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Perinatal health inequalities and accessibility of maternity services in a rural French region: Closing maternity units in Burgundy

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ABSTRACT

Maternity unit closures in France have increased travel time for pregnant women in rural areas. We assessed the impact of travel time to the closest unit on perinatal outcomes and care in Burgundy using multilevel analyses of data on deliveries from 2000 to 2009. A travel time of 30 min or more increased risks of fetal heart rate anomalies, meconium-stained amniotic fluid, out-of-hospital births, and pregnancy hospitalizations; a positive but non-significant gradient existed between travel time and perinatal mortality. The effects of long travel distances on perinatal outcomes and care should be factored into closure decisions.

1. Introduction

In France, as in other countries, the regionalization of perinatal care, which is taking place in the more general context of restructuring the supply of hospital services, has led many establishments to close, especially in rural areas. It has thus made geographic accessibility a major issue for ensuring equal health opportunities (Coldefy et al., 2011), especially given the large geographical disparities that already exist (Trugeon et al., 2010). The initial objectives of this restructuring of perinatal care were better management of very preterm babies (Chung et al., 2011; HCSP, 1994; Lehtonen et al., 2011; Papiernik and Combier, 1996; Papiernik and Keith, 1995; Wehby et al., 2012) and greater safety in hospital care (HCSP, 1994; Heller et al., 2002; Merlo et al., 2005; Moster et al., 1999). An economic aim was rapidly added to these, because the potential concentration of resources in a limited number of establishments was thought to make economies of scale possible (Brousselle et al., 1999; Com-Ruelle et al., 2008; Hemminki et al., 2011; Klein et al., 2002; McKee and Healy, 2000; NHS, 1996; Pouvourville (de) et al., 1997).

We have long known that one cause of maternal and perinatal morbidity and mortality is the delay in management of obstetric emergencies at delivery – a delay that includes transportation time (Barnes-Josiah et al., 1998), which can be long even in industrialized countries (Nesbitt et al., 1990). The impact of travel time or distance on health outcomes has been repeatedly studied in trauma-related, cardiologic, and neurovascular emergencies (Blanchard et al., 2012; Fatovich et al., 2011; Meretoja et al., 2012; Shen and Hsia, 2012; Smith and von Kummer, 2012). It has rarely been examined as a risk factor in obstetrics, however, even

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though life-threatening obstetric emergencies are not rare and the onset of spontaneous labor is unpredictable (WHO, 1996). Studies conducted in industrialized countries have yielded contradictory results. Some authors (Dummer and Parker, 2004; Parker et al., 2000) have found no significant association between travel time or distance and adverse outcomes while others (Grzybowski et al., 2011; Lisonkova et al., 2011; Ravelli et al., 2011b; Viisainen et al., 1999) report that travel time to the maternity ward is associated with an increase in risks of intrapartum and neonatal mortality and morbidity. Studies in France (Blondel et al., 2011) and in other countries (Dietsch et al., 2010; Hemminki et al., 2011; Viisainen et al., 1999) have shown a positive association between travel time or distance and unplanned out-of-hospital deliveries. These deliveries are also associated with a higher risk of perinatal mortality than in-hospital births (Jones et al., 2011; Viisainen et al., 1999).

In 1996, France (excluding overseas districts and territories, here and hereafter) counted 815 maternity units (Ruffie et al., 1998), defined as hospital sites where deliveries take place. There were only 759 in 1998, 621 in 2003 and 526 in 2010 (Blondel et al., 2012; Pilkington et al., 2008) The majority of maternity units that were closed were smaller and less specialized facilities (DREES, 2009; Pilkington et al., 2008). In France, maternity units are classified into three levels of care by their capacity to provide pediatric services to high risk newborns: level 1 units have no special care unit for newborns; level 2 units have neonatal nurseries, but do not provide care for very preterm or very low birthweight infants; level 3 are maternity units with neonatal intensive care (Perinatal care: The government plan, 1995–2000, 1994). Over the period 2001 and 2010, the number of level 1 units in France decreased from 415 to 263, whereas level 3 units increased slightly in number (56–60). Closures over the period 2001–2010 led to a decrease in overall bed capacity from 19,025 to 16,986 (DREES, 2009).

However, these national figures mask substantial disparities between regions (Coldefy et al., 2011). In 2003, Burgundy was the region most heavily affected, with a closure rate of 36.0% over 1998, while no maternity wards were closed in Corsica or Limousin, other predominantly rural regions (Pilkington et al., 2008). The closures have led to widespread concern about the safety of childbirth in affected communities. Local politicians and user groups constituted committees in defense of small maternity units threatened with closure and these questions – in particular those related to increasing travel distances – were widely debated in the local and national press.

