OBSTETRICS

Early and total neonatal mortality in relation to birth setting in the United States, 2006-2009

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OBJECTIVE: We examined neonatal mortality in relation to birth settings and birth attendants in the United States from 2006 through 2009.

STUDY DESIGN: Data from the Centers for Disease Control and Prevention—linked birth and infant death dataset in the United States from 2006 through 2009 were used to assess early and total neonatal mortality for singleton, vertex, and term births without congenital malformations delivered by midwives and physicians in the hospital and midwives and others out of the hospital. Deliveries by hospital midwives served as the reference.

RESULTS: Midwife home births had a significantly higher total neonatal mortality risk than deliveries by hospital midwives (1.26 per 1000 births; relative risk [RR], 3.87 vs 0.32 per 1000; $P < .001$). Midwife home births of 41 weeks or longer (1.84 per 1000; RR, 6.76 vs 0.27 per 1000; $P < .001$) and midwife home births of women with a first birth (2.19 per 1000; RR, 6.74 vs 0.33 per 1000; $P < .001$) had significantly higher risks of total neonatal mortality than deliveries by hospital midwives. In midwife home births, neonatal mortality for first births was twice that of subsequent births (2.19 vs 0.96 per 1000; $P < .001$). Similar results were observed for early neonatal mortality. The excess total neonatal mortality for midwife home births compared with midwife hospital births was 9.32 per 10,000 births, and the excess early neonatal mortality was 7.89 per 10,000 births.

CONCLUSION: Our study shows a significantly increased total and early neonatal mortality for home births and even higher risks for women of 41 weeks or longer and women having a first birth. These significantly increased risks of neonatal mortality in home births must be disclosed by all obstetric practitioners to all pregnant women who express an interest in such births.

Key words: birth attendants, birth settings, home births, midwives, neonatal mortality, physicians

Cite this article as: Grünebaum A, McCullough LB, Sapra KJ, et al. Early and total neonatal mortality in relation to birth setting in the United States, 2006-2009. Am J Obstet Gynecol 2014;211:390.e1-7.

Despite the increase in home births in the United States over the last decade,[1] the safety of home births has remained controversial. In our previous publication using the US natality data,[2] we reported that home birth has an increased relative risk of 5 minute Apgar scores of zero and of seizures and other adverse neurological outcomes. Although a 5 minute Apgar score of zero is related to neonatal mortality,[3] the linked birth/infant datasets (for live births and infant deaths) allow for the direct assessment of neonatal mortality relative to birth setting and attendant.[4]

The purpose of this study therefore was to examine early, total, and excess neonatal mortality rates for singleton term births without congenital malformations by birth setting and birth attendant (hospital physician, hospital midwife, freestanding birth center, midwife, home midwife, and other for home births).

Materials and Methods

The 1989 revision of the US Standard Certificate of Live Birth provides additional detail for out-of-hospital births and makes it possible to distinguish among out-of-hospital births at home, in a birthing center, or other specified location.[1] In contrast to the birth certificate files, which provide information on delivery, it is necessary to go to the Centers for Disease Control and Prevention (CDC)—linked birth/infant death dataset (for live births and infant deaths) to analyze neonatal mortality.

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Received Jan. 19, 2014; revised Feb. 12, 2014; accepted March 19, 2014.

The authors report no conflict of interest.

Presented at the 34th annual meeting of the Society for Maternal-Fetal Medicine, New Orleans, LA, Feb. 3-8, 2014.

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0002-9378/$36.00 • • http://dx.doi.org/10.1016/j.ajog.2014.03.047

