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Daily patient flow unevenness in different sized delivery hospitals – An 11-year register study of 610 227 deliveries

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ABSTRACT

Objectives: To describe the unevenness in daily patient flow (quiet, optimal and busy days) in different sized delivery hospitals.
Study design: Population based register-study of 610 227 hospital deliveries. Data were collected from the Finnish Medical Birth Register from 2006 to 2016. Delivery hospitals (N = 26) were stratified into four categories by annual delivery volume: C1 <1000, C2 1000–1999, C3 2000–2999, C4 ≥3000. Uneven daily patient flow was defined based on the mean of daily delivery volume for each hospital category: quiet day (≤50% of the mean), optimal day (>50% of the mean to <two times the mean) and busy day (≥two times the mean or more).
Results: The mean of daily delivery volume varied from 2.0 to 12.6 between the smallest and the largest hospital, respectively in hospital categories C1 and C4. The daily delivery volume was optimal in 41.2%, 68.3%, 84.0%, and 91.0% of the days in hospital categories C1, C2, C3, and C4, respectively. In the smallest hospitals (C1) almost half of the days appeared to be quiet (42.9%) whereas in the larger hospitals approximately one in four (25.4%), one in seven (13.6%), and less than one in ten of the days were quiet, in the categories C2, C3, and C4 respectively. Busy days were most common in the smallest hospitals (C1) where one in six of the day (15.9%) had daily delivery volume ≥two times the mean or more. In the other hospital categories busy days were rare, and the lowest in the largest hospitals.
Conclusions: Unevenness in daily patient flow was more prominent in the smaller delivery units compared to larger ones. Quiet and busy days both caused challenges to delivery unit organisations. During quiet days, fully over-resourcing of staffing occurred whereas during busy days there was a risk of under-resourcing. It is possible to optimise the size of delivery units to minimise the variation of the daily patient flow to decrease the number of quiet and busy days.

Introduction

A decreasing birth rate in European countries has led to the trend of health care centralisation and consequently to the closure of the small delivery hospitals. The concurrent need for keeping the balance between cost-effectiveness and the provision of accessible and equitable services available to all patients is challenging. The closure of the small delivery units increases single delivery unit́s annual delivery volume and on daily bases can cause unpredictable quiet and busy time periods. The delivery hospitaĺs annual delivery volume has been used as an indicator for the quality of perinatal care. [1]. However, the earlier studies of the effect of delivery unit́s annual delivery volume have shown partly contradictory results. While some European studies demonstrate clearly improved outcomes of very preterm infants in tertiary level hospitals [2–4], the others indicate that the size of delivery units had no or minor effect on perinatal outcomes [5–7]. It is very difficult to compare the results of these studies due to the various endpoints and due to differences in maternity care services, country size and population density. Finally, the patient-mix in different sized delivery

Abbreviations: MBR, Medical Birth Register; THL, Finnish Institute of Health and Welfare.

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hospitals varies a lot since high-risk pregnancies are usually referred to central or university hospitals.

What can be relatively and objectively compared, is the uneven patient flow in daily bases in different sized delivery units. It has been shown in earlier studies that there is an association of the busy day effect on the need for blood transfusions [8]. The busy day effect on overall capacity to produce obstetrical interventions and epidural analgesia during labour has been shown to be generally good in larger sized delivery hospitals (>3000 annual deliveries and university hospitals), whereas small delivery hospitals (<2000 annual deliveries) may have difficulties to maintain this capability during all times (Submitted, Vilkko R, Räisänen S, Gissler M, Stefanovic V, Heinonen: Busy day effect on the use of obstetrical interventions and epidural analgesia during labour: A population-based register study of 601 247 deliveries).

The aim of this study was to add a new approach to observe the daily uneven patient flow, as it relates to quiet, optimal and busy days in different sized delivery hospitals.

