SPECIAL ARTICLE

Planned Out-of-Hospital Birth and Birth Outcomes

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ABSTRACT

BACKGROUND
The frequency of planned out-of-hospital birth in the United States has increased in recent years. The value of studies assessing the perinatal risks of planned out-of-hospital birth versus hospital birth has been limited by cases in which transfer to a hospital is required and a birth that was initially planned as an out-of-hospital birth is misclassified as a hospital birth.

METHODS
We performed a population-based, retrospective cohort study of all births that occurred in Oregon during 2012 and 2013 using data from newly revised Oregon birth certificates that allowed for the disaggregation of hospital births into the categories of planned in-hospital births and planned out-of-hospital births that took place in the hospital after a woman's intrapartum transfer to the hospital. We assessed perinatal morbidity and mortality, maternal morbidity, and obstetrical procedures according to the planned birth setting (out of hospital vs. hospital).

RESULTS
Planned out-of-hospital birth was associated with a higher rate of perinatal death than was planned in-hospital birth (3.9 vs. 1.8 deaths per 1000 deliveries, P=0.003; odds ratio after adjustment for maternal characteristics and medical conditions, 2.43; 95% confidence interval [CI], 1.37 to 4.30; adjusted risk difference, 1.52 deaths per 1000 births; 95% CI, 0.51 to 2.54). The odds for neonatal seizure were higher and the odds for admission to a neonatal intensive care unit lower with planned out-of-hospital births than with planned in-hospital birth. Planned out-of-hospital birth was also strongly associated with unassisted vaginal delivery (93.8%, vs. 71.9% with planned in-hospital births; P<0.001) and with decreased odds for obstetrical procedures.

CONCLUSIONS
Perinatal mortality was higher with planned out-of-hospital birth than with planned in-hospital birth, but the absolute risk of death was low in both settings. (Funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development.)

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N Engl J Med 2015;373:2642-53.
DOI: 10.1056/NEJMsa1501738

In recent years, U.S. rates of planned out-of-hospital birth (i.e., births intended to occur at home or at a freestanding birth center) have increased. The rate of birth at home increased by 20% (from 0.56% to 0.67%) between 2004 and 2008 and by approximately 60% between 2008 and 2012, reaching 0.89% of all births.[1] There has been a parallel trend in the use of birth centers, from 0.23% in 2004 to 0.39% in 2012.[2]

According to recent U.S. studies of out-of-hospital birth, women planning to deliver at home had lower rates of obstetrical intervention,[3-5] and their infants had higher rates of complications and death.[3,6,7] Potential explanations for these findings as they relate to obstetrical interventions include differences in models for obstetrical care (i.e., care provided by an obstetrician, by a certified nurse-midwife, or by certified professional midwife[8]), in the practices of the birth attendant, in provider and maternal preference for (and the availability of) medical technology, and in maternal characteristics. Few studies have compared outcomes at birth centers with those at other birth settings.[2,5,9] A key shortcoming of prior studies of planned home birth is the classification of births by the eventual rather than the intended place of birth (i.e., intrapartum home-to-hospital transfers were counted as hospital births).[3,7,10]

In 2012, the home birth rate in Oregon was 2.4%, which was the highest rate of any state; another 1.6% of women in Oregon delivered at birth centers.[11] Before licensure became mandatory in 2015, Oregon was one of two states in which licensure was not required for the practice of midwifery in out-of-hospital settings.[12] Although the 2003 revision of the U.S. Standard Certificate of Live Birth distinguishes planned home births from unplanned home births, at the national level there is still no way to disaggregate hospital births that were intended to occur at a hospital and those that had not been intended to occur at a hospital. On January 1, 2012, Oregon introduced new questions on the birth certificate to document the planned place of delivery at the time a woman began labor.[13] We used birth-certificate data to assess maternal outcomes and fetal and neonatal outcomes according to the planned place of delivery.

METHODS

STUDY DESIGN

Our intent was twofold: to assess the rates of outcomes according to planned place of delivery (hospital or out of hospital) in Oregon with the use of multiple adjustment techniques and to show the effects of the misclassification of out-of-hospital-to-hospital transfers on these comparisons. With this second aim, we used new data on planned birth setting to improve the interpretation of studies in which investigators could not disaggregate in-hospital births that had been planned to be out-of-hospital births from births that had been planned to be in-hospital births.

We analyzed data from Oregon state birth, infant death, and fetal death certificates from January 1, 2012, through December 31, 2013 (certificates were provided by the Oregon Center for Health Statistics). We matched death records with birth records; the linkage rate for infant deaths was 95%.

The new Oregon birth certificate queries the planned place of delivery by asking all women who have in-hospital deliveries the question "Did you go into labor planning to deliver at home or at a freestanding birthing center?"[13] This step enabled us to disaggregate out-of-hospital-to-hospital transfers from planned hospital births and analyze them according to planned place of delivery. Since the question does not distinguish between planned home births and planned birth-center deliveries, we used a single "planned out-of-hospital" group for the purposes of analysis. We excluded home births that were unplanned, births whose status with regard to intended plan was unknown, and births that occurred in other locations recorded on the birth certificate (e.g., clinic or doctor's office).

Planned hospital births included all births that occurred in the hospital with the exception of births that occurred after intrapartum transfer to the hospital of a woman who had planned an out-of-hospital delivery. We compared planned hospital births with planned out-of-hospital births (an aggregate group of planned home births and planned birth-center births), including the out-of-hospital-to-hospital transfers. We also calculated outcome rates before reclassification to determine the effect of misclassification in standard vital statistics data, including prior U.S. studies on place of birth.

We characterized the maternal demographic and health-related profile of women who chose hospital birth, women who chose out-of-hospital birth (overall, home, and birth center), and women who chose out-of-hospital birth but delivered in the hospital after transfer. We stratified planned out-of-hospital births according to eventual place of delivery to enable the comparison between completed out-of-hospital births and planned out-of-hospital births that took place in the hospital after the mother's intrapartum transfer and to better characterize differences between the women with these two types of birth experiences. We also described pregnancy characteristics (e.g., planned type of birth attendant when the woman entered labor and length of gestation).

