# Oxytocin administration for induction and augmentation of labour in Polish maternity units– an observational study

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**Research article**

**Keywords:** oxytocin, labour, induction, augmentation, practice protocol

**Posted Date:** December 11th, 2020

**DOI:** https://doi.org/10.21203/rs.3.rs-43678/v2



**Version of Record:** A version of this preprint was published at BMC Pregnancy and Childbirth on November 11th, 2021.
See the published version at https://doi.org/10.1186/s12884-021-04190-w.

# Abstract

**Background:** There is not enough data regarding practices and protocols that healthcare personnel follow and the amount of oxytocin that women receive during labour. Empirical evidence indicates that compliance with the guidelines improves the quality of healthcare and reduces adverse effects. The study aimed to evaluate practices of oxytocin provision for labour induction and augmentation in Polish maternity units.

**Methods:** The article presents a prospective observational study. Data collection took place in two selected maternity units between January 15 and July 31, 2019 (n=545). The analysis included the total amount and cumulative dose of oxytocin during labour. We analysed the relationship between the cumulative dose of oxytocin and short term perinatal outcomes (mode of delivery, use of epidural anaesthesia, Apgar scores, birth weight and postpartum blood loss). The study examines the compliance of oxytocin supply during labour with national guidelines in the following five criteria: medium, start dose, escalation rate, interval, the continuation of infusion after established labour.

**Results:** The average total amount of oxytocin administrated to women before birth was 7.329μg following labour induction and 3.952μg following labour augmentation. The actual administration of oxytocin deviated both from the unit and national guidelines in 93.6% of all observed labours (mainly because of continuation of infusion after established labour). We found no statistically significant correlation between the cumulative dose of oxytocin administered and mode of delivery, immediate postpartum blood loss or Apgar scores. There was no observed effect of cumulative dose oxytocin on short-term perinatal outcomes. Hospitals with similar protocols did not differ significantly in terms of total oxytocin amount, rates of induction and augmentation - the only observed difference was the mode of delivery.

**Conclusions:** There was no practical effect of cumulative dose oxytocin on short-term perinatal outcomes. In the study, we observed significant discrepancies between protocols and practice.


# Background

The number of women who have their labour induced or augmented with synthetic oxytocin is increasing in high-income countries throughout the world [1,2]. At the same time, there are considerable differences in the intrapartum oxytocin administration regimens between and within countries, regions and hospitals in Europe [3]. In Poland, there is no official data regarding oxytocin administration. Surveys of postpartum women revealed that between 43% and 63% of all births are induced or stimulated with synthetic oxytocin [4]. In 2017, the Polish Society of Gynaecologists and Obstetricians (PSOGO https://www.ptgin.pl/) issued national guidelines on the use of synthetic oxytocin for labour induction and augmentation [5]. They recommend two oxytocin administration regimens: (i) low dose (start dose 0.5-2 milliUnits per minute (mU/min), escalating at 1-2 mU/min at 15-40 min intervals) and (ii) high dose (start dose 6mU/min, escalating at 3-6mU/min at 15-40 min intervals). The guidelines also state that there are no apparent benefits to continuing oxytocin infusion after achieving effective uterine contractions and reaching the active phase of labour (dilatation > 5 cm). The guidelines on the use of synthetic oxytocin for labour induction and augmentation do not include case-specific variations.

However, there is not enough data regarding practices and protocols that healthcare personnel follow and the amount of oxytocin that women receive during labour. Observed differences in the practice of oxytocin use should stimulate efforts to standardise the procedures [3]. Following a strict protocol may face resistance from those responsible for labour care [6].

Routine oxytocin use presents no benefits when there are no medical indications for labour augmentation [7,8]. Despite its widespread use during labour, and its effectiveness in labour induction and augmentation [9], there is still little

research on the short and long-term consequences of synthetic oxytocin on both the woman and child [10].