Material and methods

This study was conducted in Finland, a Nordic country of five million inhabitants, where the health and maternity care is publicly funded and free of charge for all pregnant women. However, privately funded delivery units are not available. Local and central level hospitals provide the secondary level care, while the tertiary level care is implemented in five university hospitals [9]. With the guidance of Finnish legislation to maintain and ensure patient safety, the hospital centralisation and closure of small delivery hospitals has concerned delivery hospitals, which have <1000 annual deliveries. These small delivery units have been located in the area of low population density, mostly in the northernmost parts of Finland. The trend of decreasing birth rate has been noticed as the total fertility rate was 4.8 in the 19th century, 1.7 in the 20th century, and 1.4 in 2018 [10]. During these last two decades, the number of Finnish delivery hospitals has diminished from 42 to 23 currently. This study included 26 delivery hospitals, which had delivery activity during the study period (2006–2016). In total, the data consisted of 610 227 hospital deliveries. Deliveries which occurred in delivery hospitals (n = 8) with a very low number of annual deliveries (104–694 deliveries per year) were excluded (n = 24 439).

This data (from 2006 to 2016) were collected from the Finnish Medical Birth Register (MBR) which includes data on all live births and stillbirths with a birth weight $\geq$500 g or gestational age $\geq$ 22 weeks, as well as prospectively collected pregnancy and delivery data. The data were collected and used in accordance with the Finnish national data protection legislation. The data is owned by the Finnish Institute of Health and Welfare (THL). This study received the data's owner's (THL) permission to use the data (THL/1749/5.05.00/2011, THL/998/5.05.00/2013 and THL/876/5.05.00/2017). In Finland, the statement of ethics committee was not required for this study since all of the data were anonymised by the register keeper and patients or the public were not involved in this study.

Theory

To determinate the distribution of uneven daily patient flow different sized delivery hospitals (N = 26) were stratified into four categories (C) based on the annual delivery volume: C1 <1000 deliveries, C2 1000–1999 deliveries, C3 2000–2999 deliveries, C4 $\geq$3000 deliveries. The hospital category C1 included local and central level delivery units, with the number of <1000 annual deliveries. This delivery hospital categorisation was chosen based on the Finnish legislation, where hospitals' annual delivery volume is suggested to be >1000 deliveries annually to maintain and ensure patient safety. Hospital category C2 included medium sized (n = 9) and C3 (n = 4) local and central level delivery units across country with annual deliveries from 1000 to 1999 and from 2000 to 2999, respectively. The hospital category C4 included one large sized non-university hospital with $\geq$3000 annual deliveries and all five university hospitals with the profile of taking care of the most complicated cases and well covered referral system.

To define the daily variation of the patient flow (quiet, optimal and busy days) for each hospital category (C1-C4), the daily delivery frequency, range, and the mean number of delivery units daily number of patient flow was calculated.

Based on these calculations, the data were pooled to determine the daily delivery volume distribution for each hospital category and the daily delivery volume was used as a proxy of patient flow in each hospital category. Arithmetic mean was used as an estimate for optimal daily patient flow in each hospital category. To describe the quiet day, patient flow distribution $\leq$50% of the mean was calculated, including days with zero deliveries. Optimal days were calculated from >50% of the mean to <two times the mean and busy days from $\geq$two times the mean and more. Differences in the delivery volume distribution within these four hospital categories were calculated by using univariate and bivariate statistical analyses (mean, standard deviation (SD), range and Chi-square test) by Statistical Package for the Social Sciences (SPSS) version 25. All results are reported and discussed based on the varying daily patient flow (quiet, optimal, busy days) of the four (C1-C4) hospital categories.

Results

Description of annual and daily delivery volumes as well as distribution of optimal, quiet, and busy days determined based on mean and range of daily delivery volume in each of the four hospital categories are shown in the Table 1. The mean and range length of daily delivery volume varied from 2.0 to 12.6, and 10 to 34 between the hospital categories with the lowest (C1) and highest (C4) annual delivery volume categories, respectively.

Fig. 1 shows distribution of optimal, quiet, and busy days by hospital categories. In hospital category C1, 42.9% (12 055 of 28 126), 41.2% (11 592 of 28 126), and 15.9% (4479 of 28 126) represented the frequencies of quiet, optimal and busy days, respectively. In hospital category C2, distributions of quiet, optimal and busy days were 25.4% (9172 of 36 162), 68.3% (24697 of 36 162), and 6.3% (2293 of 36 162) delivery volume days, respectively. The same distribution for the hospital category C3 was 13.6% (2180 of 16 072), 84.0% (13 506 of 16 072) and 2.4% (386 of 16 072), respectively. In category C4 with the largest hospitals, the values were 8.1% (1958 of 24 108), 91.0% (21 945 of 24 108) and 0.9% (205 of 24 108), respectively.

