AOGS
ACTA Obstetricia et Gynecologica Scandinavica

AOGS MAIN RESEARCH ARTICLE

Characteristics and outcome of unplanned out-of-institution births in Norway from 1999 to 2013: a cross-sectional study

BJÖRN GUNNARSSON[1,2], ALEXANDER K. SMÁRASON[3], EIRIK SKOGVOLL[2,4] & SIGURD FASTING[2,4]

[1]*Norwegian Air Ambulance Foundation, Drøbak, Norway,* [2]*Faculty of Medicine, Norwegian University of Science and Technology, Trondheim, Norway,* [3]*Institute of Health Science Research, University of Akureyri, Akureyri, Iceland, and* [4]*Department of Anesthesiology and Intensive Care Medicine, St. Olavs Hospital, Trondheim, Norway*

Key words
Norway, birthing centers, delivery of health care, rural health services, perinatal mortality

Correspondence
Björn Gunnarsson, Norwegian Air Ambulance Foundation, 1441 Drøbak, Norway.
E-mail: bjorn.gunnarsson@norskluftambulanse.no

Conflict of interest
The authors have no relations with any company that might have an interest in the submitted work in the previous 3 years and no financial interests that may be relevant to the submitted work.

Please cite this article as: Gunnarsson B, Smárason AK, Skogvoll E, Fasting S. Characteristics and outcome of unplanned out-of-institution births in Norway from 1999 to 2013: a cross-sectional study. Acta Obstet Gynecol Scand 2014; 93: 1003–1010.

Received: 26 September 2013
Accepted: 25 June 2014

DOI: 10.1111/aogs.12450

Abstract

Objective. To study the incidence, maternal characteristics and outcome of unplanned out-of-institution births (= unplanned births) in Norway. *Design.* Register-based cross-sectional study. *Population.* All births in Norway (n = 892 137) from 1999 to 2013 with gestational age ≥22 weeks. *Methods.* Analysis of data from the Medical Birth Registry of Norway from 1999 to 2013. Unplanned births (n = 6062) were compared with all other births (reference group). *Results.* The annual incidence rate of unplanned births was 6.8/1000 births and remained stable during the period of study. Young multiparous women residing in remote municipalities were at the highest risk of experiencing unplanned births. The unplanned birth group had higher perinatal mortality rate for the period, 11.4/1000 compared with 4.9/1000 for the reference group (incidence rate ratio 2.31, 95% confidence interval 1.82–2.93, $p < 0.001$). Annual perinatal mortality rate for unplanned births did not change significantly ($p = 0.80$) but declined on average by 3% per year in the reference group ($p < 0.001$). The unplanned birth group had a lower proportion of live births in all birthweight categories. Live born neonates with a birthweight of 750–999 g in the unplanned birth group had a more than five times higher mortality rate during the first week of life, compared with reference births in the same birthweight category. *Conclusions.* Unplanned births are associated with adverse outcome. Excessive mortality is possibly caused by reduced availability of necessary medical interventions for vulnerable newborns out-of-hospital.

Abbreviations: BW, birthweight; CI, confidence interval; ENMR, early neonatal mortality rate; GA, gestational age; IRR, incidence rate ratio; OR, odds ratio; PMR, perinatal mortality rate.

Key Message

Unplanned births outside institutions are relatively common in Norway at 7/1000 deliveries since 1999. Women most likely to have unplanned deliveries are young, of higher parity and live in a remote area. Young multiparous women are at 20 times higher risk of experiencing unplanned birth, compared with older nullipara. The perinatal mortality rate for unplanned births of extremely low birthweight is very high, possibly due to limited access to specialized care.

Introduction

There has been a trend in many countries towards centralization of births to fewer and larger units. In Norway, the number of birth institutions went down from 158 in the year 1972 to 82 in 1990 and 57 in the year 2000 (>10 deliveries/year), and has now levelled off at 51 (1–4). The perinatal mortality rate (PMR) decreased simultaneously, from 21.9/1000 births for the years 1967–1971 to 4.9/1000 in 2011 (5,6). More centralized and specialized care has undoubtedly contributed, but a potential downside of centralization is an increased risk for unplanned out-of-institution births with adverse outcomes (2,4,7–9).

The annual rate of unplanned births in Norway has increased from approximately 4/1000 births in 1979–1983 to 7/1000 births during the last 10 years (3,4). A study for the period 1967–1988 found a similar PMR for births during transport to hospital and other births during the last 3 years studied (10). A more recent study of 430 unplanned births in 2008 revealed no stillbirths and only two early neonatal deaths, both after 22 weeks of gestation (3). Recent studies from other European countries have revealed high perinatal mortality associated with unplanned births (8,11–13). The causes are not well known, but infants with low birthweight (BW) or low gestational age (GA) are particularly vulnerable (8,12–15). Is the situation different in Norway? The aim of this study was to examine risk factors, incidence and outcome of all unplanned births in Norway during last 15 years.