From 1998 through 2003, as the number of births increased by +3%, the number of women in France who gave birth and lived more than 30 km from a maternity ward rose from 10,310 to 13,679 (+33%) and the number more than 45 km away from 736 to 1520 (+106%) (Pilkington et al., 2008). Although these closures had only a limited impact on the distribution of distance in urban areas, the increase in these two distance classes (>30 km and >45 km) in rural sectors was respectively +52% and +105% (Pilkington et al., 2008). In an earlier study in Burgundy, conducted at the scale of municipalities, the mean travel time increased only 4 min from 2000 to 2009, but the maximum travel time rose from 65 min to 86 min (Charreire et al., 2011). Moreover, the number of municipalities in the region located more than 30 min from a maternity ward grew; these municipalities were home to 11,345 women aged 15–45 years (Charreire et al., 2011).

Given the concerns in France with increasing travel distances for pregnant women, this study aimed to analyze the effect of travel time to the closest maternity ward on pregnancy outcome and prenatal management in Burgundy, where nearly 90% of women give birth in the maternity ward closest to their home (Combier et al., 2004).

2. Methods

2.1. Study area

Burgundy is a vast region made up of four districts (Côte d'Or, Saône-et-Loire, Nièvre and Yonne) with 1,631,000 inhabitants in 2008 (2.6% of the population of France) (Fig. 1). With an area of

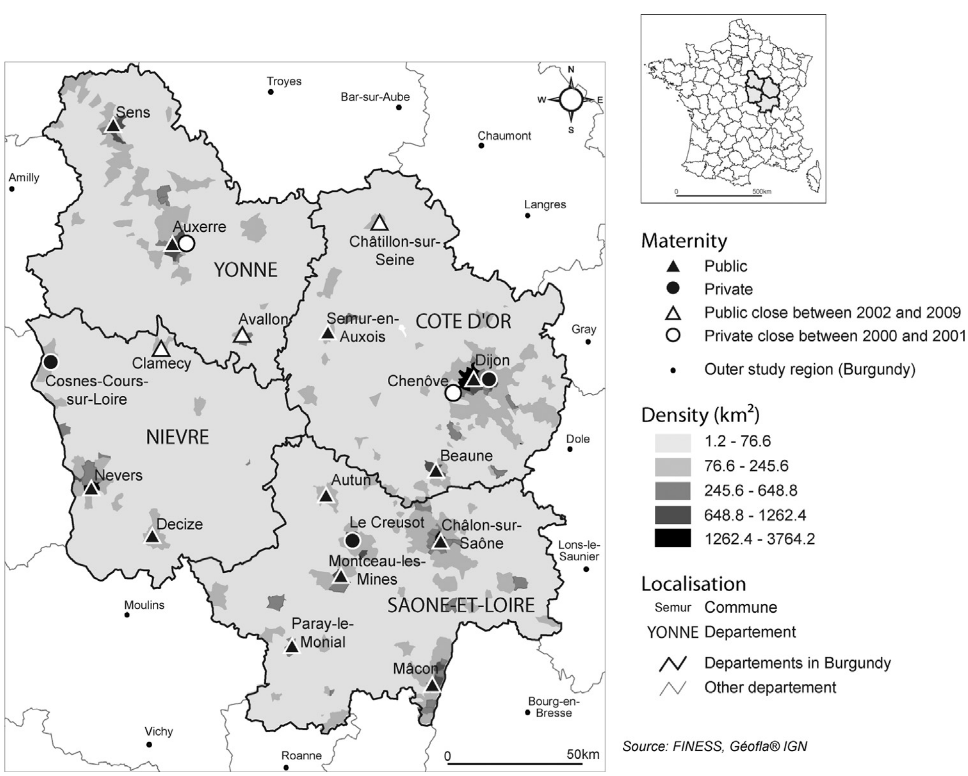

Fig. 1. Localisation of maternity units (between 2000 and 2009) in Burgundy and in surrounding *"departments"* – Density of population in Burgundy in 2009.

31,600 km^2, the region accounts for 6% of the landmass of France. Its population density is low (51 inhabitants/km^2 compared with 108 for the entire country), and the population distribution very unequal. The most heavily populated area lies along the axis linking Dijon, Beaune, Chalon-sur-Saône, and Mâcon, and only 16 municipalities count more than 10,000 inhabitants. Dijon is the only municipality in Burgundy with a population exceeding 100,000 inhabitants; its larger metropolitan area, which had 244,600 inhabitants in 2008, accounts for 15% of the region's population. On the other hand, 33% of the population lives in municipalities in predominantly rural areas (national mean: 18%) (Lix, 2009). The topography of Burgundy, characterized by important geological accidents, has played a major role in the region's settlement and functioning. Although the busiest autoroute in France (A6) crosses the region from north to south, some areas are difficult to reach, especially in the center of the region, where the districts meet at the Morvan Massif, with its 901-m peak. It is easier to go around the massif than to cross it, and its central position makes east–west routes difficult.