TABLE 1
Characteristics

Total	Hospital physician	Hospital MW	Freestanding BC MW	Home all MW	Home other
Total	12,709,881	1,096,555	39,523	61,993	28,119
Parity total	12,658,411	1,090,290	39,254	61,051	27,643
Para 0	5,193,419 (41)	432,018 (39.6)	14,036 (35.8)	13,884 (22.7)	5024 (18.2)
Para ≥1	7,464,992 (59)	658,272 (60.4)	25,218 (64.2)	47,167 (77.3)	22,619 (81.8)
GA total, wks	12,709,881	1,096,555	39,523	61,993	28,119
≥41	2,006,179 (15.8)	223,329 (20.4)	10,419 (26.4)	17,572 (28.3)	7693 (27.4)
≥42	810,809 (6.4)	84,512 (7.7)	3425 (8.7)	5913 (9.5)	3023 (10.8)
BW total	12,709,881	1,096,555	39,523	61,993	28,119
≥4000 g	1,120,028 (8.8)	97,893 (8.9)	6626 (16.8)	13,653 (22)	5387 (19.2)
≥4500 g	151,128 (1.2)	11,093 (1.0)	1171 (3)	2821 (4.6)	1256 (4.5)
Maternal age total, y	12,709,881	1,096,555	39,523	61,993	28,119
<25	4,392,994 (34.6)	449,782 (41)	9296 (23.5)	10,102 (16.3)	6097 (21.7)
25-29	3,610,725 (28.4)	317,099 (28.9)	13,385 (33.9)	19,292 (31.1)	8315 (29.6)
30-34	2,920,352 (23)	218,075 (19.9)	10,864 (27.5)	18,916 (30.5)	7602 (27)
≥35	1,785,860 (14.1)	111,599 (10.2)	5978 (15.1)	13,683 (22.1)	6105 (21.7)
R/E total	12,622,924	1,089,006	39,298	61,097	27,666
NH white	6,939,531 (55)	572,702 (52.6)	31,552 (80.3)	55,466 (90.8)	22,269 (80.5)
NH black	1,710,594 (13.6)	143,371 (13.2)	1835 (4.7)	1132 (1.9)	2316 (8.4)
NH other	846,850 (6.7)	75,083 (6.9)	1042 (2.7)	1263 (2.1)	809 (2.9)
Hispanic	3,125,949 (24.8)	297,850 (27.4)	4869 (12.4)	3236 (5.3)	2272 (8.2)

BC, birthing center; *BW*, birthweight; *GA*, gestational age; *MW*, midwife; *NH*, non-Hispanic; *R/E*, race/ethnicity.

Grünebaum. Total neonatal mortality in relation to birth setting. Am J Obstet Gynecol 2014.

This dataset (linked file) is generally the preferred source for infant and neonatal mortality in the United States.[4]

It contains detailed information for the approximately 4 million births in the United States each year, including birth setting, birth attendant, and neonatal mortality.[5] Period-linked files use all births in a year as the denominator and all deaths in a year as the numerator, regardless of when the birth occurred (eg, if the birth was in late 2008, then neonatal death could have been 2008 or 2009 but counted in the 2008 numerator only if the death occurred in 2008).

The 2006-2009 period-linked birth/infant deaths dataset was analyzed to examine early (deaths <7 days of life) and total (deaths <28 days of life) neonatal mortality in term singleton births (≥37 weeks and newborn weight of ≥2500 g) without documented congenital malformations by birth setting (hospital, birthing center, home) and provider: hospital midwife (certified nurse midwives [CNMs] and other midwife [MW]; hospital MW), hospital physician (MD or DO), free-standing birthing center midwife (CNM and other MW), home midwife (CNM and other MW, home MW), home other (including emergency situations, such as unattended births and "any other person delivering the baby, such as a husband or family member, emergency medical technician, or taxi driver").[1]

Total neonatal mortality (tNNM) is defined as the death of a live-born neonate before 28 days of life, and early neonatal mortality (eNNM) is defined as neonatal death before 7 days of life. We also examined the relative risks associated with delivery by provider and setting compared with hospital midwives. Excess neonatal mortality is defined as the increased number of neonatal deaths per 10,000 births by provider and setting, using hospital-based midwife deliveries as the reference group. Data on patient characteristics included parity, race and ethnicity, maternal age, and clinical factors such as neonatal weight and weeks of gestation at delivery.

