health, which show a poorer health status globally  
289 throughout the DOM [24].

290

## 291 **Conclusion**

292 Regional differences in maternal mortality in France are not explained by individual  
293 characteristics in this study. Although we cannot exclude the implication of socio-economic  
294 factors that were incompletely characterized, this analysis suggests that disparities exist in the

295 provision of care and flaws in the organization of the healthcare system. The hypotheses that  
296 the application of national clinical guidelines may differ from region to region or that the  
297 resources are used or mobilized differently should be explored.

298  
299

#### 300 **4.-Acknowledgements**

301 We thank the medical assessors of the national confidential enquiry into maternal deaths who  
302 collected all the information about maternal deaths; the members of the National Expert  
303 Committee on Maternal Mortality; the coordinators of the national perinatal survey of  
304 Epidemiological research unit on perinatal health and women's health (INSERM U953) and  
305 the Directorate of Research, Studies, Evaluation and Statistics (Ministry of Health).

306

#### 307 **5.-Disclosure of Interests**

308 The authors have no potential conflicts of interest to disclose.

309

#### 310 **6.-Contribution to Authorship**

311 M.S. conducted the analysis, drafted and revised the article. C.D-T had the original idea for  
312 this study. M-H.B-C. has coordinated the confidential national survey on maternal deaths in  
313 France since 1996. C.D-T. and M-H.B-C., both collaborated in the drafting and revision of the  
314 paper.

315

#### 316 **7.-Details of ethics approval**

317 The Confidential Enquiry into Maternal Deaths (ENCMM) and the National Perinatal Survey  
318 (NPS) were approved by The Commission nationale de l'informatique et des libertés  
319 (National Data Protection Authority).

320

321 **8.-Funding**

322 The ENCMM is funded in part by the Institute for Health Surveillance (InVS) and by

323 INSERM.

324 The 2003 NPS was funded in part by the General Health Directorate (Ministry of Health).

325 **9.-References**

- 326 1. Atrash HK, Alexander S, Berg CJ. Maternal mortality in developed countries: not just  
327 a concern of the past. *Obstet Gynecol.* 1995 Oct;86(4 Pt 2):700-5.
- 328 2. Berg CJ, Harper MA, Atkinson SM, Bell EA, Brown HL, Hage ML, et al.  
329 Preventability of pregnancy-related deaths: results of a state-wide review. *Obstet*  
330 *Gynecol.* 2005 Dec;106(6):1228-34.
- 331 3. Graham WJ. Now or never: the case for measuring maternal mortality. *Lancet.* 2002  
332 Feb 23;359(9307):701-4.
- 333 4. Bouvier-Colle MH. [Confidential enquiries and medical expert committees: a method  
334 for evaluating healthcare. The case of Obstetrics]. *Rev Epidemiol Sante Publique.*  
335 2002 Apr;50(2):203-17.
- 336 5. Report of the National Expert Committee on Maternal Mortality (CNEMM), France  
337 2001-2006. Institut de veille sanitaire; 2010. Available from:  
338 [http://www.invs.sante.fr/publications/2010/mortalite\\_maternelle/rapport\\_mortalite\\_ma](http://www.invs.sante.fr/publications/2010/mortalite_maternelle/rapport_mortalite_ma)  
339 [ternelle\\_anglais.pdf](http://www.invs.sante.fr/publications/2010/mortalite_maternelle/rapport_mortalite_maternelle_anglais.pdf)
- 340 6. Cantwell R, Clutton-Brock T, Cooper G, Dawson A, Drife J, Garrod D, et al. Saving  
341 Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008.  
342 The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United  
343 Kingdom. *BJOG.* 2011 Mar;118 Suppl 1:1-203.
- 344 7. Schutte JM, Steegers EA, Schuitemaker NW, Santema JG, de Boer K, Pel M, et al.  
345 Rise in maternal mortality in the Netherlands. *BJOG.* 2010 Mar;117(4):399-406.
- 346 8. Philibert M, Deneux-Tharaux C, Bouvier-Colle MH. Can excess maternal mortality  
347 among women of foreign nationality be explained by suboptimal obstetric care?  
348 *BJOG.* 2008 Oct;115(11):1411-8.