In 2009, there were 290,520 women of childbearing age living in Burgundy for a total of 17,677 births per year. The birth rate of 10.9 was lower than the overall birth rate for metropolitan France (12.5). Maternity care in Burgundy is organized around one level III hospital, the University Hospital of Dijon which provides care for high risk neonates throughout the region. There are six level II units. Other maternity units are community facilities providing care for women with low risk pregnancies and their newborns. During the 2000–2009 period covered by our study, two maternity units in urban areas (Chenôve, in Dijon's metropolitan area, and Auxerre) and three serving remote areas of Morvan and the Châtillonnais closed (Avallon in 2002, Clamecy and Châtillon-sur-Seine in 2008); the number of maternity units thus fell from 20 in 2000 to 15 in 2009 (Fig. 1). All of these facilities were level I maternity units. These closures corresponded to a decrease in bed capacity from 702 (INSEE, 2003) to 395 (DREES, 2009).

2.2. Data and scale of analysis

This study used the Burgundy perinatal network (RPB) database which is based on hospital discharge summary data (PMSI, *Programme de médicalisation des systèmes d'information)* for all deliveries in the region's maternity units (Rousseau et al., 2008; Sagot et al., 2003) from 22 weeks of gestation. The data in the PMSI are enhanced by linking the admissions of mother and child, thus enabling the collection of information about gestational age and birth weight (Cornet et al., 2001; Quantin et al., 1998, 2009). In addition, the maternity units routinely provide information about gestational age at birth and some socioeconomic risk factors that are not in the hospital discharge summary; nine also supplied information about induction of labor. The network's evaluation committee checks the completeness of data collection annually. Data are available from 2000 onward.

The geographic scale used for this analysis is the geographic residence code in the PMSI which is based on the postal codes (n=223). Some analyses, which concern only travel time, were also performed at a finer scale – that of municipalities (n=2046).

2.3. Study population

We studied all singleton births at or after 22 weeks of gestation in maternity units in Burgundy from 2000 through 2009 to parents living in Burgundy. We excluded medically indicated interruptions of pregnancy, multiple pregnancies and PMSI geographic residence codes where 6% or more of births took place outside Burgundy (Coldefy et al., 2011). This latter exclusion, which corresponded to 202 communes out of 2046, included women for whom the closest maternity unit was outside the region. We excluded these communes in order to minimize bias due to different selection criteria for women with low risk pregnancies (based more often on proximity and thus out of region) versus high risk pregnancies (based on referral to specialized units within the region). We also excluded births in 2002 and 2008, the years during which the three rural maternity units closed because women delivering in these years may have experienced specific problems associated with the closures which were distinct from those caused by distance to the nearest maternity unit. After these exclusions, our study covered 111,001 singleton deliveries occurring in Burgundy to women residing in Burgundy.

2.4. Morbidity and mortality

The following data were available in the PMSI to describe perinatal outcomes and care during pregnancy and delivery: (a) for pregnancy outcome: in utero fetal mortality (stillbirths) and extended perinatal mortality (deaths in utero or in the first 28 days of life), fetal heart rate (FHR) abnormalities, and meconium-stained amniotic fluid, both of which can be signs of acute fetal distress, and unplanned out-of-hospital deliveries; (b) for care during pregnancy and delivery: hospitalization during pregnancy, regardless of whether delivery or discharge followed (prenatal hospitalization), and hospitalization for more than 24 h immediately before delivery. All these variables were dichotomous and coded yes=1 or no=0.

2.5. Travel time between the mother's home and the closest maternity ward

The travel time separating the mother's home from the closest maternity ward during the year of delivery was calculated for each woman in a two-step procedure.

(1) The time to reach the closest maternity ward was calculated for each of the 2046 municipalities. This was calculated as the time to go by road from the town hall of the municipality to the town hall of the municipality where the closest maternity ward was located. By definition, the travel time to the closest maternity ward for women living in a municipality with a maternity unit was estimated at 0. Then, the travel time for each PMSI geographic residential code was computed as the mean time of the municipalities composing it.
The chronological change in travel time after the closures was considered by calculating this time for three separate periods: (a) 2000–2001, before the Avallon maternity ward closed; (b) 2003–2007, the Avallon maternity ward was closed but those of Clamecy and Châtillon were open; (c) 2009: all three rural maternity units were closed. Because the maternity units of the Chenôve clinic and the Auxerre hospital were in urban areas close to other establishments, their closing did not modify the access time estimated in the models (data not shown).