Material and methods

Data were obtained from the Medical Birth Registry of Norway for the period 1999–2013. Birth institutions and, in the case of out-of-institutional births, the physician or midwife assisting during or after the birth, are obliged to submit data to the register for each birth (6,16). The mortality data in the register are considered accurate and the internal validity of many variables is checked regularly (6,16). Permission to use the register data was obtained from the Medical Birth Registry of Norway and the Regional Ethics Committee of South-East Norway.

The study population consisted of 892 137 births with GA $\geq$ 22 weeks (secondary criteria is BW $\geq$ 500 g). Main outcome measures were maternal risk factors related to unplanned births, PMR (number of stillbirths and live births that die within the first week of life per 1000 births), living status at birth (stillbirth vs. live birth), and early neonatal mortality rate (ENMR, number of live births that die within the first week per 1000 live births). A number of variables are recorded for all births by the Medical Birth Registry of Norway (6,16). This includes the mother's postal code, civil status, obstetric history, use of health care, interventions during pregnancy and delivery, and the child's health up to the age of 7 days. Information on place of birth is collected with the following alternatives: birth at an institution (hospital or midwife-led unit); out-of-institution birth (= planned at home, unplanned at home, during transportation, unspecified).

We compared the unplanned out-of-institution births (unplanned at home, during transportation, unspecified) with all other births (reference group: all births in hospitals, midwife-led units and planned home births). Mortality data included living status at birth, time of death for stillbirths (prior to delivery, during delivery, unknown) and for those born alive (0–24 h, days 1–6).

Based on geographical location in relation to urban settlements and availability of services, municipal centrality is classified by Statistics Norway into four categories: remote, fairly remote, fairly central and central. Municipal centrality classification was obtained from the official website of Statistics Norway (17). The classification was issued in 1994, based on information obtained in the population census on 3 November 1990, with later updates (18).

Data analysis

Descriptive statistics were generated for background and perinatal information. Unplanned births were plotted and time trends investigated with Poisson regression, reporting incidence rate ratio (IRR) with 95% confidence intervals (CI) when appropriate. Differences in mean values between groups were tested with independent-samples *t*-test and reported as mean $\pm$ SD.

Measures of interaction between maternal factors and birthplace group (unplanned births vs. reference) were investigated with binary logistic regression and adjusted for covariates. Odds ratios (OR) and their 95% CIs were calculated and differences in proportions between groups tested with chi-squared statistics. Age- and parity group-specific IRR of unplanned births per 1000 births were calculated and shown graphically. Weight-specific IRRs with 95% CI for PMR and ENMR were calculated and adjusted for covariates using Poisson regression. Time trends for PMR in the two birthplace groups were plotted and investigated with Poisson regression. Significance tests were two-tailed and a significance level of 0.05 chosen.

Calculations were performed with STATA STATISTICAL SOFTWARE, Release 12.1 (StataCorp LP, College Station, TX, USA).

Results

During the 15-year study period there were 6062 unplanned births, an average annual incidence of 6.8/1000 births. Figure 1 shows the number of unplanned births by year according to birthplace category. Poisson regression revealed no change in the total number of unplanned births (IRR 1.00, 95% CI 0.99–1.00, $p = 0.141$). However, there was a decrease within the subcategory of births during transportation (IRR 0.98, 95% CI 0.97–0.98, $p < 0.001$) and an increase in the number of births at an unspecified site (IRR 1.02, 95% CI 1.01–