- 349 9. Stirbu I, Kunst AE, Bos V, Mackenbach JP. Differences in avoidable mortality  
350 between migrants and the native Dutch in The Netherlands. *BMC Public Health*.  
351 2006;6:78.
- 352 10. Temmerman M, Verstraelen H, Martens G, Bekaert A. Delayed childbearing and  
353 maternal mortality. *European Journal of Obstetrics & Gynecology and Reproductive*  
354 *Biology*. 2004;114(1):19-22.
- 355 11. Saucedo M, Deneux-Tharoux C, Bouvier-Colle MH. Regional disparities in maternal  
356 mortality in France: specificities of Ile-de-France region and French overseas  
357 departments, 2001-2006. *Bulletin épidémiologique hebdomadaire (France)*. 2010  
358 Jan(2-3):15-8.
- 359 12. Sullivan SA, Hill EG, Newman RB, Menard MK. Maternal-fetal medicine specialist  
360 density is inversely associated with maternal mortality ratios. *American Journal of*  
361 *Obstetrics and Gynecology*. 2005;193(3, Supplement 1):1083-8.
- 362 13. World Health Organisation. ICD 10: international statistical classification of diseases  
363 and related health problems. 10th revision. Geneva (Switzerland): World Health  
364 Organization; 1992.
- 365 14. B. Blondel, K. Supernant, C. du Mazaubrun and G. Bréart, Enquête nationale  
366 périnatale 2003. Situation en 2003 et évolution depuis 1998, Inserm Unité 149, Paris  
367 (2005) p. 51. Available from:  
368 [http://www.sante.gouv.fr/IMG/pdf/ENP\\_2003\\_rapport\\_INSERM.pdf](http://www.sante.gouv.fr/IMG/pdf/ENP_2003_rapport_INSERM.pdf).
- 369 15. Blondel B, Supernant K, Du Mazaubrun C, Breart G. [Trends in perinatal health in  
370 metropolitan France between 1995 and 2003: results from the National Perinatal  
371 Surveys]. *J Gynecol Obstet Biol Reprod (Paris)*. 2006 Jun;35(4):373-87.
- 372 16. Callaghan WM, Berg CJ. Pregnancy-related mortality among women aged 35 years  
373 and older, United States, 1991-1997. *Obstet Gynecol*. 2003 Nov;102(5 Pt 1):1015-21.

- 374 17. Maine D. How do socioeconomic factors affect disparities in maternal mortality? J  
375 Am Med Womens Assoc. 2001 Fall;56(4):189-90, 92.
- 376 18. Cevik B, Ilham C, Orskiran A, Colakoglu S. Morbid obesity: a risk factor for maternal  
377 mortality. Int J Obstet Anesth. 2006 Jul;15(3):263-4.
- 378 19. Harper MA, Byington RP, Espeland MA, Naughton M, Meyer R, Lane K. Pregnancy-  
379 related death and health care services. Obstet Gynecol. 2003 Aug;102(2):273-8.
- 380 20. Rey G, Jouglu E, Fouillet A, Hemon D. Ecological association between a deprivation  
381 index and mortality in France over the period 1997 - 2001: variations with spatial  
382 scale, degree of urbanicity, age, gender and cause of death. BMC Public Health.  
383 2009;9:33.
- 384 21. Breart G. Delayed childbearing. European Journal of Obstetrics & Gynecology and  
385 Reproductive Biology. 1997;75(1):71-3.
- 386 22. Ibison JM, Swerdlow AJ, Head JA, Marmot M. Maternal mortality in England and  
387 Wales 1970-1985: an analysis by country of birth. Br J Obstet Gynaecol. 1996  
388 Oct;103(10):973-80.
- 389 23. Driessen M, Bouvier-Colle MH, Dupont C, Khoshnood B, Rudigoz RC, Deneux-  
390 Tharaux C. Postpartum haemorrhage resulting from uterine atony after vaginal  
391 delivery: factors associated with severity. Obstet Gynecol. 2011 Jan;117(1):21-31.
- 392 24. Bazely P., Catteau C. État de santé, offre de soins dans les départements d'Outre-Mer  
393 (Guadeloupe, Guyane, Martinique, Réunion). Paris : Drees, coll. Série études, n°14,  
394 juin 2001. Available from: <http://www.sante.gouv.fr/IMG/pdf/serieetud14.pdf>