(2) For each period (2000–2001; 2003–2007; 2009), travel time was divided into four classes: 0–15 min, 16–30 min, 31–45 min, and 46 min or more. We selected 15-min time classes because the mean travel time to a maternity ward in France in 2007 was 14.26 min and 30 min because this corresponds to the governmental objective for emergency services (Baillot and Evain, 2012; Ministère des affaires sociales et de la santé, 2012). The Chronomap© extension of MapInfo© software and IGN500®, the digitalized road network, were used to calculate these travel times. The times used are based on those calculated for rapid emergency vehicles. We selected this option to measure the minimum travel time for women in emergency

situations, such as imminent delivery. We also recalculated travel times using Google Maps itinerary after localizing the maternity units at their exact addresses to verify that this did not change the distance classifications for the PMSI codes (data not shown).

2.6. Adjustment variables

(1) The **individual variables** selected were maternal age, the child's sex and gestational age at birth (less than 37 weeks: preterm birth=1, and 37 weeks or more: preterm birth=0), history of preterm delivery (at least 1 delivery before 37 weeks, variable coded 1; otherwise coded 0), and adverse obstetrical history. This synthetic variable was coded 1 when the history included at the least a history of in utero death or a past diagnosis included the ICD10 codes Z352 or Z875. When no history was noted, the variable was coded 0.
(2) The **residential environment** was characterized by social and demographic variables and by the level of urbanization at the scale of the PMSI geographic codes. The methods we used to construct these variables are detailed below.

2.7. Creation of adjustment variables describing the environment

2.7.1. Deprivation index

A deprivation index was calculated for each PMSI geographic code, based on the one developed in 1999 for the Ile de France region (Lasbeur et al., 2006; Zeitlin et al., 2011). The data come from the 2006 population census, distributed by the National Institute for Statistics and Economic Studies (INSEE). This composite index includes the proportion of blue-collar workers, intermediate white-collar and office workers, people with only primary school education, single-parent families, and households without automobiles and the number of people per room. The score is the sum of these proportions normalized around their means.

The scores obtained after normalization and aggregation of data were then divided into four classes based on the quartiles of the distribution; class 1 was the most advantaged, and class 4 the most deprived. This deprivation index was selected because it is the only one that has been validated for the study of perinatal outcomes in France.

2.7.2. Description of level of urbanization

The physical environment was characterized as rural or urban; this variable was based on a classification developed by the office for land use planning and regional activity (DATAR) (DATAR, 2003) according to level of attractiveness (commuting network and ratio of employment in each area). The areas classified as (1) urbanized cantons, (2) local suburbs: dominantly residential, (3) rural area becoming suburbanized; and (4) rural dense, residential and productive were all grouped together (urban=1), while the other classes, which describe more rural areas constituted the other category (urban=0).

When the PMSI geographic code extended over several cantons, some classified urban=0 and others urban=1, we attributed to the entire PMSI code area to the urban variable value (0 or 1) that corresponded to the greatest part of its area.

2.7.3. Methods of analysis

Hierarchical logistic regression was used to assess the associations between the travel time classes and the outcome variables; the reference category was the class with a travel time of 0–15 min. To analyze the specific effect of time, we used multilevel logistic regressions for each outcome variable. The model used as its level 1 data the individual maternal and child characteristics, as level 2 data, the periods with the travel times calculated at each period for each PMSI code, and as level 3 data, the residential environment data, that is, the level of urbanization and the deprivation index for the (PMSI) geographic codes for the place of residence.

The descriptive analyses were performed with SAS version 9.3 (SAS Institute Inc., Cary, NC, USA) and the multilevel analyses with HLM version 6 (Scientific Software International Inc., Lincolnwood, IL, USA).

3. Results

Of the 111,001 deliveries studied, 87.8% took place at the maternity ward nearest to the mother's home (88.4% of the term and 77.4% of the preterm births). Table 1 presents the trends of mean and maximum access time to the nearest maternity ward from 2000 through 2009, calculated using the PMSI geographic code (n=223). Mean time was estimated at 21 min in 2000 and at 24 min in 2009, while maximum time increased from 61 (in 2000) to 72 min (in 2009).

In our population of 111,001 women (Table 2) in all periods combined, 70,427 (63.5%) lived within 15 min of a maternity ward at delivery, 31,792 (28.6%) 16 to 30 min, 8445 (7.6%) from 31 to 45 min and 337 (0.3%) at 46 min or more. The increase in distance due to the closures of maternity units is very clear when we compare the three periods (*Somers' D* $< 10^{-3}$). In 2000–2001, 6.7% of women took more than 30 min to get to the closest maternity ward, compared with 8.8% in 2009 ($p < 0.001$).