OUTCOMES

We considered a range of prespecified maternal, fetal, and neonatal outcomes, including fetal death, neonatal death (defined as death during the first 28 days after birth), perinatal death (a composite of fetal and neonatal deaths), and infant death (defined as death during the first year of life). Other neonatal outcomes that were assessed included a 5-minute Apgar score of less than 7, a 5-minute Apgar score of less than 4, neonatal seizure, ventilator support (of any duration), and admission to the neonatal intensive care unit (NICU). Outcomes of labor and delivery included induction of labor, augmentation of labor, and type of delivery, which was categorized as unassisted vaginal delivery (vaginal delivery without the use of forceps or vacuum), operative vaginal delivery, or cesarean delivery. Maternal outcomes included admission to the intensive care unit (ICU), blood transfusion, and severe perineal lacerations (third or fourth degree). These analyses were restricted to nonanomalous, singleton, cephalic-presenting births, at or after term (defined as gestational age ≥37 weeks). Because stillbirth is a crucial outcome that may result from variations in obstetrical care, we included stillbirths in the denominator for analyses of stillbirth and perinatal death. We restricted the denominator to live births for all other outcomes, since only live-born neonates were at risk for those outcomes (e.g., neonatal death).

STUDY OVERSIGHT

This research was approved by the institutional review board at Oregon Health and Science University, which did not require informed consent for the use of preexisting administrative data. The first author, who had full access to all study data, assumes responsibility for the data analysis.

STATISTICAL ANALYSIS

We used chi-square tests to compare outcomes according to planned place of delivery and used Fisher's exact test when necessary (if the subgroup size was ≤5). Two-sided P values of less than 0.05 were considered to indicate statistical significance. We used multivariable logistic-regression models to adjust for potential confounders, including maternal race or ethnic group (non-Hispanic white vs. other), parity (nulliparous vs. multiparous), insurance status (public or none vs. other), extent of prenatal care (≥5 visits vs. <5 visits), advanced maternal age (≥35 years vs. <35 years), maternal education (>12 years vs. ≤12 years), history or no history of cesarean delivery, and a composite marker of conditions that confer increased medical risk. This composite variable denoted the presence of one or more of the following conditions: chronic hypertension, gestational hypertension, preeclampsia, eclampsia, prepregnancy diabetes, or gestational diabetes. We calculated the odds ratio and the absolute risk difference to provide estimates of effect on both relative and absolute scales.

To assess the robustness of the results of our regression analysis, we performed covariate adjustment with derived propensity scores to calculate the absolute risk difference (details are provided in the Supplementary Appendix, available with the full text of this article at NEJM.org).[14,15] To calculate the adjusted absolute risk difference, we used predictive margins and G-computation (i.e., regression-model–based outcome prediction in both exposure settings: planned in-hospital and planned out-of-hospital birth).[16,17] Finally, we conducted post hoc analyses to assess associations between planned out-of-hospital birth and outcomes (cesarean delivery and a composite of perinatal morbidity and mortality), which were stratified according to parity, maternal age, maternal education, and risk level. All data management and analyses were performed with the use of Stata software, version 12 (StataCorp).

RESULTS

POPULATION CHARACTERISTICS

Our sample included 79,727 cephalic, singleton, term, nonanomalous deliveries in Oregon in 2012 and 2013. A total of 75,923 women (95.2%) planned to deliver in the hospital and did so, 3203 women (4.0%) chose and completed out-of-hospital birth (1968 at home and 1235 at a birth center), and 601 women (0.8%) planned out-of-hospital birth but delivered in the hospital after intrapartum transfer.

The proportions of women who were white, had private insurance or paid out of pocket, or were of advanced maternal age were higher among women who planned out-of-hospital birth than among those who planned in-hospital birth (Table 1). Preexisting medical conditions (e.g., hypertension and diabetes mellitus) and pregnancy-related medical conditions (e.g., gestational hypertension or preeclampsia and diabetes) were less common among women planning out-of-hospital birth than among those planning in-hospital birth (Table 2). Among women who planned to deliver outside the hospital, women who were transferred to the hospital had higher rates of these conditions than did women who completed an out-of-hospital birth. Women who planned to deliver in hospitals were more likely than women who planned and completed out-of-hospital births to deliver during the early-term period (37 to 38 weeks' gestation) (21.6% vs. 11.1%, P<0.001) and less likely to deliver at 42 weeks' gestation and beyond (1.1% vs. 4.9%, P<0.001).

OUTCOMES

The rate of fetal death did not differ significantly between groups before reclassification (1.3 per 1000 deliveries among in-hospital births vs. 0.6 deaths per 1000 deliveries among out-of-hospital births, P=0.30). After hospital transfers were reclassified as belonging to the planned out-of-hospital birth category, the rate of fetal death was higher (though not quite reaching the level of significance) among out-of-hospital births than among in-hospital births (2.4 vs. 1.2 deaths per 1000 deliveries, P=0.05) (Table 3). Similarly, rates of perinatal and neonatal death did not differ significantly before transfers were reclassified (P>0.1 for all comparisons) but were higher in the case of planned out-of-hospital births than in the case of planned in-hospital births after reclassification (perinatal death, 3.9 vs. 1.8 deaths per 1000 deliveries, P=0.003; neonatal death, 1.6 vs. 0.6 deaths per 1000 deliveries, P=0.02).

Obstetrical procedures were more common among women who had planned in-hospital births than among women who delivered out of the hospital (30.4% vs. 1.5% for induction of labor and 26.4% vs. 1.1% for augmentation of labor, P<0.001 for both comparisons) (Table 3). Hospital procedure rates were unaffected by the reclassification of transferred patients, but the out-of-hospital rates for obstetrical procedures rose after reclassification of transfers (to 4.8% for induction and to 7.5% for augmentation). Among all women who delivered in the hospital, 24.7% had cesarean deliveries. After the reclassification of transferred patients, the out-of-hospital rate of cesarean delivery (performed by a physician who was not the planned birth attendant) was 5.3%. Serious adverse events in the mother were rare in all birth settings.