395 **10.- List of tables**

396 Table 1. Distribution of characteristics of women and deliveries among cases and  
 397 controls.

	<b>Cases (n=328)</b>	<b>Controls (n=14878)</b>	<i>p</i> value <sup>a</sup>
<b>Region</b>	<b>328</b>	<b>14878</b>	<b>&lt;0.001</b>
Ile-de-France	29.9	21.3	
Overseas districts (DOM)	12.8	4.1	
Rest of continental France	57.3	74.6	
<b>Age</b>	<b>328</b>	<b>14687</b>	<b>&lt;0.001</b>
<25	11.6	19.2	
25-34	47.3	64.7	
35+	41.2	16.1	
<b>Nationality</b>	<b>328</b>	<b>14469</b>	<b>&lt;0.001</b>
French	80.8	88.0	
Foreign	19.2	12.0	
<b>Marital status</b>	<b>328</b>	<b>14423</b>	0.4
Married	50.0	52.4	
Not married	50.0	47.6	
<b>Work status</b>	<b>286</b>	<b>14212</b>	0.8
Yes	60.8	60.1	
No	39.2	39.9	
<b><u>Only continental France</u></b> <sup>b</sup>	(n=214) <sup>c</sup>	(n=14269)	
<b>Parity</b>	<b>182</b>	<b>14050</b>	<b>&lt;0.001</b>
0	21.9	43.3	
1-3	63.2	53.8	
More than 3	14.8	2.9	
<b>Hospitalization during pregnancy</b>	<b>188</b>	<b>13825</b>	<b>&lt;0.001</b>
No	68.6	81.4	
Yes	31.4	18.6	
<b>Hypertensive disorder during pregnancy</b>	<b>187</b>	<b>14112</b>	0.001
No	90.4	95.4	
Yes	9.6	4.6	
<b>Induced labor</b>	<b>195</b>	<b>14234</b>	<b>&lt;0.001</b>
No	38.5	67.8	
Yes	61.5	32.1	
<b>Mode of delivery</b>	<b>209</b>	<b>14230</b>	<b>&lt;0.001</b>
Vaginal	38.2	80.4	
Caesarean	60.8	19.6	
<b>Emergency caesarean</b>	<b>208</b>	<b>14010</b>	<b>&lt;0.001</b>
No	47.1	90.2	
Yes	52.9	9.8	
<b>Preterm delivery</b>	<b>198</b>	<b>14204</b>	<b>&lt;0.001</b>
No	67.2	93.6	
Yes (less than 37 wk)	32.8	6.4	
<b>Multiple birth</b>	<b>211</b>	<b>14269</b>	0.03
No	96.2	98.2	
Yes	3.8	1.8	

<sup>a</sup>For chi2 test.

<sup>b</sup>Ile-de-France and the rest of continental regions.

<sup>c</sup>Only postpartum maternal deaths reviewed by the National Committee of Experts

398  
 399  
 400

401 Table 2. Overall and cause-specific postpartum maternal mortality associated with region, crude and adjusted odds ratios (controlling for socio-  
 402 demographic factors).