Table 3 presents the associations between the distance to the nearest maternity ward and the pregnancy outcome and care variables. The crude associations were significant ($p < 0.05$) except for the rate of stillbirths, and extended perinatal mortality. The crude stillbirth rate nonetheless rose from 0.47% among women living fewer than 16 min from a maternity ward to 0.89% in those more than 45 min away. For perinatal mortality, those rates were 0.64% and 1.19%.

The trend tests (Cochran-Armitage) were statistically significant ($p < 0.05$) except for the rates of stillbirths, perinatal mortality, and meconium-stained amniotic fluid.

A positive gradient for the β coefficients was observed for stillbirths, perinatal mortality, fetal heart rate abnormalities and maternal hospitalization, at any point or 24 h before delivery, after adjustment for the study period, individual data and contextual characteristics of the place of residence at delivery (Table 4). Trends were visible for the stillbirth and perinatal mortality rates, but their associations with travel time were not significant. A positive association was observed from the 16–30-min class for prenatal hospitalization, before or more than 24 h before delivery, and from the 31–45-min class for FHR abnormalities and meconium-stained amniotic fluid. Finally, a positively significant

Table 1
Travel time (in minutes) to the closest maternity by geographical code (n=223).

Period	Time (minutes)		
	Mean	Median	Maximum
2000–2001	21	20	61
2003–2007	21	21	61
2009	24	22	72

Table 2
Distribution of births according to travel time to the maternity ward and the effect of closures on travel time.

Travel time	Total 3 study periods		study periods						χ^2	Somers'D
			2000–2001		2003–2007		2009			
	N	%	N	%	N	%	N	%		
< =15 min	70 427	63.45	17 943	65.01	43 960	63.02	8 524	62.45	$< 10^{-3}$	$< 10^{-3}$
16–30 min	31 792	28.64	7 818	28.33	20 055	28.75	3 919	28.71		
31–45 min	8 445	7.61	1 814	6.57	5 551	7.96	1 080	7.91		
> =46 min	337	0.30	24	0.09	187	0.27	126	0.92		
Total Dyades	111 001	100.00	27 599	100.00	69 753	100.00	13 649	100.00		

Somers'D=0.021: CI95% (0.0028–0.0155).

Table 3
Travel time (in minutes) to the closest maternity ward and outcomes.

Minutes to the nearest maternity ward	Crude rates			Crude OR	
	Number	%		95% CI	
				Min	Max
Stillbirth and perinatal mortality					
Total stillbirths (% total: 0.48%)					
≤ 15	333	0.47	1	Ref	
16–30	148	0.47	0.98	0.81	1.20
31–45	50	0.59	1.25	0.93	1.69
≥ 46	3	0.89	1.89	0.60	5.92
Perinatal deaths (% total: 0.64%)					
< =15	452	0.64	1	Ref	
16–30	195	0.61	0.96	0.81	1.13
31–45	59	0.7	1.09	0.83	1.43
≥ 46	4	1.19	1.86	0.69	5.01
Signs of acute fetal distress					
Fetal heart rate abnormalities (% total 16.66%)					
≤ 15	12,235	17.37	1	Ref	
16–30	4878	15.34	0.86	0.83	0.89
31–45	1310	15.51	0.87	0.82	0.93
≥ 46	65	19.29	1.14	0.87	1.49
Meconium-stained amniotic fluid (% total 7.71%)					
≤ 15	5448	7.74	1	Ref	
16–30	2393	7.53	0.97	0.92	1.02
31–45	676	8.00	1.04	0.96	1.13
≥ 46	38	11.28	1.52	1.08	2.17
Hospitalization of mothers					
Prenatal hospitalization (consecutive to or separate from delivery) Total 13.40%					
≤ 15	9209	13.08	1	Ref	
16–30	4252	13.37	1.03	0.99	1.07
31–45	1351	16.00	1.27	1.19	1.35
≥ 46	65	19.29	1.59	1.21	2.08
Hospitalisation 24 h or more before delivery: Total 6.50%					
≤ 15	4408	6.26	1	Ref	
16–30	2090	6.57	1.05	1.00	1.11
31–45	673	7.97	1.30	1.19	1.41
≥ 46	42	12.46	2.13	1.54	2.95
Out-of-hospital deliveries (% total: 0.23%)					
≤ 15	132	0.19	1	Ref	
16–30	93	0.29	1.56	1.20	2.04
31–45	29	0.34	1.84	1.23	2.75
≥ 46	0	0			
Medical induction of labor (*N*=65,334: total 16.86%)					
≤ 15	6752	17.08	1	Ref	
16–30	3332	16.53	0.96	0.92	1.01
31–45	886	16.42	0.95	0.88	1.03
≥ 46	44	18.11	1.07	0.77	1.49

[a]Cochran-Armitage Test for trend [b] (consecutive to or separate from delivery).

association appears between unplanned out-of-hospital deliveries and both the 16–30 and 31–45-min classes. Because none of the 337 women living more than 45 min from a maternity ward gave birth outside a hospital, we were unable to assess the association between such a delivery and access distance longer than 45 min (Table 4).