While an increasing number of studies suggest possible adverse effects of intrapartum synthetic oxytocin, there is only a few works study impact of the total and cumulative dose of synthetic oxytocin administered during labour [11–14]. These studies concentrate primarily on the effects of maternal obesity and indicate that significantly higher dosages of oxytocin are used in obese women. Additionally, the Carlson study shows that hourly oxytocin dose in obese women was also related to neonatal birth weight and cervical dilation at oxytocin initiation [11].

Studying these aspects is particularly crucial in the light of the latest reports on the longer than the previously believed half-life of oxytocin that can lead to high accumulation and unnecessary exposure in women [15].

This study aimed to assess administration practices of oxytocin for labour induction and augmentation in maternity units. The assessment included calculation of total amounts of oxytocin, accordance with national guidelines and analysis of maternal and neonatal outcomes.

# Methods

### *Study design and setting*

The study was conducted between January 1 and July 31 2019, in Warsaw, Poland. Currently, there are 378 maternity units in Poland, organised on a three-level referral system, with tertiary hospitals providing the most specialist care [16]. Sixteen of these maternity units are in Warsaw, catering for approximately 21,000 births per annum [17]. In 2018 in Poland, the caesarean section (CS) rate was 43.9%, and labour induction and augmentation rates were 43% and 61%, respectively [4,18], which gives the third place among 21 OECD countries (the Organization for Economic Co-operation and Development ) [19].

### *Data collection*

Sixteen maternity units were invited to participate in the study. The inclusion criteria for maternity units was consent for participation and implemented internal written protocols compatible with the national guidelines for oxytocin administration during labour. Five hospitals did not consent to participation in the study. Eight hospitals did not have a written protocol. One hospital had a written protocol, but it did not adhere to the national guidelines. Two hospitals fulfilled the established inclusion criteria (unit A and B). Both of these units were tertiary hospitals. In those units, contemporaneous observation of labour assessing oxytocin use was performed by trained volunteer midwives between January 15 and July 31 2019. Midwives working in labour and delivery wards in both units were invited to volunteer their participation in the study. Volunteer midwives were trained on how to record intrapartum oxytocin administration and complete the data collection form [see Additional file 1]. Convenience sampling was used to collect the data. Trained midwives observed and filled the data collection forms of induced or augmented labours during their planned shifts. The inclusion criteria were women in term pregnancies, women > 18 years of age, no known fetal abnormalities.

Data were collected on maternal age, parity, gestational age, indication(s) for induction or augmentation of labour, type and volume of infusion solution (ml), amount of oxytocin in the infusion (International Units - IU), start dose (ml/h), maximum dose (ml/h), escalation rate and exact time of each escalation (ml/min), use of epidural anaesthesia, Apgar scores and blood loss (ml). The total amount of oxytocin administrated during labour is defined as the total amount of oxytocin provided from the beginning in the labour ward until delivery (including the III and IV stage of labour) and calculated in micrograms (µg). The cumulative dose is defined as the amount of oxytocin given until the birth of the neonate and is calculated in micrograms (µg). Short term perinatal outcomes assessed in the study were the mode of delivery, use of epidural anaesthesia, Apgar scores, birth weight and blood loss.

In cases of emergency CS, we excluded the amount of oxytocin administered after birth. The total time of oxytocin administration was calculated from the start of the infusion until delivery. The time during which the infusion was stopped/disconnected (e.g., for the administration of epidural anaesthesia) was deducted from the administration time. The protocol in unit A included:  Infusion medium - 5 IU oxytocin in 0.9% NaCl 50 ml, Starting dose - 1ml/h, Maximum dose - 6 ml/h,  Escalation rate - 1 ml every 10-15 mins. In unit B: Infusion fluid - 5 IU oxytocin in Glucose 50 ml, Starting dose - 0.6-1.2 ml/h, Maximum dose - 18 ml/h, Escalation rate - 0.6-1.2 ml every 30 mins. now żadym None of the protocols stated contraindications and provision in particular situations.