Causes of death	Region	Cases	Controls	Crude OR	95% CI	adjusted OR <sup>a</sup>	95% CI
<b>All causes</b>	DOM	42	<b>609</b>	<b>4.1</b>	2.9 - 5.7	<b>3.5</b>	2.4 – 5.0
	Ile-de-France	98	<b>3166</b>	<b>1.8</b>	1.4 - 2.3	<b>1.6</b>	1.2 – 2.0
	Rest of continental France	188	<b>11103</b>	<b>1</b>		<b>1</b>	
Haemorrhage	DOM	17		7.6	4.2 – 13.4	<b>6.5</b>	3.6 – 11.6
	Ile-de-France	34		2.9	1.8- 4.6	<b>2.3</b>	1.4 – 3.7
	Rest of continental France	41		<b>1</b>		<b>1</b>	
Amniotic fluid embolism	DOM	5		3.1	1.2 – 8.1	<b>2.8</b>	1.1 – 7.3
	Ile-de-France	21		2.5	1.4 – 4.6	<b>2.1</b>	1.2 – 3.8
	Rest of continental France	28		<b>1</b>		<b>1</b>	
Thromboembolism	DOM	4		3.8	1.3 – 11.3	<b>3.3</b>	1.1-9.8
	Ile-de-France	4		0.7	0.3 – 2.2	0.6	0.2 – 1.9
	Rest of continental France	20		<b>1</b>		<b>1</b>	
Hypertensive disorders	DOM	4		6.6	2.1 – 20.9	<b>5.6</b>	1.7 – 17.7
	Ile-de-France	9		2.9	1.2 – 6.9	<b>2.7</b>	1.1 – 6.8
	Rest of continental France	11		<b>1</b>		<b>1</b>	
Other direct causes <sup>b</sup>	DOM	8		6.1	2.7 – 13.6	<b>5.2</b>	2.3-11.8
	Ile-de-France	16		2.3	1.2 – 4.4	<b>1.9</b>	1.0 – 3.7
	Rest of continental France	24		<b>1</b>		<b>1</b>	
Indirect causes	DOM	4		1.1	0.4 – 3.1	1.0	0.4 – 2.8
	Ile-de-France	14		0.8	0.4 – 1.4	0.8	0.4 – 1.3
	Rest of continental France	64		<b>1</b>		<b>1</b>	

403 Data for the columns for cases and controls are numbers.

404 DOM, overseas districts; OR, odds ratio; CI, confidence interval.

405 <sup>a</sup> Logistic model including maternal age and nationality

406 <sup>b</sup> Complications of anaesthesia, infections and other complications directly related to pregnancy

407 Table 3. Overall and cause-specific postpartum maternal mortality associated with region in continental France, crude and adjusted odds ratios  
 408 (controlling for socio-demographic and obstetric factors).  
 409

Causes of death	Cases		Controls		Crude OR	95% CI	Adjusted OR <sup>a</sup>	95% CI
	Rest of continental France	Ile-de-France	Rest of continental France	Ile de France				
<b>All causes</b>	<b>143 (100)</b>	<b>71 (100)</b>	<b>11103</b>	<b>3166</b>	1.7	1.3 – 2.3	<b>1.8</b>	1.3 – 2.6
Haemorrhage	29 (20.3)	22 (31.0)			2.7	1.5 – 4.6	<b>2.2</b>	1.2 – 4.0
Amniotic fluid embolism	23 (16.1)	13 (18.3)			1.9	1.0 – 3.7	1.8	0.8 – 3.8
Indirect causes	56 (39.2)	14 (19.7)			0.9	0.5 – 1.6	0.7	0.3 – 1.6
<b>Singleton term deliveries only</b>								
<b>All causes</b>	<b>78 (100)</b>	<b>49 (100)</b>	<b>10252</b>	<b>2909</b>	2.2	1.5 – 3.2	<b>2.3</b>	1.5 – 3.5
Haemorrhage	19 (24.4)	18 (36.7)			3.3	1.8 – 6.4	<b>2.8</b>	1.3 – 5.9
Amniotic fluid embolism	21 (26.9)	12 (24.5)			2.0	1.0 – 4.1	<b>2.1</b>	1.0 – 4.7

410 Data for the case column are numbers (%).

411 OR, odds ratio; CI, confidence interval.

412 <sup>a</sup> Logistic model including maternal age, nationality, parity, hospitalization during pregnancy and emergency caesareans.

413 Table 4. Expert judgment about the quality of care and avoidability of postpartum maternal deaths according to region.