4. Discussion

Our study found significant positive associations among singleton pregnancies between travel time to the nearest maternity unit and key risk factors for perinatal mortality and morbidity including FHR abnormalities, meconium-stained amniotic fluid and unexpected out-of-hospital deliveries (Blondel et al., 2011; Brailovschi et al., 2012; Fischer et al., 2012; Maisonneuve et al., 2011; Maymon et al., 1998; Viisainen et al., 1999; Xu et al., 2009). We also observed a positive, but insignificant, gradient between stillbirth and perinatal mortality rates. These associations persisted after adjustment for the mothers' individual characteristics and for some characteristics of the residential environment. Ninety percent of the women in our sample gave birth at the maternity ward closest to their home, and our results suggest that for obstetric emergencies, as for other emergencies of unexpected onset (Blanchard et al., 2012; Meretoja et al., 2012; Shen and Hsia, 2012; Smith and von Kummer, 2012), the time until medical care begins is an important prognostic factor. Prenatal hospitalizations and hospitalizations 24 h before delivery were also associated with travel time.

These results are consistent with those found both in France (Blondel et al., 2011) and in international studies. Accordingly, they are similar to the mortality results reported by Ravelli (Ravelli et al., 2011a), who showed that in the Netherlands a transportation time exceeding 20 min increased the risk of stillbirths and adverse outcomes. They are also consistent with those of various studies comparing perinatal mortality and morbidity rates in rural and urban areas (Grzybowski et al., 2011; Larimore and Davis, 1995; Lisonkova et al., 2011; Mine and Babazono, 2004; Nesbitt et al., 1990; Tromp et al., 2009). Nonetheless our conclusions diverge from those of the studies of Parker (Parker et al., 2000) and Dummer (Dummer and Parker, 2004) conducted in Cumbria (UK) for the period from 1950 to 1993, which found no associations between perinatal mortality rate and travel time to the maternity ward. It should nonetheless be noted that these results were not adjusted for gestational age and that in other studies in Cumbria during the same period the authors showed a risk of mortality higher in urban than rural areas (Dickinson et al., 2002). They also found strong geographic heterogeneity of environmental risk factors: stillbirth and lethal congenital anomaly rates were higher near the incinerators, crematoriums (Dummer et al., 2003a), and landfill sites (Dummer et al., 2003b) of the region. This geographic configuration of the distribution of risks may explain the absence of an association between travel time to the maternity ward and perinatal mortality observed in Cumbria. Moreover, given the length of the study period (1950–1993), major changes in obstetric practices could have occurred (and probably did); this was not the case in Burgundy from 2000 through 2009.

On the other hand, it is also likely that professionals have, through experience, developed strategies aimed at minimizing the risks associated with the random nature of the spontaneous onset of labor. This would explain the increase in antenatal hospitalization observed in our study in Burgundy between 2000 and 2009. The maternity ward might thus be a French transposition of the Scandinavian “maternity waiting homes" (WHO, 1996). “Maternity waiting homes" located near maternity units, are facilities where women who live in distant isolated areas can stay for the final weeks before term (WHO, 1996) and thus be near a hospital when spontaneous labor begins. Examples in Europe include the conversion of nurses' dormitories to “patient hotels" for this purpose in Finland (WHO, 1996), and the maintenance of “maternity homes" in regions of Norway where travel time to the closest maternity ward is 2–3.5 h. A maternity home is a delivery unit run by midwives with a general practitioner (GP) as the formal medical leader (Smith and von Kummer, 2012). Only women whose pregnancy is at very low risk and who have no predictable risk of intrapartum complications can give birth in these facilities.

Our study has some limitations. Although the enhanced PMSI database we used enabled an exhaustive longitudinal description of hospitalization in Burgundy, these data cannot be used to construct fine-area geographic analyses that take local regional specificities into account, since the PMSI geographic code is the only information available for the women's residence. All women living in the same geographic code were thus assigned the same travel time to the closest maternity ward.