In analyses adjusted for maternal race and ethnic group, age, parity, and medical conditions associated with greater risk, the associations between planned location of delivery and most adverse outcomes and obstetrical procedures remained significant (Table 4). Planned out-of-hospital birth was associated with increased odds of perinatal death (adjusted odds ratio, 2.43; 95% confidence interval [CI], 1.37 to 4.30; adjusted risk difference, 1.52 deaths per 1000 births; 95% CI, 0.51 to 2.54 per 1000) and neonatal death (adjusted odds ratio, 2.87; 95% CI, 1.10 to 7.47; adjusted risk difference, 0.63 deaths per \1000 births; 95% CI, 0.03 to 1.24 per 1000), but there was no significant increase in the odds of infant death. The odds of NICU admission were lower with planned out-of-hospital births than with planned in-hospital births (adjusted odds ratio, 0.71; 95% CI, 0.55 to 0.92).

Planned out-of-hospital birth remained strongly associated with decreased odds of induced labor (adjusted odds ratio, 0.11; 95% CI, 0.09 to 0.12), cesarean delivery (adjusted odds ratio, 0.18; 95% CI, 0.16 to 0.22), and other obstetrical procedures and increased odds of unassisted vaginal delivery (adjusted odds ratio, 5.63; 95% CI, 4.84 to 6.55). However, the odds of maternal blood transfusion were increased among women who had planned out-of-hospital delivery (adjusted odds ratio, 1.91; 95% CI, 1.25 to 2.93). The results of propensity-score-adjusted analyses

Table 1. Demographic Characteristics of Women According to Planned Birth Setting, Oregon, 2012 and 2013.

Characteristic	All Births (N=79,727)*	Planned Hospital Birth (N=75,923)	Planned, Completed Out-of-Hospital Birth			Transfer from Planned Out-of-Hospital Birth to Hospital Birth (N=601)	P Value†
			Total (N=3203)	Planned Home Birth (N=1968)	Planned Birth-Center Birth (N=1235)		
Race or ethnic group — no. (%)‡							<0.001
White	54,555 (68.4)	51,238 (67.5)	2847 (88.9)	1780 (90.4)	1067 (86.4)	470 (78.2)	
Black	1,979 (2.5)	1,945 (2.6)	24 (0.7)	15 (0.8)	9 (0.7)	10 (1.7)	
Hispanic	15,074 (18.9)	14,882 (19.6)	134 (4.2)	72 (3.7)	62 (5.0)	58 (9.7)	
Asian	4,993 (6.3)	4,896 (6.4)	70 (2.2)	35 (1.8)	35 (2.8)	27 (4.5)	
American Indian or Alaskan native	2,027 (2.5)	1,940 (2.6)	69 (2.2)	38 (1.9)	31 (2.5)	18 (3.0)	
Other	1,099 (1.4)	1,022 (1.3)	59 (1.8)	28 (1.4)	31 (2.5)	18 (3.0)	
Parity — no. (%)							<0.001
0	32,272 (40.5)	30,758 (40.5)	1110 (34.7)	582 (29.6)	528 (42.8)	404 (67.2)	
1	25,958 (32.6)	24,739 (32.6)	1089 (34.0)	678 (34.5)	411 (33.3)	130 (21.6)	
2	12,684 (15.9)	12,136 (16.0)	506 (15.8)	332 (16.9)	174 (14.1)	42 (7.0)	
≥3	8,813 (11.1)	8,290 (10.9)	498 (15.5)	376 (19.1)	122 (9.9)	25 (4.2)	
Insurance status — no./total no. (%)§							<0.001
Public	36,115/79,233 (45.6)	35,243/75,523 (46.7)	681/3122 (21.8)	431/1908 (22.6)	250/1214 (20.6)	191/588 (32.5)	
Private	41,225/79,233 (52.0)	39,507/75,523 (52.3)	1365/3122 (43.7)	615/1908 (32.2)	750/1214 (61.8)	353/588 (60.0)	
Self-pay	1,893/79,233 (2.4)	773/75,523 (1.0)	1076/3122 (34.5)	862/1908 (45.2)	214/1214 (17.6)	44/588 (7.5)	
≥5 Prenatal care visits — no./total no. (%)	75,334/79,727 (94.5)	71,717/73,335 (97.8)	3063/3198 (95.8)	1839/1966 (93.5)	1224/1232 (99.4)	554/572 (96.9)	<0.001
Maternal age — no. (%)							<0.001
<20 yr	4,934 (6.2)	4,887 (6.4)	32 (1.0)	14 (0.7)	18 (1.5)	15 (2.5)	
20–34 yr	62,315 (78.2)	59,383 (78.2)	2483 (77.5)	1466 (74.5)	1017 (82.3)	449 (74.7)	
≥35 yr	12,478 (15.7)	11,653 (15.3)	688 (21.5)	488 (24.8)	200 (16.2)	137 (22.8)	

Education — no./total no. (%)							<0.001
No high school	3,092/79,315 (3.9)	3,072/75,540 (4.1)	10/3179 (0.3)	8/1955 (0.4)	2/1224 (0.2)	10/596 (1.7)	
Some high school or high-school diploma	27,255/79,315 (34.4)	26,461/75,540 (35.0)	701/3179 (22.1)	494/1955 (25.3)	207/1224 (16.9)	93/596 (15.6)	
Some college or college degree	40,480/79,315 (51.0)	38,100/75,540 (50.4)	2007/3179 (63.1)	1201/1955 (61.4)	806/1224 (65.8)	373/596 (62.6)	
Some graduate education	8,488/79,315 (10.7)	7,907/75,540 (10.5)	461/3179 (14.5)	252/1955 (12.9)	209/1224 (17.1)	120/596 (20.1)	

* Included are nonanomalous, term, postterm, singleton, and cephalic births.
† P values are for the comparison of planned in-hospital births with planned out-of-hospital births that were completed out of the hospital and planned out-of-hospital births that occurred in the hospital after a woman's intrapartum transfer to the hospital.
‡ Race or ethnic group was self-reported.
§ Data on insurance status were analyzed only among women with liveborn infants.

were similar to the main findings of our regression analysis in magnitude and direction (Table 4).