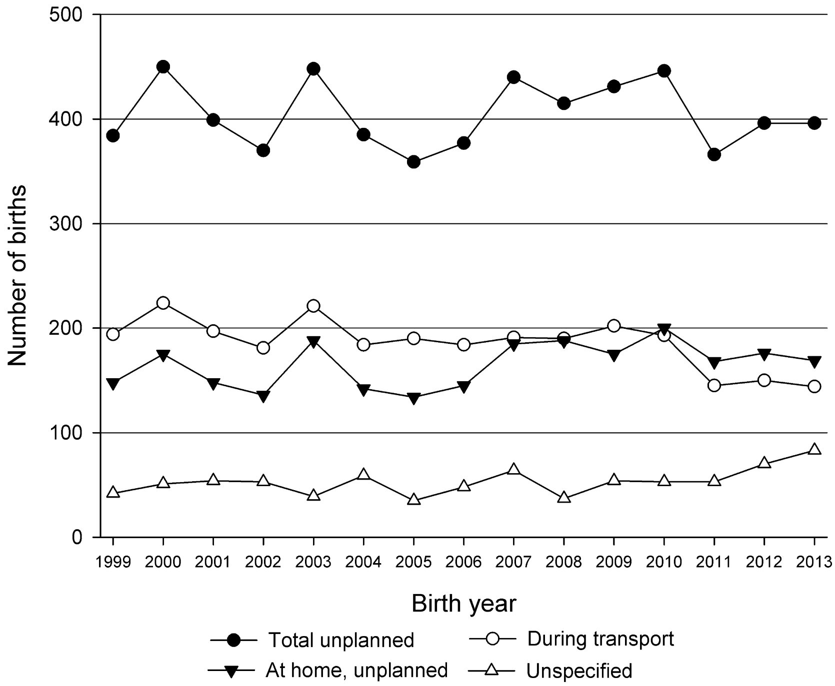

Figure 1. Number of unplanned births out-of-institution according to birthplace during the study period. Data include all births with gestational age ≥22 weeks.

1.04, $p = 0.003$). The number of unplanned births at home increased slightly but this did not reach statistical significance (IRR 1.01, 95% CI 1.00–1.02, $p = 0.054$). Overall, 40.9% of the births were registered as unplanned at home (average annual incidence of 2.8/1000 births), 46.0% as occurring during transport (3.1/1000 births) and 13.1% (0.9/1000 births) occurring at unspecified sites.

The mean maternal age was 30.5 ± 5.1 years for unplanned births, compared with 30.1 ± 5.2 in the reference group ($p < 0.001$). Comparison of maternal background characteristics for unplanned births and reference births, before and after adjustments for covariates, is shown in Table 1. The estimates for maternal age changed in both direction and magnitude after adjustment for parity. Figure 2 shows age- and parity group-specific rates of unplanned births per 1000 births. High parity was strongly associated with unplanned births, and younger maternal age was also strongly associated with unplanned births, irrespective of parity.

The unplanned birth group had a lower proportion of multiple births. Mothers of unplanned births were less likely to be married/cohabiting and more likely to have smoked, occasionally or daily, in early pregnancy. Women living in remote municipalities were four times more likely to experience unplanned birth, compared with women who resided in more central municipalities.

The mean GA for unplanned births was slightly lower than in the reference group, 38.9 ± 2.6 and 39.2 ± 2.5 weeks, respectively ($p < 0.001$). Accordingly, the proportion of births in the lowest GA categories was slightly higher in the unplanned birth group than in the reference group (GA 22–24 weeks: 0.4% vs. 0.2%; 25–27 weeks: 0.5% vs. 0.3%; 28–31 weeks 0.7% vs. 0.8%; 32–36 weeks: 5.1% vs. 5.7%; ≥37 weeks: 93.3% vs. 93.1%). The mean BW for unplanned births was also slightly lower than in the reference group, 3432 ± 618 and 3507 ± 621 g, respectively ($p < 0.001$).

Comparison of weight-specific IRR for perinatal mortality and living status at birth is shown in Table 2. The PMR was markedly higher for unplanned births with extremely low BW (500–999 g). Adjustments for covariates, as detailed in footnotes to the Table, had minimal effect on the IRR estimates. It should be noted that calculations in Tables 2 and 3 do not include 820 births with missing values for BW or 935 births with BW < 500 g. Calculations including all cases revealed significantly higher PMRs, 13.7 and 6.0/1000 for all unplanned births and all reference births, respectively (IRR 2.29, 95% CI 1.84–2.85, $p < 0.001$).

Annual trends in PMR for all births with GA ≥ 22 weeks are presented graphically in Figure 3. Poisson regression revealed no significant change in annual PMR for the unplanned birth group (IRR 1.01, 95% CI 0.96–1.06,

Table 1. Maternal characteristics and odds ratios (OR) for unplanned births.