It must nonetheless be noted that after excluding the PMSI geographic codes with more than 6% of deliveries outside Burgundy, all women had a nearest maternity unit within the Burgundy region thus eliminating bias from our focus on maternity units within the region. This bias could arise if low risk women left the region (to deliver in units closest to their homes) while high risk women were referred to specialized units within the region. This threshold of 6% for the exclusions was chosen because it provided a clear threshold differentiating between zones with few women delivering outside the region and those where these deliveries were more common.

Because of this limitation and despite the fact that travel times were calculated simulating rapid ambulance type vehicles, they might well be underestimates. Data aggregation minimizes travel times, and especially maximum times (Table 1). Furthermore, travel times were set to 0 in municipalities with a maternity ward. These problems inherent in calculation of travel time using geographic codes have been reported in numerous French (Blondel et al., 2011; Coldefy et al., 2011) and foreign studies (Ravelli et al., 2011a).

Moreover, in view of the size of our sample and the small number of women living more than 45 min away [337 births (Table 2)], we could not study the outcome of children born outside the hospital or those with signs of acute fetal distress. We know that even in populations at low risk (Maymon et al., 1998), meconium-stained amniotic fluid and FHR abnormalities are risk factors not only for stillbirth (Brailovschi et al., 2012; Ohana et al., 2011) but also for neonatal mortality and morbidity (Fischer et al., 2012; Maymon et al., 1998; Sheiner et al., 2002a; Xu et al., 2009), and neurologic disabilities (Boog, 2010; Kamoshita et al., 2010). Finally, diverse studies have shown an increase in the risk of perinatal mortality and severe neonatal morbidity among children born unexpectedly outside of a hospital (Jones et al., 2011; Sheiner et al., 2002b), including among full-term children (Hadar et al., 2005).

Our results must nonetheless be confirmed and detailed, in Burgundy as in other regions, by studies conducted over a longer period, to increase the number of subjects, to be able to study the consequences – both during the neonatal period and over a longer period – of prolonging travel time to the nearest maternity ward. By comparing across regions, for example, it would be possible to consider different strategies that may mitigate the impact of longer travel distances on pregnancy outcomes in different regions. As mentioned above with respect to maternity homes or policies of hospitalizing higher risk women before delivery, there are varying approaches to minimizing the potential adverse health impacts of long distances. For services provided during pregnancy, for instance, perinatal proximity centers (CPP) were opened to provide prenatal care and screening visits. However, these centers are not open around the clock, are not permitted to deliver babies, and do not have the capacity to provide emergency services in cases of imminent delivery.

Confirming the existence of a negative association between distance and outcome is especially important given that one of the objectives of the closures of small maternity units (JO, 1998), including in rural areas, was to improve the safety of mothers and

Table 4
Travel time (in minutes) to the nearest maternity ward and outcomes – Multilevel models.

Time (minutes)[a]	β Coef	Std	*p-value*	Adjusted OR[b]	95% CI	
					Min	Max
Mortality						
Stillbirths						
≤ 15	–	–	–	1	Ref	
16–30	0.15	0.10	0.12	1.16	0.96	1.40
31–45	0.27	0.20	0.17	1.31	0.89	1.93
≥ 46	0.64	0.51	0.21	1.90	0.70	5.15
Perinatal mortality						
≤ 15	–	–	–	1	Ref	
16–30	0.08	0.09	0.40	1.08	0.90	1.29
31–45	0.17	0.16	0.31	1.18	0.86	1.62
≥ 46	0.61	0.53	0.25	1.85	0.66	5.19
Signs of acute fetal distress						
Abnormalities fetal heart rate (FHR)						
≤ 15	–	–	–	1	Ref	
16–30	−0.03	0.08	0.68	0.97	0.82	1.14
31–45	0.25	0.12	0.04	1.28	1.01	1.63
≥ 46	0.96	0.15	$< 10^{-3}$	2.60	1.95	3.48
Meconium-stained amniotic fluid						
≤ 15	–	–	–	1	Ref	
16–30	0.12	0.11	0.27	1.13	0.91	1.41
31–45	0.46	0.16	0.01	1.59	1.16	2.19
≥ 46	1.30	0.20	$< 10^{-3}$	3.68	2.50	5.40
Hospitalization of mothers						
Prenatal hospitalisation (consecutive to or separate from delivery)						
≤ 15	–	–	–	1	Ref	
16–30	0.10	0.05	0.04	1.11	1.01	1.22
31–45	0.16	0.06	0.01	1.17	1.04	1.32
≥ 46	0.32	0.26	0.21	1.38	0.83	2.28
Hospitalization 24 h or more before delivery						
≤ 15	–	–	–	1	Ref	
16–30	0.10	0.05	< 0.05	1.10	1.00	1.22
31–45	0.15	0.07	< 0.05	1.16	1.00	1.34
≥ 46	0.58	0.26	0.03	1.78	1.07	2.97
Out-of-hospital deliveries						
≤ 15	–	–	–	1	Ref	
16–30	0.55	0.18	$< 10^{-3}$	1.73	1.23	2.46
31–45	0.50	0.22	0.03	1.64	1.06	2.54
≥ 46	No out-of-hospital birth recorded					
Medical induction of labor						
≤ 15	–	–	–	1	Ref	
16–30	0.03	0.05	0.57	1.03	0.94	1.12
31–45	0.14	0.07	0.05	1.15	1.00	1.32
≥ 46	0.23	0.13	0.08	1.25	0.97	1.62

NS: Not Significant.

