Midwife annual delivery workload and maternal and neonatal adverse outcomes, is there an association?

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Abstract

Objective: To evaluate the association between certified nurse midwife (CNM) annual delivery workload and short-term, adverse maternal and neonatal outcomes occurring in vaginal deliveries. Design: A retrospective cohort study Setting: A single tertiary academic center. Population: All single, live vertex term vaginal deliveries between 2006 and 2018 were included Methods: deliveries were categorized into two groups based on the CNM median annual volume of deliveries during the study duration. The "high-volume" and "low-volume" groups included deliveries above and below the median annual delivery volume, respectively as a dichotomous variable. Further analyses were performed for the annual volume by deciles. Main outcomes measures: Short term maternal and neonatal outcomes were compared between "high-volume" and "low-volume" groups and between deciles. Results: During the study period 140,856 deliveries met the study criteria. The median annual deliveries of a single CNM was 152 [114-195]. Maternal and labor characteristics were comparable between the groups. Maternal outcomes were not significantly associated with the CNM's annual workload. However, neonates delivered by CNMs with "low" annual volume had higher a higher rate of neonatal jaundice (aOR 1.07, 95% CI [1.00-1.14]) and mechanical ventilation (aOR 1.32, 95% CI [1.05-1.66). Conclusion: Adverse perinatal outcomes are only mildly affected by CNM's annual volume after controlling for the CNM, parturient and neonate's characteristics. Funding: This study was not funded by any organization.

Introduction

The role of the certified nurse midwife (CNM) during labor and delivery varies greatly around the world[1] and the appropriate model of maternity care is a matter of debate[2]. While in some countries physicians are the primary care providers, there are countries where the model of "midwifery continuity of care" prevails. The most prevalent and typical model of maternity care is a medically led system with varying levels of midwifery input, referred to as "shared model of care" [2]. According to a recent Cochrane review, parturients in the midwife led continuity of care model as oppose to other models of care were less likely to undergo an episiotomy and there were no reported differences in maternal antepartum and postpartum hemorrhage and neonatal Apgar scores[2].

In recent years the impact of the individual practitioner's workload as well as medical center volume on patients' outcome has been a matter of growing interest [3–6]; Specifically in the obstetric practice, studies showed an increased rate of adverse maternal and neonatal outcomes among low obstetric volume hospitals.

Although there exists considerable amount of literature on the different models of care and center obstetrical volume, there is a paucity of information with respect to the association between the individual CNM's experience and adverse maternal and neonatal outcomes. In the present study, we aim to examine the

relationship between the individual CNM workload, measured by annual volume per CNM, and adverse maternal and neonatal outcomes.

Materials and Methods

We performed a retrospective cohort study, which included all live, vertex, term vaginal deliveries (defined as 37-42 weeks of gestation) in a single large tertiary center between January 2006 and December 2018. We excluded stillbirths, cesarean deliveries (CD), vacuum assisted vaginal deliveries (VAVD), multifetal gestations, home deliveries, non-vertex deliveries, vaginal deliveries following more than two previous CD and deliveries by non- CNMs.

Anonymized patient data were extracted from the real time electronic computerized medical record (EMR) that is continuously updated during labor and delivery by certified midwives and obstetricians. Trained medical secretaries further validate the data before it is entered into the database. The EMR includes demographic characteristics, medical and obstetrical history, and data regarding the course of labor and delivery.

Setting

Shaare Zedek Medical Center (SZMC) is an academic medical center with a large obstetric service. The Labor and Delivery Department attends approximately 15,000 deliveries annually in 16 fully equipped delivery suits. The National Insurance Health Plan covers antepartum, labor and delivery, postpartum and neonatal care.

Briefly, in Israel, CNMs undergo an extensive training program before being licensed by the Israel Ministry of Health. Only registered baccalaureate nurses, are eligible to enroll in the CNM program. The training program includes a minimum of 350 hours of theoretical studies, 630 hours of clinical practice, delivery of 50 vaginal deliveries, attending an additional 100 women in various stages of their labor while being mentored by an experienced CNM clinical instructor based on “one on one” preceptorship.