Maternal characteristics	Reference group	Unplanned births	OR (95% CI)	Adjusted[d] OR (95% CI)	Adjusted[e] OR (95% CI)
Maternal age, years					
≤19	19 625	117	1.00	1.00	1.00
20–24	129 662	802	1.04 (0.85–1.26)	0.51 (0.42–0.63)	0.62 (0.49–0.78)
25–29	286 186	1858	1.09 (0.90–1.31)	0.37 (0.30–0.45)	0.50 (0.40–0.63)
30–34	293 853	2105	1.20 (1.00–1.45)	0.31 (0.25–0.37)	0.44 (0.35–0.55)
35–39	132 774	1015	1.28 (1.06–1.54)	0.27 (0.22–0.33)	0.40 (0.32–0.51)
≥40	23 881	164	1.15 (0.91–1.46)	0.22 (0.18–0.29)	0.32 (0.24–0.43)
Parity[a]					
0 (primigravida)	369 923	675	1.00		1.00
1	315 738	2964	5.15 (4.73–5.59)	–	6.07 (5.50–6.70)
2	141 260	1588	6.12 (5.63–6.74)	–	7.10 (6.37–7.91)
3	40 049	543	7.43 (6.63–8.32)	–	8.36 (7.31–9.56)
≥4	19 105	292	8.38 (7.30–9.62)	–	9.95 (8.46–11.71)
Civil status					
Married/cohabiting	815 930	5549	1.00	1.00	1.00
Other[b]	70 145	513	1.08 (0.98–1.18)	1.32 (1.20–1.45)	1.18 (1.06–1.31)
Smoked (early pregnancy)					
No	621 414	4079	1.00	1.00	1.00
Yes (occasionally or daily)	120 970	1022	1.29 (1.20–1.38)	1.33 (1.24–1.42)	1.13 (1.05–1.22)
Plurality[c]					
1	854 552	5987	1.00	1.00	–
2	30 746	72	0.33 (0.27–0.42)	0.35 (0.28–0.43)	–
3	735	3	–	–	–
4	42	0	–	–	–
Municipal centrality (home)					
Central	567 929	2838	1.00	1.00	1.00
Fairly central	172 980	788	0.91 (0.84–0.99)	0.87 (0.80–0.94)	0.81 (0.74–0.88)
Fairly remote	55 428	437	1.58 (1.43–1.75)	1.43 (1.29–1.58)	1.37 (1.23–1.53)
Remote	88 609	1984	4.48 (4.23–4.75)	3.98 (3.75–4.22)	3.78 (3.55–4.03)

[a]Parity is the number of previous births.
[b]Civil status "other" includes: unmarried/single, divorced/separated/widow, registered partner.
[c]Plurality is the number of births in same delivery.
[d]Adjusted for parity.
[e]Adjusted for the following variables, all treated as categorical factors: maternal age, parity, civil status, smoking and centrality.

$p = 0.80$). This was contrasted by a steady decline in PMR for the reference group, on average 3% per year (IRR 0.97, 95% CI 0.96–0.97, $p < 0.001$).

There were significant differences between the groups in living status at birth (live birth/stillbirth ratio, Table 2), and outcome of live births (Table 3). The unplanned birth group had a lower proportion of live births across all BW categories, and births with extremely low BW had significantly higher ENMR than did births in the reference group.

Discussions

Our main finding is that both PMR and ENMR for unplanned births is more than twice the rate for all other births. Unplanned births with extremely low BW are at particular risk. We further observed that the annual PMR for unplanned births did not decline during the 15 years under study, although it decreased significantly for other births. Unplanned births were associated with higher parity, younger maternal age and living in a remote municipality.

The Medical Birth Registry of Norway collects information about all births in Norway and the background study material is very large. Information bias due to non-differential (random) error is therefore likely to be low. However, there are known methodological problems in the use of register-based data (19). Coding of birthplace for the study group does not account for the type of transportation used (such as family car, ambulance, airplane), and the group 'unspecified' is likely to be a very inhomogeneous group. Mortality statistics are also greatly affected by reporting practices and selection criteria. Classification of live birth vs. stillbirth is obviously crucial and reporting practices vary. It has for example been shown that fetuses with BW < 500 g were more frequently reported as stillbirths in Norway than in the USA, and that the

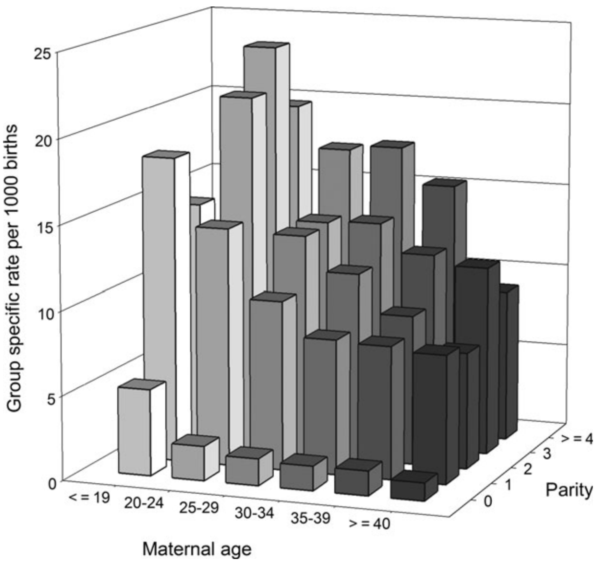

Figure 2. Age- and parity-specific rate of unplanned births per 1000 births with gestational age ≥22 weeks.

reported live birth/stillbirth ratio changes over time (20,21). The lower proportion of live births observed in low-BW categories of unplanned births in this study may be a classification error due to the absence of qualified health care personnel. A consequence of such an error would be an underestimation of ENMR associated with unplanned births, but of course with no effect on the PMR.