Discussion

This study demonstrated novel and significant data on variation in relative daily patient flow by hospital size. This can be objectively measured in different hospital size categories as opposed to the obstetric quality indicators by delivery hospitals size, since the outcomes are biased due to patient mix differences in different size hospitals. The study identified three interesting findings. First, almost one fifth (17%) of all the days had zero deliveries in the smallest hospitals (C1) whereas in the hospitals with more than two thousand deliveries (C3) the corresponding frequency was 0.3%. Second, assuming that a mean number of deliveries is an optimal day in terms of patient flow and the use of recourses, it

Table 1
Description of the hospital categories, daily deliveries and varying daily delivery volume.

Hospital		Deliveries				Days				
Category*	n	n	% of N	Daily mean	Range of daily deliveries	n**	Quiet day	Optimal day	Busy day	Zero daily deliveries n (%)
C1	7	55 892	9.2	2.0	0–10	28 126	0–1	2–3	4–10	4772 (17)
C2	9	145 471	23.8	4.0	0–16	36 162	0–2	3–7	8–16	830 (2.3)
C3	4	104 051	17.0	6.4	0–24	16 072	0–3	4–12	13–24	47 (0.3)
C4	6	304 813	50.0	12.6	0–34	24 108	0–6	7–25	26–34	6 (0.0)
Pooled	26	610 227	100.0	5.8	0–34	104 468	0–6	2–25	4–34	0–17 (6–4772)

* Category (C)1 <1000 annual deliveries, C2 1000–1999 annual deliveries, C3 2000–2999 annual deliveries, C4 ≥3000 deliveries.
** Total number of days in each category: 4018 days (total number of days in the study period) × summed n of days in each hospital category.
*** Quiet days: ≤50% of the mean.
Optimal days: >50% of the mean to <two times the mean.
Busy days: ≥two times the mean or more.

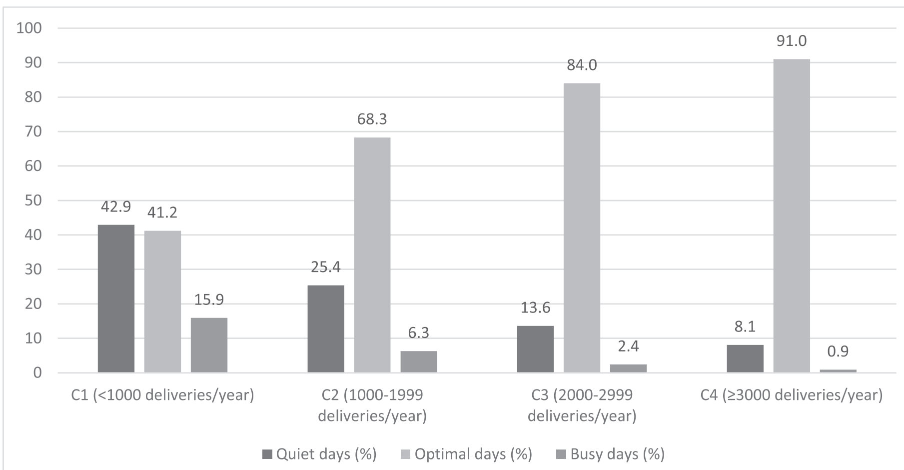

Fig. 1. Distribution of quiet, optimal and busy days determined based the mean of daily delivery volume separately in hospital categories C1-C4. Quiet days: ≤50% of the mean. Optimal days: >50% of the mean to <two times the mean. Busy days: ≥two times the mean or more.

was found that in the smallest hospitals (C1), almost half of the time (42.9% of all days), the patient flow was ≤50% of the optimal patient flow. In the hospital category C4 with annual delivery volume of ≥3000, the quiet patient flow represented 8.1% of the time. Third, in the smallest hospitals (C1) 15.9% of the days were busy with the patient flow of two-fold the optimal or more, whereas in the largest category (C4) the corresponding figure was around 1%.