In our academic medical center, "shared model of care" applies, during the labor and delivery, excluding the prenatal care. Women in labor following uncomplicated pregnancies with a singleton vertex presentation are attended, managed and delivered by CNMs. The obstetrician is ultimately responsible for the overall events and outcomes transpiring in the delivery room. In the event of complications and the need for intervention, the obstetrician is involved. The decision making process is led by the board-certified obstetricians. All vacuum assisted vaginal deliveries (VAVD) CDs, multifetal gestations and non-vertex presenting fetuses are managed / performed by obstetricians.

CNMs work shifts are every eight hours, CNM are assigned to a parturient based on availability by the CNM- shift controller. It is customary that one CNM is responsible for two parturient at the same time; usually one is in advanced labor and the other in early labor, or undergoing induction of labor. Occasionally, a situation may arise when both of the parturients in the CNM's care progress simultaneously to the second stage of labor whereby, another CNM is assigned to the delivery one of these parturients, albeit she did not care for the woman during the progress of her labor.

All CNMs who attended and assisted at least one annual vaginal birth during the study period were included in this study. Any cutoff of number of vaginal births attended annually by a single CNM chosen to evaluate the association between CNM's annual workload and incidence of maternal and neonatal complications would have been arbitrary; for the purpose of this study, the median was used as a cutoff value. The annual number of vaginal births attended was determined for each individual CNM separately for every year during the study period and was assigned to the respective group. Every birth delivery was assigned to either "low-volume" group– a vaginal birth which was attended by a CNM who attended less than the median for that year or to "high-volume" group– a vaginal birth which was attended by a CNM who attended more than the median for that year. The high group was chosen as the reference group for analysis. All CNMs names were replaced with random numbers to allow a “blind” analysis.

In order to further evaluate the association between individual CNM workload and outcome and to seek a

threshold value for the CNM optimal experience and outcome, additional analysis according to ten deciles of annual volume was performed. Every delivery was assigned to its respective group by the CNM decile. To avoid possible confounding by time, groups were assigned each year separately for all analyses. We also performed a subgroup analysis of first vaginal delivery with the same methodology as described above.

Outcome measures and definitions

Our primary outcome measure was a composite adverse maternal outcome that included the occurrence of one or more of the following: shoulder dystocia, obstetrical anal sphincter injury (OASIS), retained placenta, post-partum hemorrhage (PPH), blood products transfusion, prolonged duration of hospitalization and puerperal fever.

Even though, the association between lower obstetrician annual volume and the increased risk for CD has been shown[7], we decided not to include CD or VAVD as an outcome measure as the decision to perform CD or VAVD in our department is determined by the attending obstetrician.

CNM practice duration was defined by the time interval between her first attended delivery and index delivery. Shoulder dystocia was defined as a protraction of head-to-body delivery time of >60 seconds, and/or the use obstetrical maneuvers to facilitate safe and rapid delivery[8]. OASIS was classified as third-degree lacerations which involve external ±internal sphincter and fourth-degree rupture which involves the rectal mucosa. OASIS is diagnosed by an obstetrician and repaired in the operating room [9]. "Retained placenta" was defined as any third stage of delivery that included a diagnosis of complete or partial (fragments) remnants of the placenta[10]. PPH was defined by one of two means: a subjective assessment of blood loss (over 500 ml) or hemoglobin drop >3gr/dL[11]. Prolonged hospitalization – length of postpartum hospital stays > 5 days (routine hospitalization length is 2-3 days). Puerperal febrile morbidity - temperature of [?]100.4degF [[?]38degC] from the second day after delivery to discharge[12].