In post hoc analyses that assessed the risk of a composite neonatal outcome (fetal death, infant death, a 5-minute Apgar score of less than 4, or neonatal seizures) and the risk of cesarean delivery in subgroups defined according to parity, maternal age, maternal education, and maternal risk profile, we found a significant interaction of maternal age with the planned birth setting for the neonatal composite outcome ($P=0.02$ for interaction) and of parity and maternal education with planned birth location for the outcome of cesarean section ($P<0.001$ for interaction for both). The odds of cesarean section among women planning out-of-hospital birth were lower among multiparous women than among nulliparous women and among women with 12 years of education or less than among women with more than 12 years of education (Fig. 1).

DISCUSSION

We categorized out-of-hospital and in-hospital births in Oregon according to the intended place of delivery and in comparing outcomes found that the risks for some adverse neonatal outcomes were increased among planned out-of-hospital births. In many previous U.S. studies, it was not possible to disaggregate planned in-hospital births from planned out-of-hospital births that took place in the hospital after a woman's intrapartum transfer to the hospital.[3,9,10] The latter births represent 16.5% of planned out-of-hospital births in our population, and misclassification of these births as in-hospital births caused rates of adverse outcomes among planned out-of-hospital births to be underestimated (in some cases, substantially).

We observed higher rates of perinatal deaths, depressed 5-minute Apgar scores, neonatal seizures, and maternal blood transfusions among planned out-of-hospital births; these persisted after multivariable and propensity-score adjustment. In other, similar studies in which it was not possible to account for intrapartum transfers to the hospital, results similar to ours were reported for neonatal deaths, neonatal seizures, and Apgar scores.[3,6,7,9,18]

Out-of-hospital births were also associated with a higher rate of unassisted vaginal delivery

Table 2. Health-Related and Clinical Characteristics of Women According to Planned Birth Setting, Oregon, 2012 and 2013.*

Characteristic	All Births (N=79,727)	Planned Hospital Birth (N=75,923)	Total Planned and Completed Out-of-Hospital Birth (N=3203)	Planned Home Birth (N=1968)	Planned Birth-Center Birth (N=1235)	Planned Out-of-Hospital Birth Transferred to Hospital Birth (N=601)	P Value
	number of women (percent)						
Chronic hypertension	1,050 (1.3)	1,037 (1.4)	7 (0.2)	7 (0.4)	0	6 (1.0)	<0.001
Prepregnancy diabetes	568 (0.7)	567 (0.7)	1 (<0.01)	1 (0.1)	0	0	<0.001
Gestational hypertension, preeclampsia, or eclampsia	4,493 (5.6)	4,442 (5.9)	22 (0.7)	9 (0.5)	13 (1.1)	29 (4.8)	<0.001
Gestational diabetes	5,462 (6.9)	5,392 (7.1)	54 (1.7)	35 (1.8)	19 (1.5)	16 (2.7)	<0.001
Prior cesarean section	10,515 (13.2)	10,350 (13.6)	118 (3.7)	87 (4.4)	31 (2.5)	47 (7.8)	<0.001
Planned birth attendant†							<0.001
M.D. or D.O.	61,275 (76.9)	61,248 (80.7)	0	0	0	27 (4.5)	
Naturopathic doctor	450 (0.6)	2 (<0.1)	417 (13.0)	372 (18.9)	45 (3.6)	31 (5.2)	
Certified nurse-midwife	15,310 (19.2)	14,375 (18.9)	641 (20.0)	195 (9.9)	446 (36.1)	294 (48.9)	
Licensed direct-entry midwife	1,970 (2.5)	4 (<0.1)	1822 (56.9)	1078 (54.8)	744 (60.2)	144 (24.0)	
Other midwife	344 (0.4)	0	247 (7.7)	247 (12.6)	0	97 (16.1)	
Other licensed health care professional, such as R.N. or E.M.T.	284 (0.4)	284 (0.4)	0	0	0	0	
Other person, such as a relative	94 (0.1)	10 (<0.1)	76 (2.4)	76 (3.9)	0	8 (1.3)	
Weeks of gestation — no. (%)							<0.001
37	5,477 (6.9)	5,346 (7.0)	100 (3.1)	64 (3.3)	36 (2.9)	31 (5.2)	
38	11,180 (14.0)	10,887 (14.3)	254 (7.9)	154 (7.8)	100 (8.1)	39 (6.5)	
39	29,942 (37.6)	29,232 (38.5)	582 (18.2)	335 (17.0)	247 (20.0)	128 (21.3)	
40	22,608 (28.4)	20,876 (27.5)	1543 (48.2)	942 (47.9)	601 (48.7)	189 (31.4)	
41	9,496 (11.9)	8,774 (11.6)	567 (17.7)	363 (18.4)	204 (16.5)	155 (25.8)	
≥42	1,024 (1.3)	808 (1.1)	157 (4.9)	110 (5.6)	47 (3.8)	59 (9.8)	

* E.M.T. denotes emergency medical technician.

† Planned birth attendant refers to the attendant present at the time of labor onset.