It is meaningless in the context of this study to compare mortality rates without taking BW or GA into account. We analyzed weight-specific mortality with BW of 500 g as the lower limit. By doing so, we excluded from our analysis a number of extremely immature births with no potential for survival. However, although the crude PMR was significantly higher when all cases are included, the IRR was unaffected (2.29 vs. 2.31), but the rate difference was somewhat attenuated (7.7 vs. 6.5). We did not attempt to adjust for a number of potential confounding variables and we chose to limit our analysis to covariates that do not depend on the reporter's clinical judgment. This was due to concerns about data quality, i.e. missing data and a potential for systematic errors in reporting, dependent on birthplace category. Classification of living status at birth is an exception to this rule.

The association of unplanned births with higher mortality rates was strong. There are probably many underlying causes for this. One possible explanation is higher underlying morbidity among unplanned births. Our data do not allow us to draw a conclusion about this, but unplanned births are undoubtedly a risk group and further studies are warranted.

A study based on birth register data for the period 1967–1988 showed a dramatic reduction in perinatal

Table 2. All births with gestational age ≥22 weeks and BW ≥ 500 g. Weight-specific perinatal mortality rate for the reference group and unplanned births.

	Reference group						Unplanned births						IRR (95% CI)	
BW category (g)	All births (%)	Live births	Stillbirths	L/S ratio	PM	PMR	All births (%)	Live births	Stillbirths	L/S ratio	PM	PMR	Unadjusted	Adjusted[a]
500–749	1749	1192	557	2.1	858	490.6	29	16	13	1.2	25	862.1	1.76 (1.18–2.62)	1.69 (1.12–2.26)
750–999	1900	1664	236	7.1	355	186.8	20	13	7	1.9	12	600.0	3.21 (1.81–5.71)	3.12 (1.91–6.11)
1000–1499	5073	4709	364	12.9	490	96.6	36	32	4	8.0	6	166.7	1.73 (0.77–3.86)	1.79 (0.82–4.03)
1500–2499	35 874	35 230	644	54.7	867	24.2	212	205	7	29.3	10	47.2	1.95 (1.05–3.64)	1.82 (0.97–3.04)
≥2500	839 759	838 383	1376	609.3	1 807	2.2	5 730	5 716	14	408.3	16	2.8	1.30 (0.79–2.12)	1.27 (0.78–2.08)
Total	884 355	881 178	3177	277.4	4 377	4.9	6 027	5 982	45	132.9	69	11.4	2.31 (1.82–2.93)	2.36 (1.85–3.01)

BW, birthweight; L/S ratio: live birth/stillbirth ratio; PM, stillbirths and live births that die within the first week of life; PMR, perinatal mortality rate per 1000 births.
[a]Adjusted for the following covariates by Poisson regression, all treated as categorical factors as specified: maternal age (years): ≤19, 20–24, 25–29, 30–34, 35–39, ≥40; parity: 0, 1, 2, 3, ≥4; civil status: married/cohabiting, other; centrality: remote, fairly remote, fairly central, central; and time period (years): 1999–2003, 2004–2008, 2009–2013.

Table 3. Perinatal outcome for live births only.

	Reference group			Unplanned births			IRR (95% CI)	
BW category (g)	Live births	ENM	ENMR	Live births	ENM	ENMR	Unadjusted	Adjusted[a]
500–749	1192	301	252.5	16	12	750.0	2.97 (1.67–5.29)	2.94 (1.62–5.31)
750–999	1664	119	71.5	13	5	384.6	5.38 (2.19–13.16)	7.13 (2.84–17.92)
1000–1499	4709	126	26.8	32	2	62.5	2.34 (0.58–9.44)	2.64 (0.65–10.76)
1500–2499	35 230	223	6.3	205	3	14.6	2.31 (0.74–7.23)	2.14 (0.68–6.70)
≥2500	838 383	431	0.5	5716	2	0.3	0.68 (0.17–2.73)	0.61 (0.15–2.47)
Total	881 178	1200	1.4	5982	24	4.0	2.95 (1.97–4.41)	2.94 (1.95–4.42)

BW, birthweight; ENM: early neonatal mortality (death of a live born within the first week); ENMR, ENM per 1000 live births.
[a]Adjusted for the following covariates by Poisson regression, all treated as categorical factors as specified: maternal age (years): ≤19, 20–24, 25–29, 30–34, 35–39, ≥40; parity: 0, 1, 2, 3, ≥4; civil status: married/cohabiting, other; centrality: remote, fairly remote, fairly central, central; and time period (years): 1999–2003, 2004–2008, 2009–2013.