Secondary outcomes were various maternal and neonatal outcomes. The maternal outcomes assessed were those that composed the composite adverse maternal outcome, as described above. The neonatal outcomes included the following composite adverse neonatal outcomes defined by at least one of the following: : rates of 1-min Apgar score< 7, 5-min Apgar score < 7, neonatal asphyxia, meconium aspiration, jaundice, transient tachypnea of the newborn (TTN), mechanical ventilation, convulsions, neonatal intensive care unit (NICU) admission, sepsis, hypoxic ischemic encephalopathy (HIE).

Statistical analysis:

Univariate analysis was performed for categorical variables with the use of the χ^2 or Fisher's exact tests. Continuous variables were compared with the use of the Student t test or Mann-Whitney U test. To evaluate the independent association between CNM annual volume and maternal outcomes, we conducted multivariate logistic regression modeling, adjusting for patient demographic parameters and comorbidities: maternal age, parity, gestational age, trial of labor after cesarean delivery (TOLAC), second stage duration, persistent occipito-posterior, 2^{nd} degree perineal tear and episiotomy. Additional analysis was performed to assess whether association exists between CNM's annual volume and each neonatal outcome adjusting for: maternal age, parity, gestational age, TOLAC and second stage duration. All tests are 2-tailed; a probability value below .05 was considered statistically significant. Analyses were carried out with SPSS software package (version 25.0; IBM Corporation, Armonk, NY).

The study was approved by the local Institutional Review Board of SZMC (IRB-0044-20, 15.08.2108) and was exempted from obtaining informed consent as the study was based on patient records.

Results

During the study period, 197,185 deliveries were recorded; 140,855 (71.4%) deliveries met the study inclusion criteria (**Figure 1**). A total of 159 CNMs worked during the study period at the SZMC, attended at least one delivery annually and were included in the study. The median annual vaginal births attended, during the study period was 152 deliveries [114-195]; 70,849 deliveries (50.3%) were assigned to the "low group"

and 70,006 deliveries (49.7%) to the "high group" in accordance with the CNM "low" and "high" annual volume, respectively.

Per definition, there was a difference in the number of deliveries attended by the CNM in the two groups; the "low volume" group was delivered by CNMs with an average of 108.3±30.5 deliveries annually and the "high volume" group was delivered by CNMs with an average of 208.2±49.6 deliveries annually. The "low volume" group was delivered by CNMs with a longer mean practice duration as compared with the "high volume" group (12.6±10.7 vs 7.5±8.2 years, p<0.001).

Several statistical significant differences were noted in maternal characteristics between groups and these are detailed in **Table 1** . These differences were noted in the following variables (low volume vs. high volume): higher maternal age, higher gravidity, higher parity, higher rate of previous CD, advanced gestational age at delivery, higher rates of diabetes mellitus, lower rate of augmentation of labor, lower rate of persistent occiput posterior and shorter duration of second stage. The incidence of previous miscarriages, hypertensive pregnancy disorders, fertility treatments, induction of labor, epidural analgesia, chorioamnionitis as well as prolonged second stage did not differ significantly between groups.

Primary outcome

The rate of the composite adverse maternal outcome was statistically higher among the low annual volume group (9.8% vs. 9.4%, p<0.01). However, a multivariate regression analysis adjusting for: maternal age, parity, TOLAC, oxytocin augmentation, persistent occipito-posterior presentation and CNMs' practice duration, revealed no significant association between low annual volume and composite adverse maternal outcomes, aOR 1.01, 95% CI [0.97-1.05].

Secondary outcomes

Maternal outcomes

Various maternal outcomes are presented in **Table 2** . The low annual volume group had higher rates of any spontaneous perineal tears (32.3% vs 31.2%, p<0.01) with higher rates of spontaneous 1st and 2nd degree perineal tears (26.4% and 26.9% vs 25.6% and 25.8% p=0.05 and p=0.01 respectively). While, they had lower rates of episiotomy (33% vs. 36%, p<0.01), rates of 3rd and 4th degree perineal tears did not differ. The low annual volume group had higher rates of manual uterine exploration for suspected placental products (2.2% vs. 1.9%, p<0.01), yet rates of manual lysis of the placenta did not differ between the groups. No differences were noted for other maternal outcomes, including; shoulder dystocia, PPH, mean hemoglobin drop, blood products transfusions, endometritis, maternal ICU admissions and prolonged hospitalization.