Table 3. Outcomes for Hospital vs. Out-of-Hospital Births, with and without Reclassifying Transfers as Planned Out-ofHospital Births.*

Outcome	Without Reclassifying Transfer					With Reclassifying Transfer		
	Hospital Birth	Total Out-of-Hospital Births	Planned Home Birth	Planned Birth-Center Birth	P Value	Hospital Birth	Out-of-Hospital Birth	P Value
	percent					*percent*		
Fetal and neonatal								
Fetal death	0.13	0.06	0.10	0	0.30	0.12	0.24	0.05
Perinatal death	0.19	0.19	0.15	0.24	0.97	0.18	0.39	0.003
Neonatal death	0.06	0.12	0.05	0.24	0.16	0.06	0.16	0.02
Infant death	0.16	0.19	0.05	0.40	0.66	0.15	0.21	0.39
5-Minute Apgar score								
<7	1.9	1.7	1.2	2.5	0.51	1.8	2.3	0.05
<4	0.4	0.4	0.3	0.6	0.96	0.4	0.6	0.04
Neonatal seizures	0.04	0.16	0.10	0.24	0.004	0.04	0.13	0.02
Ventilator support	3.3	3.3	2.5	4.5	0.92	3.3	3.8	0.07
NICU admission	3.0	0.9	0.8	1.1	<0.001	2.9	1.7	<0.001
Maternal								
Induction of labor	30.4	1.5	1.3	1.9	<0.001	30.4	4.8	<0.001
Augmentation of labor	26.4	1.1	1.2	1.1	<0.001	26.3	7.5	<0.001
Type of delivery					<0.001			<0.001
Unassisted vaginal	71.8	100.0	99.9	100.0		71.9	93.8	
Operative vaginal	3.5	0	0.1	0		3.5	1.0	
Cesarean	24.7	0	0	0		24.7	5.3	
ICU admission	0.1	0.1	0.1	0.2	0.92	0.1	0.1	0.69
Blood transfusion	0.4	0.6	0.5	0.7	0.15	0.4	0.6	0.05
Severe perineal lacerations	1.3	0.8	0.4	1.4	0.02	1.3	0.9	0.07

* Births include nonanomalous, term, postterm, singleton, and cephalic births. The denominator for fetal death and perinatal death is all births (79,727); for all other outcomes, the denominator is live births (79,626). All P values are calculated for the comparison of in-hospital births with total out-of-hospital births. The rates of outcomes in planned, completed home births and planned, completed birth-center births are presented for the sake of completeness but do not figure into the calculation of P values. ICU denotes intensive care unit, and NICU neonatal ICU.

and lower rates of obstetrical interventions and NICU admission than in-hospital births, findings that corroborate the results of earlier studies.[3-5] These associations follow logically from the more conservative approach to intervention that characterizes the midwifery model of care[8,19] and from the fact that obstetrical interventions are either rare (e.g., induction of labor)[20] or unavailable (e.g., cesarean delivery, whether at home or at a birth center) outside the hospital setting.

There are few current data available on rates of out-of-hospital-to-hospital transfer in the United States. The observed rate of 16.5% in this study is informative and is consistent with rates reported in a recent systematic review of transfers in developed countries (including the United States), in which intrapartum transfer rates ranged from 10 to 17%.[21]

The limitations of our study require consideration. First, a major limitation is the inability in the case of planned home births to distinguish between transfers from birth centers and transfers from home. Although there are important differences between these two settings,[2] most state offices of vital statistics do not as yet distinguish between them in the case of transfers.

Table 4. Planned Out-of Hospital Births after the Reclassification of Hospital Transfers as Planned Out-of-Hospital Births.*

Event or Procedure	Results after Multivariable Regression				Results after Adjustment for Propensity Score	
	Adjusted Odds Ratio (95% CI)†	P Value	Absolute Difference in Risk (95% CI)‡	P Value	Absolute Difference in Risk (95% CI)‡	P Value
			percentage points		*percentage points*	
Fetal death	2.30 (1.13 to 4.69)	0.02	0.093 (0.012 to 0.175)	0.03	0.088 (0.005 to 0.171)	0.04
Perinatal death	2.43 (1.37 to 4.30)	0.002	0.152 (0.051 to 0.254)	0.003	0.158 (0.055 to 0.261)	0.003
Neonatal death	2.87 (1.10 to 7.47)	0.03	0.063 (0.003 to 0.124)	0.04	0.077 (0.013 to 0.140)	0.02
Infant death	1.68 (0.77 to 3.66)	0.19	0.076 (−0.040 to 0.193)	0.20	0.115 (−0.004 to 0.234)	0.06
5-Minute Apgar score						
<7	1.31 (1.04 to 1.66)	0.02	0.50 (0.08 to 0.92)	0.02	0.50 (0.07 to 0.93)	0.02
<4	1.56 (0.98 to 2.47)	0.06	0.17 (−0.01 to 0.35)	0.06	0.18 (0.00 to 0.37)	0.05
Neonatal seizures	3.60 (1.36 to 9.50)	0.01	0.06 (0.01 to 0.11)	0.02	0.07 (0.02 to 0.13)	0.007
Ventilator support	1.36 (1.14 to 1.62)	0.001	0.97 (0.41 to 1.54)	0.001	1.05 (0.48 to 1.62)	<0.001
NICU admission	0.71 (0.55 to 0.92)	0.009	−0.95 (−1.65 to −0.24)	0.009	−0.85 (−1.57 to −0.14)	0.02
Induction of labor	0.11 (0.09 to 0.12)	<0.001	−42.0 (−44.9 to −39.2)	<0.001	−45.3 (−48.4 to −42.2)	<0.001
Augmentation of labor	0.21 (0.19 to 0.24)	<0.001	−27.9 (−30.1 to −25.6)	<0.001	−28.4 (−30.7 to −26.0)	<0.001
Unassisted vaginal delivery	5.63 (4.84 to 6.55)	<0.001	23.9 (21.8 to 26.0)	<0.001	27.5 (24.9 to 30.2)	<0.001
Operative vaginal delivery	0.24 (0.17 to 0.34)	<0.001	−4.5 (−5.6 to −3.4)	<0.001	−4.7 (−5.8 to −3.5)	<0.001
Cesarean delivery	0.18 (0.16 to 0.22)	<0.001	−20.5 (−22.6 to −18.5)	<0.001	−24.0 (−26.6 to −21.4)	<0.001
Maternal ICU admission	1.00 (0.31 to 3.21)	0.99	0 (−0.12 to 0.11)	1.00	−0.04 (−0.18 to 0.10)	0.58
Maternal blood transfusion	1.91 (1.25 to 2.93)	0.003	0.28 (0.09 to 0.47)	0.003	0.27 (0.08 to 0.46)	0.006
Severe perineal lacerations	0.69 (0.49 to 0.98)	0.04	−0.45 (−0.87 to −0.02)	0.04	−0.54 (−0.98 to −0.11)	0.02