We assessed each observation for compliance with the national protocols in all the defined criteria: medium, start dose, escalation rate, interval, the continuation of infusion after established labour. We achieved the sample size through convenience sampling over a limited time, as described above (244 births in unit A and 301 in unit B). There was no prespecified sample size calculated because no comparisons regarding outcome and interventions were made between the studied units.

### *Data analysis*

All analysis was conducted using statistical program R with statistical significance set at p=<0.05 for all analysis [20]. Nominal variables were compared using the Chi-square test. Ordinal variables were checked for normality of distribution, using the Shapiro-Wilk test and compared with the ANOVA Kruskal-Wallis and U Mann-Whitney tests. Correlations between ordinal variables were analysed using Spearman test, and correlations between nominal variables were calculated using a linear model. The results are presented as an average and standard deviation and as numbers and percentages of the total. Correlations with induction or augmentation of labour and mode of birth were calculated using Wilcoxon rank-sum test with continuity correlation.

### *Ethical issues*

The Bio-ethical Commission approved the study of the Medical University of Warsaw (reference number AKB/226/2018). According to Polish law, non-interventional observational studies do not require patient consent.

## Results

The data on 545 births were analysed, 244 births in unit A and 301 in unit B (Table 1). Women's average age was 31 years [range 19 to 44 years, SD=4.5], 68% (n=375) were nulliparous. The rate of augmentation of labour was 33% (n=182), while the percentage of induction was 67% (n=363). In the studied group, most deliveries were vaginal (84%; n=456), and only 16% (n=89) ended up in a cesarean section. In unit A cesarean section rate was 13% and in Unit B 20%. The most common indications for labour induction were maternal gestational diabetes mellitus, pregnancy-induced hypertension, small for gestational age (fetal growth $\leq 10^{th}$ percentile for gestational weight) and prelabour rupture of membranes. The only indication for labour augmentation was hypotonic uterine action (weakening of uterine contractions in the first and second stage of labour). The maternal characteristics and obstetric outcome at the two units shown in Table 1.

Tab 1. The maternal characteristics and obstetric outcome at the two study sites.

| | Unit A<br>N=244 | Unit B<br>N=301 | Total<br>N=545 | p -value |
|---|---|---|---|---|
| | n (%) | n (%) | n (%) | |
| Age (years) | | | | p=0.117 |
| ≤24 | 16 (7) | 20 (7) | 36 (7) | $\chi^2$=4,29 |
| 25-34 | 162 (66) | 222 (73) | 384 (70) | |
| ≥ 35 | 66 (27) | 59 (20) | 125 (23) | |
| Gestational age (weeks) | | | | p=0.000* |
| 37-39 | 108 (44) | 186 (62) | 294 (54) | $\chi^2$=16,67 |
| >40 | 136 (56) | 115 (38) | 251 (46) | |
| Parity | | | | p=0.576 |
| Nulliparous | 165 (68) | 210 (70) | 375 (69) | $\chi^2$=4,81 |
| Multiparous | 79 (32) | 91 (30) | 170 (31) | |
| Type of delivery | | | | p=0.021* |
| Vaginal delivery | 214 (88) | 242 (80) | 456 (84) | $\chi^2$=5,26 |
| Cesarean sections | 30 (12) | 59 (20) | 89 (16) | |
| Induction | 161 (66) | 202 (67) | 363 (67) | p=0.802 |
| Augmentation | 83 (34) | 99 (323) | 182 (33) | $\chi^2$=0,06 |
| Postpartum blood loss (ml) | | | | p=0.000* |
| <300 | 34 (14) | 179 (59) | 213 (39) | $\chi^2$=121,00 |
| 301-500 | 202 (83) | 111 (37) | 313 (57) | |
| >501 | 8 (3) | 11 (4) | 19 (4) | |
| Epidural | | | | p=0.000* |
| Yes | 92 (38) | 194 (64) | 286 (52) | $\chi^2$=38,65 |
| No | 152 (62) | 107 (36) | 259 (48) | |
| Apgar score (points) | | | | - |
| 1 min <7 | 1 (0.4) | 1 (0.3) | 2 (0.4) | |
| 5 min <7 | 2 (0.8) | 0 | 2 (0.4) | |
| 10 min <7 | 0 | 0 | 0 | |
| Birth weight (g) | | | | p=0.924 |

| | | | | |
|---|---|---|---|---|
| >4000 | 224 (92) | 277 (92) | 501 (82) | $\chi^2$=0,09 |
| ≥4000 | 20 (9) | 24 (8) | 44 (8) | |