Multivariate regressions adjusted for: maternal age, parity, TOLAC, oxytocin augmentation, persistent occipito-posterior presentation and CNMs' practice duration, revealed no significant association between low annual volume and manual exploration of uterus aOR 1.06, 95% CI [0.97-1.15].

Neonatal outcomes

Neonatal outcomes of the two study groups are presented in **Table 3** . We observed differences between the low annual volume and the high annual volume in the following outcomes: higher rates of neonatal jaundice (4.1% vs. 3.7%, p<0.01), higher rates of mechanical ventilation rates (0.3% vs 0.2%, p<0.01), and higher rates of composite adverse neonatal outcome (10.9% vs. 10.3%, p<0.01). Other neonatal outcomes were comparable between the study groups.

Multivariate regression analysis adjusted for: maternal age, parity, gestational age, TOLAC, oxytocin augmentation, persistent occipito-posterior and CNMs' practice duration revealed an independent significant positive risk association between low annual volume and mechanical ventilation, neonatal jaundice, and composite adverse neonatal outcome (aOR 1.32, 95% CI [1.05-1.66], aOR 1.07, 95% CI [1.00-1.14]. and aOR 1.05 (1.01-1.09) respectively)

Planned subgroup analysis

We conducted an additional analysis according to ten deciles of annual volume in order to assess an existence of a threshold. The number of vaginal births attended by a single CNM in the 10 deciles was: [?]83 (G1), 84-106 (G2), 107-123 (G3), 124-134 (G4), 135-150 (G5), 151-163 (G6), 164-193 (G7), 185-207 (G8), 208-245 (G9), 246-390 (G10).

Maternal outcomes by the different deciles are presented in**Figure 2** . Neonatal outcomes by the different percentile are presented in **Figure 3** . Overall, we could not detect a difference of a lower rate of maternal or neonatal complications associated with the higher CNM workload.

Primiparity analysis :

Maternal and neonatal outcomes in primiaparous women according to the CNM annual volume revealed a similar trend as was apparent in the entire study population (Table S1 and S2, respectively). Briefly women delivered by CNM with lower annual delivery volume had statistically significant ($p<0.01$) higher rates of any degree of spontaneous perineal lacerations (72.3% vs. 69.8%), 2nd degree perineal tear (20.6% vs. 19.2%), and lower rates of episiotomy (56.1% vs. 58.8%), and higher rates of uterine manual exploration for suspected retained placental products (2.1% vs 1.7%). There was no statistically significant difference in any of the neonatal outcomes aside from the composite adverse neonatal outcome that occurred in 12.3% of the neonates delivered by the low annual delivery volume CNM as opposed to 11.3% of those delivered by high annual delivery volume CNM ($p=0.01$).

Discussion

Main findings: In this retrospective study, we examined the association between the CNM's annual workload and short-term maternal and neonatal outcomes of term singleton vaginal vertex deliveries. Only few minor differences in maternal and neonatal outcomes were noted between those delivered by CNM with low workload as opposed to those with high workload. Even though univariate analysis revealed higher rates of some maternal outcomes (composite adverse maternal outcomes, spontaneous perineal tears both 1^{st} and 2^{nd} degrees, uterine manual revision for suspected retained placental products and lower rates of episiotomies) on multivariate analysis these differences were no longer apparent. However, some neonatal outcomes differed between CNM with high and low annual delivery workload both using univariate analysis and multiple regression analysis. Low CNM annual delivery workload was associated with higher composite adverse neonatal outcome, neonatal jaundice and mechanical ventilation rates. Further analysis in deciles revealed similarly that there is no reduction in maternal or neonatal morbidity in higher deciles and that the findings reported for the entire population valid for somewhat higher risk population – the nulliparous population.