414

	Ile-de-France	Rest of continental France	<i>p</i> value
<b>General quality of care</b>	<b>(N=71)</b>	<b>(N=143)</b>	
Optimal	19.7	28.6	0.01
Not optimal	64.8	43.4	
Could not be determined	15.5	28.0	
<b>Avoidability of death according to the experts</b>	<b>(N=71)</b>	<b>(N=143)</b>	
Not avoidable	33.8	49.0	0.1
Avoidable <sup>a</sup>	45.1	35.0	
Could not be determined	21.1	16.0	
<b>Reasons (if death was avoidable)</b>	<b>(N=32)</b>	<b>(N=50)</b>	
Delay in treatment (therapeutic or intervention)	37.5	26.5	0.07 <sup>b</sup>
Inadequate or insufficient treatment	6.3	28.6	
Medical error	25.0	26.5	
Missed diagnosis	21.8	16.4	
Negligence of the patient	9.4	2.0	

415

416

417

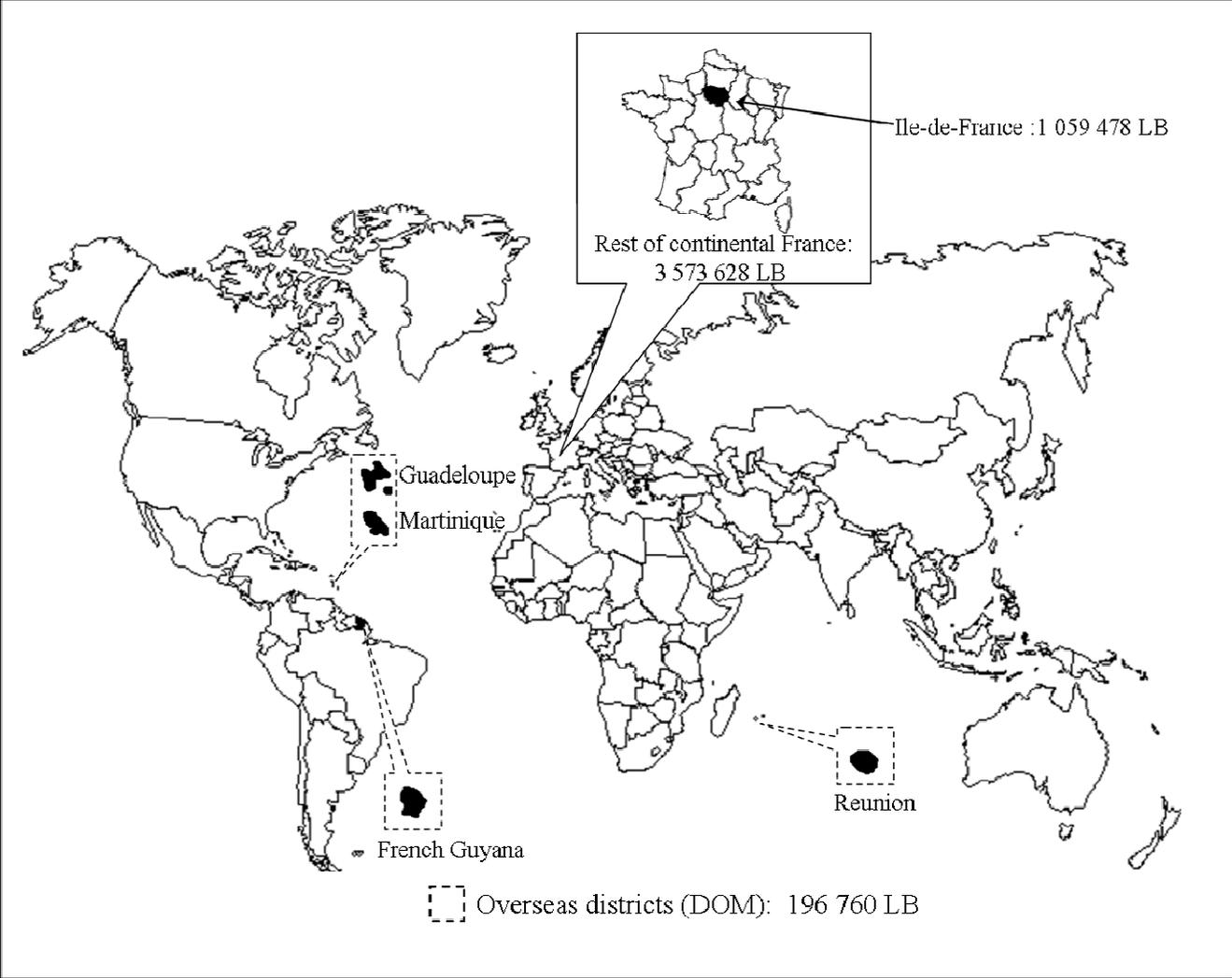
<sup>a</sup> Certainly avoidable or perhaps

<sup>b</sup> Fisher's exact test

Data are %, unless otherwise specified.