[a] Adjusted for individual level (maternal age, infant sex, term, history of preterm delivery and obstetric history) and environmental level (deprivation and level of urbanization) factors.

[b] Residual variance.

their babies. These closures resulted directly from recommendations of the High Council of Public Health (HCSP, 1994), which had considered that safety was not adequate in maternity units that delivered fewer than 300 babies a year. The experts then extrapolated the safety requirements for pregnancies at high risk to all births and applied the widespread idea that a higher number of patients or admissions are associated with better outcomes.

However, data from the literature about the relation between volume and results in obstetrics are far from concordant. Research in numerous countries including Finland (Hemminki et al., 2011), Australia (Tracy et al., 2006), and New Zealand (Rosenblatt et al., 1985), has concluded that risk does not rise in small maternity units. In Germany, an increase in the risk of per-partum and neonatal mortality was observed in maternity units with fewer than 500 deliveries (Heller et al., 2002). A Norwegian study showed a U-shaped relation between volume and the neonatal mortality rate, with equivalent associations for maternity units delivering 101–500 infants a year and those with more than 3000 (Moster et al., 1999). A study in Sweden found no relation between volume and neonatal mortality for high-risk pregnancies, but a negative association for pregnancies at low risk (Merlo et al., 2005). The results of studies comparing outcomes between geographical areas with different sizes of reference maternity units are equally heterogeneous (Finnstrom et al., 2006; Moster et al., 2001; Viisainen et al., 1994). Furthermore, these analyses based on areas of residence can cause methodological problems (Moster et al., 2000), and the variations in mortality rate observed in different catchment areas (Finnstrom et al., 2006) can be difficult to relate to the reference maternity units in the area, in particular because of interregional flows, women's own choices for their maternity unit (Combier et al., 2004), and the transfer of high-risk pregnancies (Finnstrom et al., 2006) toward level III maternity units. Moreover, the results found in countries where the distances or travel time are short cannot necessarily be extrapolated to regions where the distance and time are longer, as in Burgundy (Pilkington et al., 2010).

In France a perinatal audit in the district of Seine Saint-Denis from 1989 through 1992 found no differences in per-partum and neonatal mortality between maternity units, regardless of their size or level of care, after adjustments for gestational age and obstetric complications (Combier et al., 2007). For preterm infants born before 33 weeks, only level of care influenced mortality rates (Papiernik and Combier, 1998). Finally, in Burgundy, no particular danger in small maternity units has ever been reported during the annual assessment by the perinatal network (Cornet et al., 2001; Sagot et al., 2003).

Obstetrics is not the only specialty for which the association between volume and outcome can be challenged (McKee and Healy, 2000; Sowden et al., 1997). The authors of a literature review on this subject concluded that many studies were of poor quality and did not adequately adjust for case mix and that the best research did not support the existence of a general volume–quality relationship (NHS, 1996). To explain the contradictory results in this field, some hypothesize that the different health-care systems and funding models affect the relationship between volume and outcomes (Urbach et al., 2005). New studies on the beneficial effects of the concentration of resources in a limited number of maternity facilities appear necessary. They must take into account harmful effects of the longer access time if that is confirmed.

Another objective of the restructuring of the hospital care supply has been to reduce costs (Hemminki et al., 2011; McKee and Healy, 2000; NHS, 1996) through economies of scale. If further studies confirm our results, the increase in obstetrical and neonatal complications associated with travel time, by the expensive care they will require, will modify the costs of this hospital care. The additional costs, as well as those due to modifications in obstetrical practices aimed at minimizing risk, will reduce the expected short-term benefits. These additional costs should be taken into account during assessments of the economic value of restructuring already performed or planned.

5. Conclusion

Our results show that in the region of Burgundy longer travel time to the nearest maternity unit had a negative effect on perinatal health outcomes. This type of study should be extended to other geographic regions of the same type, because if these results are generalizable, they should be considered in the assessments of the benefits, both medical and economic, expected from hospital restructuring especially in rural regions.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.healthplace.2013.09.006.

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