Despite the statistically significant statistics in specified outcomes, the relatively low odds ratio, the fact that confidence intervals were close to one and the lack of difference in other analysis such as deciles or specific higher risk groups such as primiparity led us to think that these noted differences could be simply a reflection of our relatively large sample size and thus lacks major clinical significance.**Interpretation:** The association between an individual practitioner and / or medical center annual volume rates of surgical procedures, morbidity and mortality had been well established in previous studies[13,14]. Annual procedure volume is an accepted quality marker and has been shown to correlate directly with morbidity and mortality rates in surgical and high-risk medical procedures[4,14–16]. It has also been suggested that volume outcome relationship is not always linear and that, in some instances, there appears to be a threshold which differs according to the procedure[13].

In the current study, rates of spontaneous 1^{st} (26.4% vs. 25.6%, $p=0.05$) and 2^{nd} (26.9% vs. 25.8%, $p=0.01$) degree perineal tears and overall perineal tears (32.3% vs. 31.2%, $p<0.001$) were higher among parturient delivered by the low annual volume group. These rates are parallel with what has been recently published in a systematic review and meta-analysis of rates of birth-related perineal trauma[17]. These findings are also in accordance with a previous studies that showed an association between overall perineal tears and 1^{st} and 2^{nd} degree perineal tears and midwife experience[18,19]. In our study rates of 3^{rd} and 4^{th} degree perineal tears did not differ between the groups. These rates are similar to what has been previously published, however

in one study there was an association between all 4 degrees of perineal tears and the midwife's experience[19].

With regard to neonatal outcomes, the statically significant higher rates of the composite adverse neonatal outcome among the low annual volume group (10.9% vs. 10.3%, p<0.001%) was attributed to jaundice (4.1% vs. 3.7%, p<0.001%) and mechanical ventilation (0.3% vs. 0.2%, p<0.001). These rates were comparable with a large Norwegian population-based study that assessed adverse perinatal outcomes in 665,244 term and post-term deliveries[20]

Even with the statistically significant difference in the mechanical ventilation rate (0.3% vs. 0.2%) no other statistically significant difference in Apgar scores, neonatal asphyxia and NICU Admissions rates were determined.

In the planning of the current study, we anticipated that higher individual CNM delivery volume would translate into better perinatal outcome, however, we have noted only some statistically significant differences. The absolute magnitude of these differences was minor and likely without clinically significant meaning. We believe that this may be attributed to several factors.

Primarily, labor and delivery is a natural process, and when compared to CD, spontaneous vaginal delivery is associated with decreased maternal morbidity[21]. Even in the surgical field, in some procedures such as rectal cancer surgery, surgeon volume appears to have no effect or a small beneficial effect on complication rates, and survival[22]. Furthermore, the CNM's extensive training program and the "shared model" of care applied in our setting may be related to the favorable outcome of the low annual volume group. Using the shared model of care enables the on duty CNM controller (an experienced CNM who oversees the entire CNM team working in her shift) together with an attending obstetrician to oversee all deliveries and CNM work. As a result, each delivery is objectively observed by several independent care givers, allowing for better teamwork, nursing and medical care, shared thinking, decision making and responsibility. This model eliminates, at least in part, the option of preventable medical mistakes, "near misses" during labor and facilitates proper delivery management. Finally, it is possible that most of adverse outcomes seen during labor and delivery are a direct result of the inherent maternal and fetal characteristics (i.e neonatal macrosomia, maternal BMI etc.) and little may be attributed to inexperience CNM techniques[2].

Strengths and imitations: Our study possesses several strengths. Predominantly, to the best of our knowledge this is the first study that examines the association between CNM's annual volume and various maternal and neonatal outcomes. It is based on a large sample size of deliveries and of CNMs. All records used in this study were derived from real time updated computerized database, minimizing the possibility of bias. In addition, our study outcomes rates, both maternal and neonatal, are on par with what is reported in the literature.