* All models were adjusted for maternal race or ethnic group, parity, maternal insurance status (for all models except those for fetal death and perinatal death, since maternal insurance status does not appear on the fetal death certificate), utilization of prenatal care, maternal age, education, prior cesarean delivery, and a composite of maternal conditions associated with an increased medical risk (a composite of chronic hypertension, gestational hypertension, preeclampsia, eclampsia, prepregnancy diabetes, or gestational diabetes).

† Odds ratios were calculated for the comparison of planned out-of-hospital delivery with planned hospital delivery.

‡ The absolute difference in risk compares the marginal prevalence of outcomes in planned out-of-hospital delivery with the prevalence of outcomes in planned hospital delivery. Positive values indicate higher rates in planned out-of-hospital births.

Second, we controlled for maternal characteristics in regression models, but there are probably differences between women who choose to give birth in a hospital and those who choose out-of-hospital birth. Women who choose out-of-hospital birth have different values and goals for their delivery (e.g., control over surroundings and a nonmedicalized experience without unnecessary interventions) than do women who choose hospital birth (e.g., the availability of pain relief and access to emergency services).[22] Third, although Oregon has a high out-of-hospital birth rate, the annual number of births in the state is relatively small (approximately 45,000, before exclusions), which provides low power for the analysis of rare outcomes. Our study was underpowered to analyze specific outcomes according to provider type, making this a useful area for future research. Fourth, since we analyzed data from only one state, it is hard to generalize our findings. Fifth, the accuracy of vital statistics data has well-known limitations, especially in regard to patient conditions before pregnancy; the coding of these conditions is less sensitive than that for procedures.[23-26]

Finally, misclassification or residual confounding may have affected our results. There are also differences in completion of birth certificates according to birth setting,[2,25,27] and the accuracy of the reporting of many demographic and clinical variables is unknown. For example, the fact that 27 transfer patients are listed as having a physician as their planned birth attendant is most likely due to errors in birth-certificate completion; data are currently lacking to inform the degree of misclassification related to this and others factors that affect the study outcomes.

Out-of-hospital birth remains controversial. Studies from Europe have shown that out-of-hospital birth can be a safe option for women and their babies when the risk of complications is low.[28-30] The European Union defines uniform standards for the education and training of midwives,[31] whereas the United States takes a piecemeal approach to the training and credentialing of out-of-hospital birth attendants. The American College of Nurse-Midwives and the North American Registry of Midwives recommend that midwives should at minimum meet the standards of midwifery established by the International Confederation of Midwives (ICM), which include completion of a formal midwifery educa-

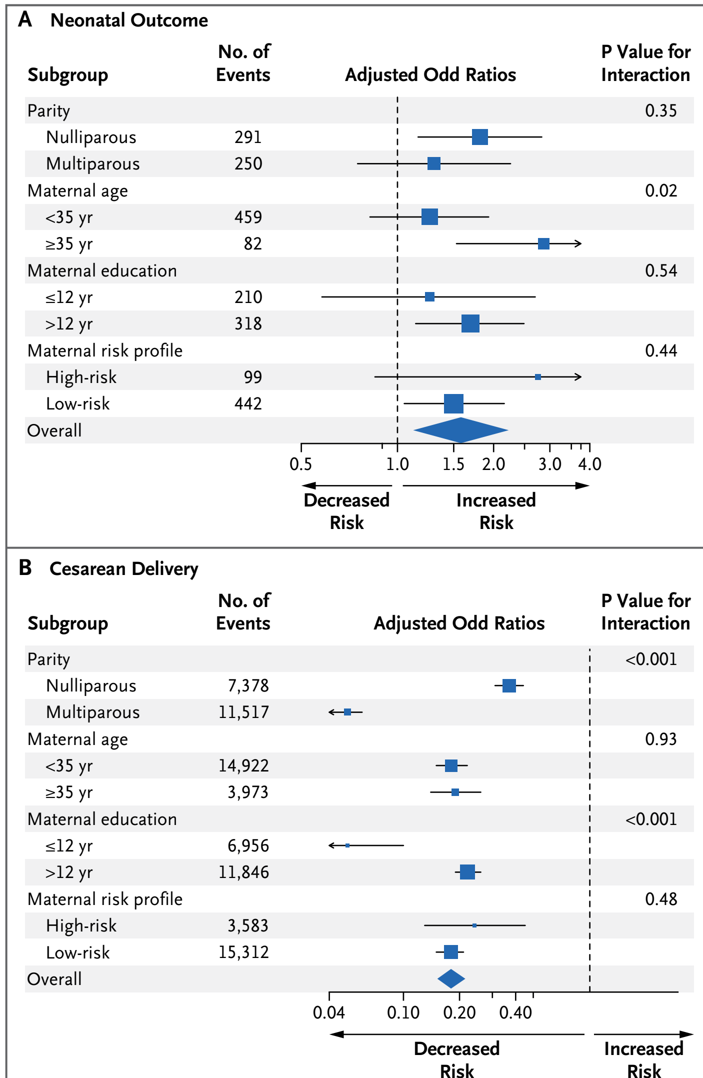

Figure 1. Association between Planned Out-of-Hospital Birth and a Composite Neonatal Outcome and Cesarean Delivery, According to Subgroups.