418 Figure 1.

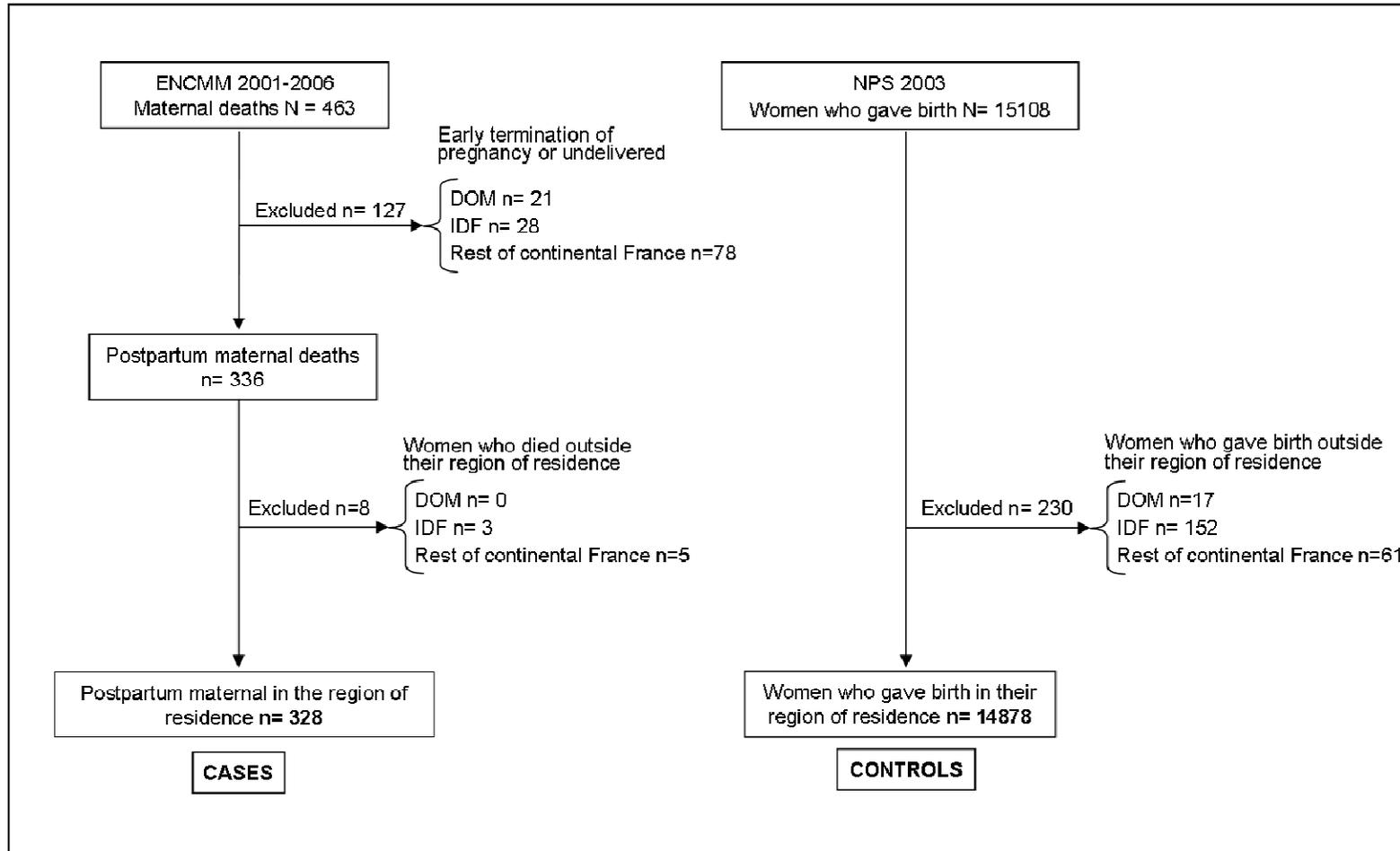
419 Map of study sites and corresponding numbers of live births (LB), France 2001-2006.