We excluded infants if they met any of the following criteria: birth attendant type was not recorded; birth place was anywhere else but the hospital, home, or freestanding birthing center, or not recorded; gestational age was less than 37 weeks or not recorded; birthweight was less than 2500 g or not recorded; multiple gestations; any congenital anomaly,

TABLE 2
Term neonatal mortality (0-27 days) by birth setting, birth attendant, and parity and postdates

Neonatal mortality	Per 1000 (n/total)	RR (95% CI)	*P* value
Hospital midwife	0.32 (356/1,096,555)	1	
Hospital physician	0.55 (6977/12,709,881)	1.69 (1.52–1.88)	
Freestanding BC midwife	0.59 (23/39,523)	1.81 (1.19–2.75)	
Home midwife	1.26 (78/61,993)	3.87 (3.03–4.95)	
Home other	1.87 (52/28,119)	5.75 (4.31–7.68)	
Total	0.54 (7486/13,936,071)		
Neonatal mortality (para = 0)			
Hospital midwife	0.33 (141/432,018)	1	
Hospital physician	0.57 (2946/5,193,19)	1.74 (1.47–2.06)	
Freestanding BC midwife	1.01 (14/14,036)	3.1 (1.8–5.36)	
Home midwife	2.19 (30/13,884)	6.74 (4.55–9.96)	
Home other	3.01 (15/5024)	9.26 (5.45–15.72)	
Total	0.56 (3146/5,658,381)		
Neonatal mortality (para >0)			
Hospital midwife	0.32 (213/658,272)	1	
Hospital physician	0.53 (3981/7,464,992)	1.65 (1.43–1.89)	
Freestanding BC midwife	0.36 (9/25,218)	1.10 (0.57–2.15)	NS
Home midwife	0.96 (45/47,167)	2.97 (2.16–4.09)	
Home other	1.43 (32/22,619)	4.41 (3.05–6.38)	
Total	0.52 (4280/8,218,268)		
Neonatal mortality (<41 wks)			
Hospital midwife	0.34 (295/873,226)	1	
Hospital physician	0.55 (5862/10,703,702)	1.62 (1.44–1.82)	
Freestanding BC midwife	0.48 (14/29,104)	1.44 (0.85–2.46)	NS
Home midwife	1.02 (45/44,421)	3.03 (2.22–4.14)	
Home other	2.12 (43/20,426)	6.29 (4.57–8.64)	
Total	0.54 (6259/11,670,879)		
Neonatal mortality (≥41 wks)			
Hospital midwife	0.27 (61/223,329)	1	
Hospital physician	0.56 (1116/2,006,179)	2.04 (1.58–2.64)	
Freestanding BC midwife	0.86 (9/10,419)	3.17 (1.58–6.38)	
Home midwife	1.84 (32/17,572)	6.76 (4.42–10.36)	
Home other	1.19 (9/7693)	4.35 (2.17–8.72)	
Total	0.54 (1227/2,265,192)		

BC, birthing center; *CI*, confidence interval; *NS*, not significant; *RR*, relative risk.

Grünebaum. Total neonatal mortality in relation to birth setting. Am J Obstet Gynecol 2014.

Down syndrome, or other chromosomal disorder was confirmed or pending; and a resident of a foreign country.

Because nonidentifiable data from a publicly available dataset were used, our study was not considered human subjects research and did not require review by the Weill Medical College of Cornell University Institutional Review Board.

Analysis of data

We analyzed tNNM (deaths <28 days of age) and eNNM (deaths <7 days of age). We computed relative risks (RRs) for all patients with a first birth (para = 0) and with a second or higher order birth (para of ≥1), and for term and postterm (≥41 weeks) pregnancies. Hospital midwives (hospital MW) included both CNMs and other midwives and served as the reference group for the estimation of early, total, and excess neonatal mortality. A freestanding birthing center midwife (CNM and other MW) and home midwives (home MW) include both CNMs and other midwives. Home 'others' includes others identified by the CDC database as attending home births, including family members, emergency medical service, or police, and taxi drivers as well as unattended births.

Data were extracted using SAS version 9.3 (SAS Institute, Cary, NC) and compiled in Excel (Microsoft, Redmond, WA). The RRs and 95% confidence intervals were computed in SAS version 9.3 (SAS Institute). Excess mortality was computed in OpenEpi.[6]

RESULTS

Table 1 shows the characteristics of the study population. There were 13,936,071 deliveries between 2006 and 2009 that met study criteria. The majority of deliveries were by physicians in the hospital (91.2%) followed by hospital midwives (7.78%), home midwives (0.44%), midwives in freestanding birthing centers (0.28%), and home deliveries by others (0.2%).