Panel A shows a composite neonatal outcome (fetal death, infant death, a 5-minute Apgar score of less than 4, or neonatal seizures) in subgroups defined according to maternal characteristics. Panel B shows the rate of cesarean delivery according to the same maternal characteristics. An odds ratio of more than 1 indicates that the risk of the outcome is increased with planned out-of-hospital birth as compared with planned hospital birth. An odds ratio of less than 1 indicates that the risk of the outcome is decreased with planned out-of-hospital birth as compared with planned hospital birth. All the models were adjusted for maternal race or ethnic group, parity, insurance status (for cesarean delivery), extent of prenatal care, maternal age and education, history of cesarean delivery, and a composite of maternal conditions associated with an increased medical risk (chronic hypertension, gestational hypertension, preeclampsia, eclampsia, prepregnancy diabetes, or gestational diabetes). The sizes of the boxes are proportional to statistical precision. Horizontal lines represent 95% confidence intervals and arrows 95% confidence intervals that were clipped when the confidence limits extended to extreme values (e.g., odds ratios of 0.03 or 9.5) in order to maintain the readability of the central portion of the graph.

tion program, national certification, and licensure in the local jurisdiction of practice.[32,33] Certified professional midwives (CPMs) may achieve certification through apprenticeship and portfolio evaluation without obtaining a formal midwifery degree; within CPM professional organizations efforts are under way to uniformly adopt ICM standards.[33,34] Oregon has followed this trend; in 2015 licensure became mandatory for attendants at out-of-hospital births.

The extent to which midwifery is integrated into a health care system probably explains some of the differences in practice and outcomes reported in U.S. and European studies. For example, the Dutch home-birth system (in which home birth is common and adverse outcomes are rare) includes formal collaborative agreements between out-of-hospital and in-hospital providers, clear and mutually agreed-upon stratification of risk, and protocols for the transfer of care.[35,36] The process of devising evidence-based guidelines for U.S. home births is under way.[37]

Rates of obstetrical intervention are high in U.S. hospitals, and we found large absolute differences in the risks of these interventions between planned out-of-hospital births and in-hospital births.[38] In contrast, serious adverse fetal and neonatal outcomes are infrequent in all the birth settings we assessed, and the absolute differences in risk that we observed between planned birth locations were correspondingly small; for example, planned out-of-hospital births were associated with an excess of less than 1 fetal death per 1000 deliveries in multivariate and propensity-score-adjusted analyses. Consideration of maternal preferences, including preferences for obstetrical services, is also important; the fact that U.S. hospitals generally decline to allow vaginal birth after a woman has undergone cesarean section may be associated with the increase in home births.[10,39,40]

Using data from Oregon birth certificates, we showed that the rates of obstetrical interventions were lower but the risks of perinatal death and other adverse neonatal outcomes were higher with planned out-of-hospital birth than with planned in-hospital birth; however, the absolute differences in the risks of adverse neonatal outcomes were small. Our findings highlight the effect that the misclassification of intended birth setting has on the accuracy of U.S. vital statistics.

Supported by a grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (K99 HD079658-01 to Dr. Snowden). Dr. Tilden is supported by the Oregon Building Independent Careers in Women's Health Scholars (K12HD043488), the Jonas Doctoral Scholars Program, Sigma Theta Tau Beta Psi, and the American College of Nurse-Midwives.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

We thank Stella Dantas, Lani Doser, Judith Rooks, and the staff at the Oregon Center for Health Statistics for their work in advancing the collection of vital statistics data in Oregon.

REFERENCES

1. MacDorman MF, Matthews TJ, Declercq E. Trends in out-of-hospital births in the United States, 1990-2012. NCHS Data Brief 2014;144:1-8.
2. MacDorman MF, Declercq E, Mathews TJ. Recent trends in out-of-hospital births in the United States. J Midwifery Womens Health 2013;58:494-501.
3. Cheng YW, Snowden JM, King TL, Caughey AB. Selected perinatal outcomes associated with planned home births in the United States. Am J Obstet Gynecol 2013;209(4):325.e1-328.e1.
4. Cheyney M, Bovbjerg M, Everson C, Gordon W, Hannibal D, Vedam S. Outcomes of care for 16,924 planned home births in the United States: the Midwives Alliance of North America Statistics Project, 2004 to 2009. J Midwifery Womens Health 2014;59:17-27.
5. Stapleton SR, Osborne C, Illuzzi J. Outcomes of care in birth centers: demonstration of a durable model. J Midwifery Womens Health 2013;58:3-14.
6. Grünebaum A, McCullough LB, Sapra KJ, et al. Apgar score of 0 at 5 minutes and neonatal seizures or serious neurologic dysfunction in relation to birth setting. Am J Obstet Gynecol 2013;209(4):323.e1-323.e6.
7. 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(4):390.e1-390.e7.
8. Rooks JP. The midwifery model of care. J Nurse Midwifery 1999;44:370-4.
9. Wax JR, Pinette MG, Cartin A, Blackstone J. Maternal and newborn morbidity by birth facility among selected United States 2006 low-risk births. Am J Obstet Gynecol 2010;202(2):152.e1-152.e5.
10. Grünebaum A, McCullough LB, Brent RL, Arabin B, Levene MI, Chervenak FA. Perinatal risks of planned home births in the United States. Am J Obstet Gynecol 2015;212(3):350.e1-350.e6.
11. Martin JA, Hamilton BE, Osterman MJK, Curtin SC, Mathews TJ. Births: final data for 2012. Natl Vital Stat Rep 2013;62:1-68.
12. NARM (North American Registry of Midwives) and MANA (Midwives Alliance of North America). Legal status of U.S. midwives (http://mana.org/about-midwives/legal-status-of-us-midwives).
13. OHA (Oregon Health Authority), Public Health Division. Preliminary data on Oregon birth outcomes, by planned birth place and attendant. Pursuant to: HB 2380 (2011), 2013 (https://olis.leg.state.or.us/liz/2013R1/Downloads/CommitteeMeetingDocument/10024).
14. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika 1983;70:41-55.
15. Austin PC. The performance of different propensity-score methods for estimating differences in proportions (risk differences or absolute risk reductions) in observational studies. Stat Med 2010;29:2137-48.
16. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. Stata J 2012;12:308-31.
17. Snowden JM, Rose S, Mortimer KM. Implementation of G-computation on a