420

421 Figure 2

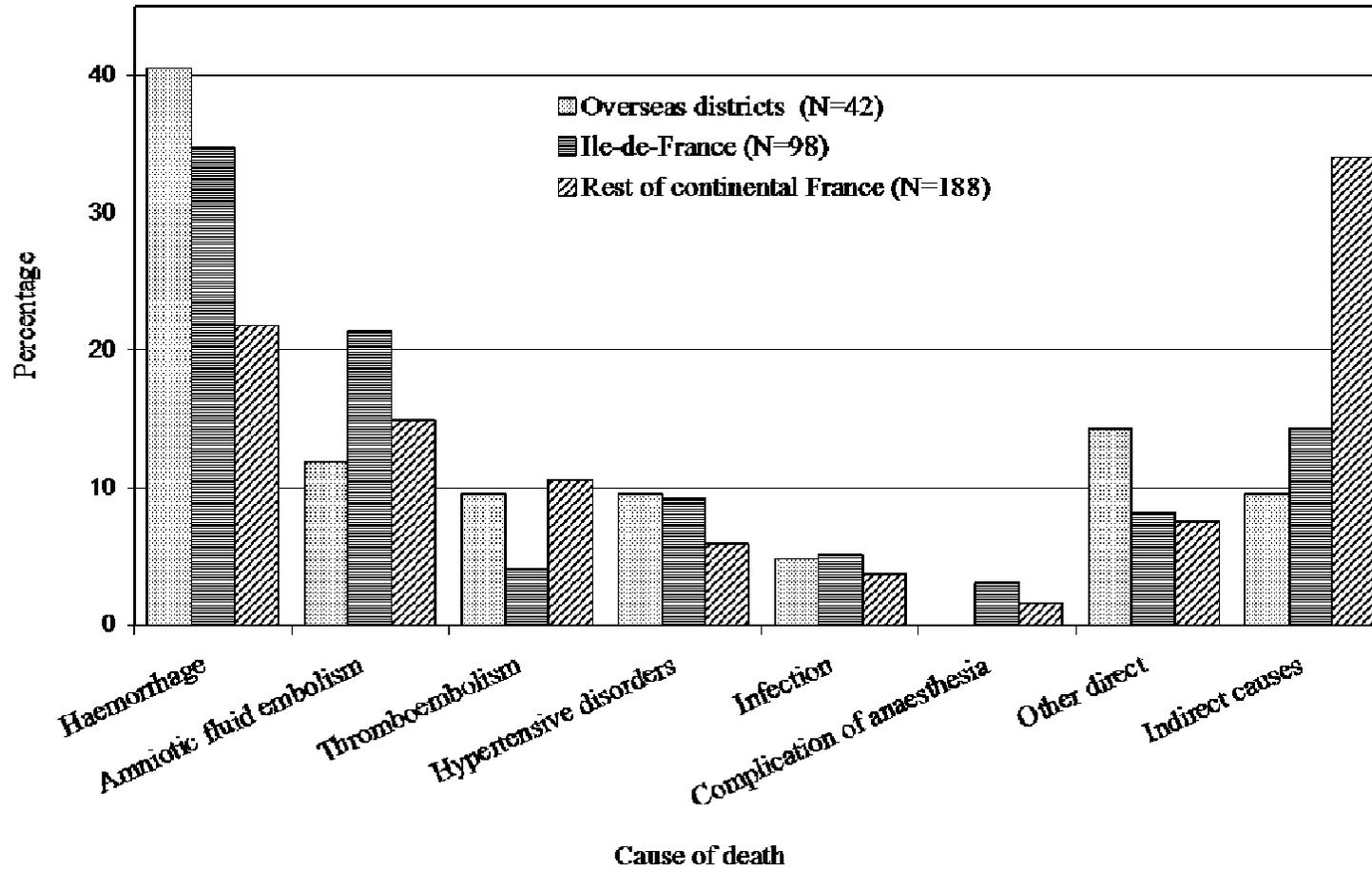
422 Selection of cases and controls.



423

424 Figure 3.

425 Distribution of causes of postpartum maternal deaths, percentage by region.



426