When compared with hospital births, home births were more likely to have a postdate pregnancy of 41 or more weeks: 28.3% for home births midwives vs 20.4% for hospital midwives and 15.7% for hospital physicians ($P < .001$); and 42 or more weeks: 9.5% in home births midwives vs 7.7% for hospital midwives and 6.4% for hospital physicians ($P < .001$). Women delivered

TABLE 3
Term early neonatal mortality (0-6 days) by birth setting, birth attendant, parity, and postdates

Early neonatal mortality	Per 1000 (n/total)	RR (95% CI)
Hospital midwife	0.14 (155/1,096,555)	1
Hospital physician	0.29 (3648/12,709,881)	2.04 (1.73–2.39)
Freestanding BC midwife	0.46 (18/39,523)	3.26 (2.01–5.31)
Home midwife	0.93 (58/61,993)	6.6 (4.88–8.93)
Home other	1.65 (46/28,119)	11.73 (8.45–16.28)
Total	0.28 (3925/13,936,071)	
Early neonatal mortality (P = 0)		
Hospital midwife	0.13 (58/432,018)	1
Hospital physician	0.31 (1634/5,193,419)	2.35 (1.81–3.05)
Freestanding BC midwife	0.8 (11/14,036)	5.94 (3.13–11.27)
Home midwife	1.82 (25/13,884)	13.62 (8.54–21.72)
Home other	2.61 (13/5024)	19.5 (10.71–35.48)
Total	0.31 (1741/5,658,381)	
Early neonatal mortality (P >0)		
Hospital midwife	0.14 (95/658,272)	1
Hospital physician	0.27 (1980/7,464,992)	1.84 (1.5–2.27)
Freestanding BC midwife	0.28 (7/25,218)	1.93 (0.9–4.16)
Home midwife	0.66 (31/47,167)	4.62 (3.09–6.91)
Home other	1.25 (28/22,619)	8.71 (5.73–13.25)
Total	0.26 (2141/8,218,268)	
Early neonatal mortality (<41 wks)		
Hospital midwife	0.15 (127/873,226)	1
Hospital physician	0.29 (3066/10,703,702)	1.97 (1.65–2.35)
Freestanding BC midwife	0.35 (10/29,104)	2.4 (1.27–4.55)
Home midwife	0.8 (35/44,421)	5.48 (3.78–7.96)
Home other	1.88 (38/20,426)	12.9 (9–18.51)
Total	0.28 (3276/11,670,879)	
Early neonatal mortality (≥41 wks)		
Hospital midwife	0.12 (27/223,329)	1
Hospital physician	0.29 (583/2,006,179)	2.36 (1.61–3.47)
Freestanding BC midwife	0.77 (8/10,419)	6.25 (2.85–13.74)
Home midwife	1.26 (22/17,572)	10.28 (5.88–17.98)
Home other	1.06 (8/7693)	8.59 (3.93–18.79)
Total	0.29 (648/2,265192)	

BC, birthing center; *CI*, confidence interval; *RR*, relative risk.

Grünebaum. Total neonatal mortality in relation to birth setting. Am J Obstet Gynecol 2014.

at home by midwives were more likely to be 35 years old or older and more likely to have macrosomic infants. Women delivered by midwives at home were more likely to be non-Hispanic white when compared with hospital births.

Table 2 shows the total neonatal mortality (prior to 28 days) and relative risks by parity and weeks before and after 41 weeks gestation by the 5 groups of settings and attendants.

Midwife home births had a significantly higher nearly 4-fold total neonatal mortality risk when compared with those delivered by hospital midwives (1.26 per 1000 births; RR, 3.87 vs 0.32 per 1000; $P < .001$).

Midwife home births of women with a first birth had a significantly higher nearly 7-fold risk of total neonatal mortality than those by hospital midwives (2.19 per 1000; RR, 6.74 vs 0.33 per 1000; $P < .001$) and a neonatal mortality more than twice that of those with a subsequent birth (2.19 vs 0.96 per 1000; $P < .001$).

Midwife home births of 41 or more weeks had a significantly higher nearly 7-fold risk of total neonatal mortality than those delivered by hospital midwives (1.84 per 1000; RR, 6.76 vs 0.27 per 1000; $P < .001$).