simulated data set: demonstration of a causal inference technique. Am J Epidemiol 2011;173:731-8.
18. Wax JR, Lucas FL, Lamont M, Pinette MG, Cartin A, Blackstone J. Maternal and newborn outcomes in planned home birth vs planned hospital births: a metaanalysis. Am J Obstet Gynecol 2010;203(3):243.e1-243.e8.
19. Renfrew MJ, McFadden A, Bastos MH, et al. Midwifery and quality care: findings from a new evidence-informed framework for maternal and newborn care. Lancet 2014;384:1129-45.
20. Grünebaum A, McCullough LB, Chervenak FA. Interventions at home births. Am J Obstet Gynecol 2014;210:487-8.
21. Blix E, Kumle M, Kjærgaard H, Øian P, Lindgren HE. Transfer to hospital in planned home births: a systematic review. BMC Pregnancy Childbirth 2014;14:179.
22. Murray-Davis B, McDonald H, Rietsma A, Coubrough M, Hutton E. Deciding on home or hospital birth: results of the Ontario Choice of Birthplace Survey. Midwifery 2014;30:869-76.
23. Lain SJ, Hadfield RM, Raynes-Greenow CH, et al. Quality of data in perinatal population health databases: a systematic review. Med Care 2012;50(4):e7-e20.
24. Lydon-Rochelle MT, Cárdenas V, Nelson JL, Tomashek KM, Mueller BA, Easterling TR. Validity of maternal and perinatal risk factors reported on fetal death certificates. Am J Public Health 2005;95:1948-51.
25. Kirby RS, Demetriou N. Planned home or hospital delivery: what outcomes provide valid comparisons? Am J Obstet Gynecol 2014;210:488-9.
26. Northam S, Knapp TR. The reliability and validity of birth certificates. J Obstet Gynecol Neonatal Nurs 2006;35:3-12.
27. Grünebaum A, McCullough LB, Brent RL, Arabin B, Levene MI, Chervenak FA. Justified skepticism about Apgar scoring in out-of-hospital birth settings. J Perinat Med 2015;43:455-60.
28. Brocklehurst P, Hardy P, Hollowell J, et al. Perinatal and maternal outcomes by planned place of birth for healthy women with low risk pregnancies: the Birthplace in England national prospective cohort study. BMJ 2011;343:d7400.
29. de Jonge A, Geerts CC, van der Goes BY, Mol BW, Buitendijk SE, Nijhuis JG. Perinatal mortality and morbidity up to 28 days after birth among 743 070 low-risk planned home and hospital births: a cohort study based on three merged national perinatal databases. BJOG 2015;122:720-8.
30. de Jonge A, Mesman JA, Manniën J, Zwart JJ, van Dillen J, van Roosmalen J. Severe adverse maternal outcomes among low risk women with planned home versus hospital births in the Netherlands: nationwide cohort study. BMJ 2013;346:f3263.
31. Keighley T. European Union standards for nursing and midwifery: information for accession countries: second edition. Copenhagen: World Health Organization, 2009 (http://www.euro.who.int/__data/assets/pdf_file/0005/102200/E92852.pdf).
32. Position statement: principles for licensing and regulating midwives in the United States in accordance with the global standards of the International Confederation of Midwives. Silver Spring, MD: American College of Nurse-Midwives, 2014 (http://www.midwife.org/ACNM/files/ACNMLibraryData/UPLOADFILENAME/000000000287/Principles-for-Licensing-and-Regulating-Midwives-in-US-According-to-ICM-Global-Standards-March-2014.pdf).
33. Position statement: state licensure of certified professional midwives, 2012. Lilburn, GA: North American Registry of Midwives (NARM) (http://dhmh.maryland.gov/midwives/Documents/State-Licensure-of-CPMs.pdf).
34. Comparison of certified nurse-midwives, certified midwives, and certified professional midwives: clarifying the distinctions among professional midwifery credentials in the U.S. Silver Spring, MD: American College of Nurse-Midwives, 2014 (http://www.midwife.org/acnm/files/cclibraryfiles/filename/000000001031/cnm%20cm%20cpm%20comparison%20chart%20march%202011.pdf).
35. van der Kooy J, Poeran J, de Graaf JP, et al. Planned home compared with planned hospital births in the Netherlands: intrapartum and early neonatal death in low-risk pregnancies. Obstet Gynecol 2011;118:1037-46.
36. Offerhaus PM, de Jonge A, van der Pal-de Bruin KM, Hukkelhoven CW, Scheepers PL, Lagro-Janssen AL. Change in primary midwife-led care in the Netherlands in 2000-2008: a descriptive study of caesarean sections and other interventions among 789,795 low risk births. Midwifery 2014;30:560-6.
37. Cook E, Avery M, Frisvold M. Formulating evidence-based guidelines for certified nurse-midwives and certified midwives attending home births. J Midwifery Womens Health 2014;59:153-9.
38. Ananth CV, Wilcox AJ, Gyamfi-Bannerman C. Obstetrical interventions for term first deliveries in the US. Paediatr Perinat Epidemiol 2013;27:442-51.
39. Gregory KD, Fridman M, Korst L. Trends and patterns of vaginal birth after cesarean availability in the United States. Semin Perinatol 2010;34:237-43.
40. Macdorman MF, Declercq E, Mathews TJ, Stotland N. Trends and characteristics of home vaginal birth after cesarean delivery in the United States and selected States. Obstet Gynecol 2012;119:737-44.