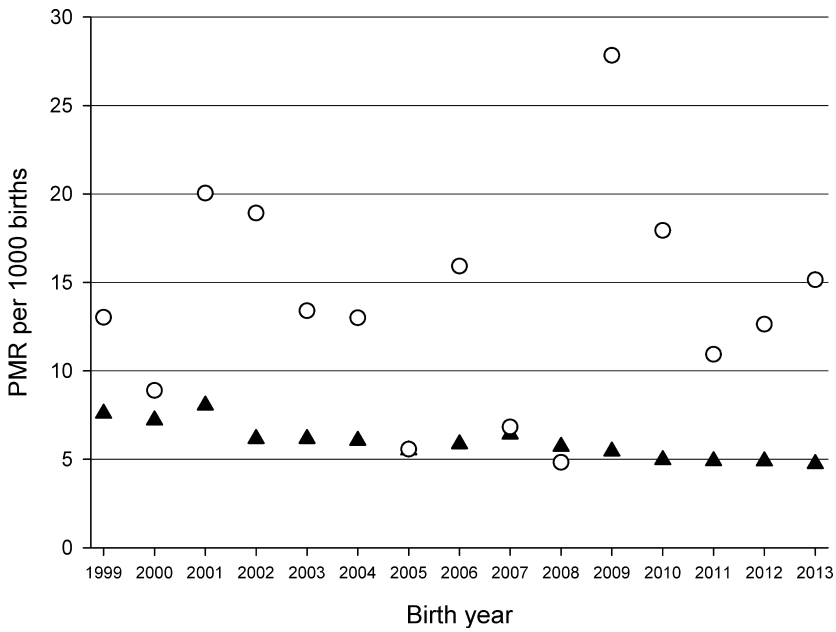

Figure 3. Annual trends in perinatal mortality rate (PMR) 1999–2013. Data includes all births with gestational age ≥22 weeks. Open circles denote unplanned births and black triangles the reference group.

mortality associated with births during transportation to hospitals in Norway. PMR for births during transportation decreased from 156/1000 at the start of the period to 16/1000 at the end (3-year periods reported), while for other births the figure was 13/1000 in 1986–1988, i.e. the rate for births during transportation became similar to the general PMR at the end of the study period (10). However, it should be noted that our results are not directly comparable with that study, where only births that took place during transportation, and apparently live births down to a GA of 16 weeks, were analyzed (10). A study similar to ours for 2008 revealed a very low mortality associated with unplanned birth (3). However, the outcome for this year was exceptionally good and not representative of the period, as shown in Figure 3.

A study from Finland showed a very low rate of unplanned births out-of-hospital, 1.0–2.5/1000 births depending on year and classification (8). PMR for unplanned births out-of-hospital was very high, 32.7/1000 births, compared with 4.9 for all hospital births. This difference is much greater than our findings and was not limited to BW < 2500 g, as almost all of the excessive mortality in our material was. We have no good explanation for the observed differences between Norway and Finland, but it is possible that the mortality rate difference in Norway is attenuated by a relatively high rate of unplanned births with low risk.

The annual number of unplanned births was fairly stable during the study period, but the number of births during transport was lower at the end, whereas the number of births at unspecified sites increased somewhat. Unplanned births at home have only been registered as a separate category since a new reporting scheme was introduced in December 1998 (16). However, despite this limitation, it is clear that unplanned births are much more common than before (4). Centralization of births in Norway occurred at a high rate during last three decades of the last century, with relatively little change after the turn of the century. It seems likely that the marked increase in number of unplanned births is explained by an increased centralization of obstetric care, which often leads to a longer transport time to an obstetric facility. We found that residing in a remote municipality, a surrogate marker for longer transport time, was a significant risk factor for unplanned birth. Other researchers have described the same effect (10,22–25). A recent study, using geographic information software for travel zone calculations, showed that the proportion of women of fertile age with more than a one-hour travel time to an obstetric institution increased from 7.9% in 2000 to 8.8% in 2010, indicating that the population of women at risk for unplanned births may be increasing (4). It is noteworthy that we found that women residing in central municipalities were more likely to experience unplanned birth than those residing in fairly central municipalities. We have no explanation for this, but women of non-Norwegian nationality and/or from a socially deprived background may be overrepresented in central municipalities. Unterscheider et al. (11) demonstrated in a study from Dublin that those two groups of patients are at increased risk.