Table 3 shows the term early neonatal mortality (0-6 days) and relative risks by parity and weeks before and after 41 weeks gestation by the 5 groups of settings and attendants. Midwife home births had a significantly higher nearly 7-fold early neonatal mortality risk when compared with those delivered by hospital midwives (0.93 per 1000 births; RR, 6.6 vs 0.14 per 1000; $P < .001$).

Midwife home births of women with a first birth had a significantly higher 13- to 14-fold risk of early neonatal mortality than those by hospital midwives (1.82 per 1000; RR, 13.62 vs 0.13 per 1000; $P < .001$) and an early neonatal mortality nearly 3 times that of those with a subsequent birth (1.82 vs 0.66 per 1000; $P < .001$).

Midwife home births of 41 or more weeks had a significantly higher nearly 10-fold risk of early neonatal mortality than those delivered by hospital midwives (1.26 per 1000; RR, 10.28 vs 0.12 per 1000; $P < .001$).

Table 4 shows the excess early and total neonatal mortality per 10,000 births for the 5 groups with hospital MW serving as the reference group. Home births by others had an excess total

TABLE 4
Term excess early and total neonatal mortality

Birth setting and provider	NNM Per 10,000 births	eNNM	Excess tNNM Per 10,000 births (95% CI)	Excess eNNM Per 10,000 births (95% CI)
Hospital midwife	3.2	1.4	0	0
Hospital physician	5.5	2.9	2.24 (1.88–2.6)	1.46 (1.22–1.7)
Freestanding BC midwife	5.9	4.6	2.62 (0.21–5.03)	3.19 (1.07–5.32)
Home midwife	12.6	9.3	9.32 (6.51–12.1)	7.89 (5.48–10.30)
Home other	18.7	16.5	15.42 (10.37–20.48)	15.12 (10.37–19.87)

BC, birthing center; *CI*, confidence interval; *eNNM*, excess neonatal mortality; *tNNM*, total neonatal mortality.

Grünebaum. Total neonatal mortality in relation to birth setting. Am J Obstet Gynecol 2014.

neonatal mortality of 15.42 per 10,000, whereas neonates delivered by midwives at home had an excess of 9.32 per 10,000 births when compared with midwife hospital births.

Comment

There has been an increase in home births in the United States over the last decade.[1] Studies have shown purported advantages of home births including fewer interventions, lower cesarean delivery rates, and less use of medications or analgesia.[7-10] The decrease in obstetric interventions in home births should be balanced against the increased neonatal risks.[10,11]

This study on early and total neonatal mortality utilized the largest and most reliable dataset on neonatal mortality for live births in the United States, which uses "...the many additional variables available from the birth certificate to conduct more detailed analyses of infant mortality patterns."[4]

Our analysis shows a substantially increased risk of neonatal deaths when delivery occurred outside the hospital. There is a clear pattern in our study: total and early neonatal mortality is significantly increased in home births. Nulliparous patients and patients at 41 or more weeks' gestation have even higher neonatal mortality risks in the home setting when compared with the hospital. The higher neonatal mortality rate for hospital physicians when compared with hospital midwives almost certainly reflects the fact that hospital physicians deliver a higher-risk population than hospital midwives and deliver patients with complications transferred from the hospital midwifery service to the hospital physician service.

Our study reports on the largest population to date comparing neonatal mortality among different birth settings and providers. Other studies have found similar patterns of adverse neonatal outcomes in home births such as an increase in Apgar scores of zero, low Apgar scores, higher neonatal mortality, and an increase in hypoxic ischemic encephalopathy.[2,10,12-14] Some studies conducted outside the United States reported similar[7-9,15,16] or better[17-19] outcomes in home births when compared with hospital births, whereas other studies from outside and within the United States have shown increased neonatal morbidity and mortality in home births.[2,10,12-14,17,20,21] Home birth studies from outside the United States such as Australia, The Netherlands, and the United Kingdom are of limited comparability with those in the United States because, contrary to the United States, in these countries this birth option is integrated more fully into the medical care system.[10]

Patients with advanced maternal age have worse outcomes and have a higher risk of reaching 41 and 42 weeks.[22,23] Advanced maternal and gestational age, as well as macrosomia, has been shown to increase neonatal mortality and morbidity,[22-26] especially in nulliparous patients,[27] and meconium aspiration syndrome.[28] Those induced at an earlier gestational age had better neonatal outcomes.[29]