This study has various limitations; We included only spontaneous term vaginal deliveries, thus the association between the CNM volume and VAVD/CD cannot be concluded from the current study[2]. Additionally, our definition of low vs. high annual volume was arbitrary and chosen as the median annual volume. However, further deciles analysis has shown the same pattern without any evident threshold for better outcomes. Lastly, it is possible that assessing single CNM experience in a large academic medical center may not reflect volume/outcome relationships in other centers.

Conclusion: In low risk term vaginal deliveries, perinatal outcomes were mostly not affected by CNM's annual workload. These findings suggest that having term singleton vaginal deliveries delivered by a low volume CNM is as safe as delivering with a higher annual volume CNM. Future studies should assess the effect of CNM's annual workload in various setups.

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Authors contribution:

Authors' contribution: M Rottenstriech: Protocol development, Data collection and management, Data analysis, Manuscript writing/editing. R Rotem: Protocol development, Data collection and management,

Data analysis, Manuscript writing/editing. P Mor : Protocol development,, Manuscript writing/editing. O Reichman: Data collection and management, Manuscript writing/editing

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Ethical approva l: The study was approved by the local Institutional Review Board of SZMC (IRB-0044-20, 15.08.2108). As the study was based on patient records, no informed consent was needed.

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Figure legend:

Figure 1: Flow chart of the study group

Figure 2: Maternal outcomes

Figure 3: Neonatal outcomes

Table 1: Baseline maternal, labor and delivery characteristics of the study population

	Low volume (n=70,849)
Maternal age	28.8±5.6
Gravidity	4±2.8
Parity	3.5±2.4
Previous miscarriages	20409 (28.8%)
Previous miscarriages>3	2453 (3.5%)
Previous cesarean delivery any	5320 (7.5%)
Assisted reproductive techniques	1444 (2%)
Hypertensive disorders of pregnancy	1269 (1.8%)
Diabetes (pre-gestational + gestational)	2709 (3.8%)
Gestational age at delivery weeks	39.5±1.2
Meconium-stained amniotic fluid	11571 (16.3%)
Epidural analgesia	39038 (55.1%)
Chorioamnionitis	138 (0.2%)
Persistent occiput posterior	2227 (3.1%)
Induction of labor	6151 (8.7%)

Table 1: Baseline maternal, labor

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Oxytocin augmentation of labor	13719 (19.4%)
Birthweight grams	3336.5±423.7
Birthweight>4000 grams	4440 (6.3%)
Large for gestational age	10259 (14.5%)
Small for gestational age	4268 (6%)
Second stage duration, hours	0:32:40±1:12:28
Prolonged second stage	2592 (3.7%)
Data are mean± standard deviation; number (%);	Data are mean± standard deviatio

Table 2: Maternal outcomes
Hospitalization length days
Prolonged hospitalization stay
Manual lysis of the placenta
Manual exploration of uterus for suspected placental products
Any spontaneous perineal tear
1st degree perineal tear
2nd degree perineal tear
3rd /4th degree perineal tear
Laceration
Episiotomy
Shoulder dystocia
Maternal ICU admissions
Postpartum hemorrhage
Hemoglobin drop gram/dl
Hemoglobin drop>4 gram/dl
Endometritis
Parenteral Iron administration
Blood products transfusion
Composite Adverse maternal outcome*
Data are mean± standard deviation; number (%); ICU intensive care unit. * included at least one of: 3^{rd} /4^{th} degree perine

Table 3: Neonatal outcomes
Apgar 1 min <7
Apgar 5 min <7
Neonatal asphyxia
Meconium aspiration
Jaundice
Scalp trauma
Transient tachypnea of the newborn
Mechanical ventilation
Convulsions
NICU Admission
Hypoglycemia
Sepsis

Table 3: Neonatal outcomes

Hypoxic ischemic encephalopathy
Adverse neonatal outcome*

Data are mean± standard deviation; number (%); NICU - Neonatal intensive care unit, * included at least one of: Apgar 1

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