We found that multiparity was strongly associated with unplanned births, as has been shown previously (13,24–26). This effect was strong and rose with each birth. The relation between age and unplanned births is confounded by parity, as a woman having her fourth child is obviously older than when she gave birth to her previous children. The converse is true if age has some independent effect on the likelihood of unplanned birth, i.e. an effect independent of maternal age being linked to parity. There is evidence that uterine contractility decreases with age (27). This phenomenon may partly explain why our adjustments for parity in a multivariate logistic model inverted the apparent association of higher maternal age with unplanned births. We are not aware of previous research showing clearly the inverse relation between advancing age and the likelihood of unplanned deliveries. Our interpretation is that the likelihood of precipitous delivery, and thereby unplanned birth, declines due to less vigorous uterine activity in older women. It is also possible that older women are monitored better or take extra precautions.

It is important to monitor perinatal outcome, both for identifying areas for improvement and for planning health services (28). The health care system aims to centralize all high risk deliveries to institutions and the mortality due to unplanned births ideally should be quite low, especially at term. However, it is likely that unplanned births will continue to occur at a relatively high rate in countries such as Norway. A better understanding of maternal risk factors and causes of mortality may help to find ways to prevent and manage such incidents. Of a particular concern is the low live birth/stillbirth ratio for unplanned births and high mortality seen among infants with BW 750–999 g (corresponds to a GA of 28 weeks in this material, 25–75th percentile: 26–29 weeks), who should in theory have a good chance of survival if they receive advanced pre-hospital medical interventions. The Norwegian physician-staffed helicopter air-ambulance can provide such services (29,30).

Conclusions

Unplanned out-of-institution births in Norway are relatively common at 7/1000 deliveries. The number of unplanned births remained stable during the study period. An increase was observed in the sub-categories unplanned births at home and unspecified site, but a decrease was noted in the number of births during transportation. Maternal risk factors include young age, multiparity and residence in rural municipality. Unplanned births are associated with increased perinatal mortality. A part of the explanation may be suboptimal risk management and medical care of newborns. Mortality is but the tip of the iceberg of morbidity, and our findings call for further studies and actions.

Funding

Norwegian Air Ambulance Foundation and National Center of Rural Medicine.

Acknowledgments

We thank the Medical Birth Registry of Norway for access to data and Torstein Vik for critical review of the manuscript.

References

1. Bergsjo P, Daltveit AK. Fødeinstitusjoner og fødsler i norske fylker i begynnelsen av 1990-årene [Birthing institutions and births in Norwegian counties in the early 1990s] (in Norwegian). Tidsskr Nor Laegeforen. 1996;116:1591–4.