Relative unevenness in daily patient flow was more extensive in small delivery units but occurred to some extent in larger units as well. From the resource perspective, one can assume that the mean load (the arithmetic mean of daily delivery volume) is a proxy of optimal daily workload. Further, it can be assumed that 50% load or less suggests that the unit is over-resourced and two times the mean load or more indicates that the unit is busy and under-resourced, even if hospital activities are planned to secure somewhat busy time periods to ensure high quality processes with patient safety and minimized delays in patient treatment. Compared to the largest hospitals (C4), the small hospitals (C1) were in the order of 5 times (42.9 vs 8.1%) more likely to be over-resourced with one fifth of the time being zero days, implying that some underutilization may occur. Similarly, approximately a sixth (15.9%) of the days in the smallest hospitals (C1) had more than a two-fold optimal load and were under-resourced or busy, which implies that the small units were 18 times more likely to be over-loaded than the largest ones (C4).

Unevenness in delivery units causes challenges during both quiet and busy days. In respect to staffing, quiet days increase the risk for over-resourcing, whereas during busy days, the risk of under-resourcing arises. However, the unevenness of patient flow is to a high extent unpredictable and unpreventable, and adjusting the staff by varying workload is very limited due to the high expertise required in obstetric care. In addition, the transfer of women during active labour increases the risks, and is far from optimal in terms of a patienťs experience. Basically, by optimizing the size of delivery hospitals, it would be possible to minimize the variation and decrease the number of over-loaded and under-resourced days. Furthermore, in 10–20% of the cases, obstetric services require cooperation across neonatology and obstetric surgery with even more uneven patient flow but still with the need for 24 h/7 days coverage. This means that the economic impacts reach far beyond obstetric services.

Strengths and weaknesses of the study

The strength of this study is the large sample size from a well-established national register (MBR), with high coverage and statistical significance. Also, the data source has shown to be reliable, as demonstrated in previous data quality studies [11–12]. A limitation of the study is that the daily number of births is a proxy of workload although birth events are not equal processes. However, in the long run and with the sample size used, it is likely that the variation of deliveries was not an important determinant of workload. Another limitation was that calendar days were used to classify workload. In practice a normal delivery may extend over a calendar day and the workload may be higher the day before birth than in the actual day of birth. However, in this kind of setting, it is likely that such bias occurs both in small and large hospitals in a similar manner and thus does not affect the results. Thirdly, small hospitals when crowded, may transfer patients to central hospitals but this traffic does not occur in the opposite direction. This source of bias rather underestimates than overestimates the results. It is understood and assumed that this aspect has not been studied previously. Due to the nature of this register study, the information of adequate space or staffing is not available. It is suggested that the present results are likely to be generalizable at least in European countries with similar delivery care services. Quality indicators by the relative workload have not been studied, but optimal staffing and risk management in light of the present results appeared to be easier to control in optimal size units. More detailed information of unevenness in daily patient flow is needed to illustrate the nature between different sized hospital categories.

Conclusions

The variation of daily patient flow, expressed as unevenness daily delivery volume, is significantly higher in small than large hospitals. This leads to relative under- and over-resourcing much more likely in small than large units.

Contributor and guarantor information

The idea for this manuscript was originally generated by Seppo Heinonen (M.D., Ph.D, Professor). Once it was decided to complete this study, all authors: corresponding author Riitta Vilkko (M.H.Sc, Ph.D candidate), Sari Räisänen (Ph.D), Vedran Stefanovic (M.D., Ph. D, Adjunct Professor), Mika Gissler (Dr.Phil, M.Soc.Sc), Seppo Heinonen as a group planned the main structure of the study. The first draft, literature search, introduction, methods, results, discussion and conclusions were written by Riitta Vilkko. All other co-authors read and commented on every section of the manuscript. The last version was read and approved by all co-authors. The Guarantor of this manuscript is Seppo Heinonen who accepts full responsibility for the work of this study and made the decision for publication.

Transparency declaration

The lead author (Riitta Vilkko) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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