Pregnancies beyond 41 weeks' gestation, nulliparous patients, and mothers who are 35 years and older have an increased risk of neonatal mortality.[24,26,27,30] This may partially explain the increased neonatal mortality among home births, in which there are more older mothers and pregnancies who deliver beyond 41 weeks. Patients delivering at home have no access to electronic fetal monitoring, which has been found to decrease neonatal mortality.[31]

The American Academy of Pediatrics in their home birth policy[32] recommends that planned home births should not exceed 41 weeks. However, 28.3% of midwife home births in our study exceeded that threshold, and according to the American Academy of Pediatrics statement, these home births should have been performed only in the hospital. Because of the increased risks of neonatal mortality in births beyond 41 weeks, midwives should not plan to deliver patients beyond 41 weeks at home and instead they should immediately transfer their patients.

Malloy[33] reported an increased term vaginal delivery neonatal mortality rate of 1.60 (89 of 55,634) for home midwives when compared with 0.5 of 1000 (614 of 1,237,129) for hospital certified midwives (RR, 3.2). Accordingly, we observed a similarly higher total neonatal mortality of 1.26 of 1000 (RR, 3.87) in midwife home deliveries.

Ananth et al[34] reported that electronic fetal monitoring appears to be associated with a modest decline in neonatal mortality. Considering that electronic fetal monitoring is not available in home births, this may explain in part the increase in neonatal mortality in home births.

In our study, hospital births included about 40% of black or Hispanic patients as compared with about 7% blacks and Hispanic in home births. Mathews and MacDorman[35] have shown that neonatal mortality is significantly higher in black

and Hispanic patients. These data suggest that the increased mortality at home births that we have documented may be understated.

The strength of our study is that we used the linked birth/infant death dataset (period-linked file), which is generally the preferred source for infant and neonatal mortality in the United States.[4] According to CDC data,[35] "almost all the home births attended by certified nurse-midwives/certified midwives (98%) or 'other' midwives (99%) were planned,"[36] and therefore, it is appropriate to use midwife-attended home births as proxy for planned home births.

There are some limitations in our study. Criticism has been expressed about certain data collected in birth and death certificates,[37] although others believe that the data are reliable.[38-40]

As in our previous study,[2] our results likely underestimate the actual neonatal mortality rates in home births because the higher adverse neonatal outcomes for patients transferred from home to the hospital are counted in the CDC-linked data as hospital and not home birth neonatal outcomes.

Hildingsson et al[41] previously recommended for Swedish records that adding information on whether this was a planned home birth for women transferred before birth could produce better statistics with the opportunity to follow up women who choose to give birth outside a hospital. On the 2003 revised US birth certificate, information on planned and unplanned home birth is collected, but information on whether a birth in the hospital is the result of a transferred home delivery is not collected. We believe that US birth certificate data would be improved by using a new revision that specifies those who originally planned a home birth and then were transferred to the hospital.

Conclusions

Our study shows that home births are at increased risk for early and total neonatal mortality, a risk that further increases for women with a first birth and pregnancies of 41 or more weeks' gestation. We emphasize that this increased risk is a function of the out-of-hospital setting rather than the provider. Patients considering a home birth should appreciate that home births are associated with not only increased neonatal deaths but also other increased neonatal risks such as low Apgar scores[2] and an increased risk of neonatal hypoxic ischemic encephalopathy.[12]

As part of the informed consent process, obstetric providers should recommend strongly for hospital births and against planned home births with evidence-based recommendations. They should explain that these recommendations are based on the documented increased risk of neonatal mortality and morbidity in home births. Doing so is essential for obstetric providers to fulfill their professional responsibility and to empower the autonomy of pregnant women in the informed consent process by providing clinically important information.[42]

Physicians and other health care providers have a professional responsibility to understand, identify, and address the root cause motivating patients' desire for out-of-hospital birth by providing evidence-based compassionate hospital care, improve hospital settings, address obstetric interventions,[43,44] and provide excellent, supportive, and nonjudgmental hospital care to women transported from a planned home birth.[45,46] ■

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