2. Nilsen ST, Daltveit AK, Irgens LM. Fødeinstitusjoner og fødsler i Norge i 1990-årene. [Obstetric departments, delivery units and births in Norway in the 1990s] (in Norwegian). Tidsskr Nor Laegeforen. 2001;121:3208–12.
3. Egenberg S, Puntervoll SA, Øian P. Prehospital fødselsomsorg i Norge [Prehospital maternity care in Norway] (in Norwegian). Tidsskr Nor Laegeforen. 2011;131:2347–51.
4. Engjom H, Morken NH, Norheim O, Klungsoyr K. Availability and access in modern obstetric care: a retrospective population-based study. BJOG. 2014;121:290–9.
5. Sarfraz AA, Samuelsen SO, Eskild A. Changes in fetal death during 40 years – different trends for different gestational ages: a population-based study in Norway. BJOG. 2011;118:488–94.
6. Årstabeller for Medisinsk fødselsregister 2011. Folkehelseinstituttet. 2013. Available online at: http://www.fhi.no/dokumenter/2a92108f4f.pdf. (accessed February 2, 2014).
7. Argent VP. Pre-hospital risks of the reconfiguration of obstetric services. Clin Risk. 2010;16:52–5.
8. Hemminki E, Heino A, Gissler M. Should births be centralised in higher level hospitals? Experiences from regionalised health care in Finland. BJOG. 2011;118:1186–95.
9. Viisainen K, Gissler M, Hartikainen AL, Hemminki E. Accidental out-of-hospital births in Finland: incidence and geographical distribution 1963–1995. Acta Obstet Gynecol Scand. 1999;78:372–8.
10. Daltveit AK, Irgens LM, Vollset SE. Risikoforhold ved transportfødsler i Norge 1967–88 [Risk factors of deliveries during transport in Norway 1967–88] (in Norwegian). Tidsskr Nor Laegeforen. 1991;111:1217–21.
11. Unterscheider J, Ma'ayeh M, Geary MP. Born before arrival births: impact of a changing obstetric population. J Obstet Gynaecol. 2011;31:721–3.
12. Jones P, Alberti C, Jule L, Chabernaud JL, Lode N, Sieurin A, et al. Mortality in out-of-hospital premature births. Acta Paediatr. 2011;100:181–7.
13. Lazic Z, Takac I. Outcomes and risk factors for unplanned delivery at home and before arrival to the hospital. Wien Klin Wochenschr. 2011;123:11–4.
14. Bhoopalam PS, Watkinson M. Babies born before arrival at hospital. BJOG. 1991;98:57–64.
15. Rodie VA, Thomson AJ, Norman JE. Accidental out-of-hospital deliveries: an obstetric and neonatal case control study. Acta Obstet Gynecol Scand. 2002;81:50–4.
16. Irgens LM. Medisinsk fødselsregister – et sentralt utgangspunkt for perinatalmedisinsk forskning [Medical birth registry – an essential resource in perinatal medical research] (in Norwegian. Abstract in English). Tidsskr Nor Laegeforen. 2002;122:2546–9.
17. Statistics Norway – official statistics about Norwegian society since 1876. Available online at: http://www4.ssb.no/stabas/ClassificationFrames.asp?ID=919597&Language=nb. (accessed December 5, 2012).
18. Standard Classification of Municipalities 1994. Oslo-Kongsvinger: Statistics Norway. 1994. Available online at: http://www.ssb.no/histstat/nos/nos_c192.pdf. (accessed December 5, 2012).
19. Moster D, Markestad T, Lie RT. Assessing quality of obstetric care for low-risk deliveries; methodological problems in the use of population based mortality data. Acta Obstet Gynecol Scand. 2000;79:478–84.
20. Wilcox A, Skjaerven R, Buekens P, Kiely J. Birth weight and perinatal mortality. A comparison of the United States and Norway. JAMA. 1995;273:709–11.
21. Skjaerven R, Gjessing HK, Bakketeig LS. Birthweight by gestational age in Norway. Acta Obstet Gynecol Scand. 2000;79:440–9.
22. Fougner B, Nakling J. Fødsler utenfor fødeinstitusjon og kort tid etter ankomst [Deliveries during transportation and shortly after admission to hospital] (in Norwegian). Tidsskr Nor Laegeforen. 2000;120:1288–90.
23. Ravelli AC, Jager KJ, de Groot MH, Erwich JJ, Rijninks-van Driel GC, Tromp M, et al. Travel time from home to hospital and adverse perinatal outcomes in women at term in the Netherlands. BJOG. 2011;118:457–65.
24. Renesme L, Garlantezec R, Anouilh F, Bertschy F, Carpentier M, Sizun J. Accidental out-of-hospital deliveries: a case-control study. Acta Paediatr. 2013;102: e174–7.
25. Blondel B, Drewniak N, Pilkington H, Zeitlin J. Out-of-hospital births and the supply of maternity units in France. Health Place. 2011;17:1170–3.
26. Aladdin BH, Jacobsson B, Sandberg K, Lilja H. Oväntad förlossning utanför sjukhus – erfarenheter från Göteborgsregionen. Centraliserad förlossningsvård kraver kompetent ambulanspersonal [Unexpected out-of-hospital deliveries – experiences from the Gothenburg area. Centralized obstetrical care requires competent ambulance staff] (in Swedish). Lakartidningen. 2004;101:3148–50.
27. Smith GC, Cordeaux Y, White IR, Pasupathy D, Missfelder-Lobos H, Pell JP, et al. The effect of delaying childbirth on primary cesarean section rates. PLoS Med. 2008;5:e144.
28. Martinussen MP. Prehospital fødselsomsorg [Prehospital maternity care] (in Norwegian). Tidsskr Nor Laegeforen. 2011;131:2330.
29. Berge SD, Berg-Utby C, Skogvoll E. Helicopter transport of sick neonates: a 14-year population-based study. Acta Anaesthesiol Scand. 2005;49:999–1003.
30. Hotvedt R, Kristiansen IS, Forde OH, Thoner J, Almdahl SM, Bjorsvik G, et al. Which groups of patients benefit from helicopter evacuation? Lancet. 1996;347:1362–6.