*p-value (p<0,05)

In the studied group, after induction of labour (n=363), 81% of women delivered vaginaly (n=295) (Table 2). Primiparas had higher rates of cesarean sections than multiparas (25% v 6%, chi2=18,34; p<0.05). In the group with augmented labour (n=182), 88% delivered vaginally (n=161) (Tabel 2). Among primiparas and multiparas, the cesarean rate was 4%, versus 14% respectively, but there were no statistical differences between the groups regarding the mode of delivery.

Tab. 2 Maternal, obstetric and neonatal data in relation to mean oxytocin dose, maximum oxytocin dose and escalation rate in induction and augmentation groups.

| | Induction N=363 | | | | Augmentation N=182 | | | |
|---|---|---|---|---|---|---|---|---|
| | n (%) | Cumulative dose (mg) (mean±SD) | Maximum dose (ml/h) (mean±SD) | Escalation rate (min) (mean±SD) | n (%) | Cumulative dose (mg) (mean±SD) | Maximum dose (ml/h) (mean±SD) | Escalation rate (min) (mean±SD) |
| Age (years) | | | | | | | | |
| ≤24 | 19 (5) | 5.47 (±3.83) | 9 (±5) | 55 (±30) | 17 (9) | 3.13 (±2.73) | 9 (±6) | 48 (±41) |
| 25-34 | 250 (69) | 7.80 (±5.24) | 11 (±5) | 62 (±38) | 134 (74) | 4.11 (±3.48) | 8 (±5) | 34 (±22) |
| ≥ 35 | 94 (26) | 6.12 (±5.65) | 10 (±6) | 56 (±34) | 31 (17) | 4.21 (±2.49) | 9 (±6) | 30 (±25) |
| Gestational age (weeks) | | | | | | | | |
| 37-39 | 217 (60) | 7.51 (±5.25) | 7 (±3) | 57 (±38) | 77 (42) | 3.68 (±2.96) | 5 (±2) | 33 (±21) |
| >40 | 146 (40) | 6.85 (±5.47) | 6 (±3) | 59 (±45) | 105 (58) | 4.16 (±3.51) | 6 (±2) | 35 (±25) |
| Parity | | | | | | | | |
| nulliparous | 243 (67) | 8.49 (±5.42) | 7 (±3) | 65 (±42) | 132 (73) | 4.51 (±3.46) | 6 (±3) | 34 (±23) |
| multiparous | 120 (33) | 4.79 (±4.19) | 5 (±2) | 44 (±35) | 50 (27) | 2.46 (±2.19) | 5 (±3) | 35 (±29) |
| Type of delivery | | | | | | | | |
| Vaginal delivery | 295 (81) | 8.31 (±6.77) | 7 (±3) | 58 (±42) | 161 (88) | 3.99 (±3.24) | 5 (±3) | 34 (±21) |
| Cesarean sections | 68 (19) | 6.99 (±4.94) | 6 (±3) | 57 (±39) | 21 (12) | 3.59 (±3.75) | 5 (±3) | 34 (±25) |
| Postpartum blood loss (ml)* | | | | | | | | |
| <300 | 148 (41) | 7.12 (±5.60) | 6 (±3) | 53 (±39) | 65 (36) | 3.41 (±3.02) | 5 (±2) | 29 (±20) |
| 301-500 | 203 (56) | 7.29 (±5.26) | 7 (±3) | 62 (±41) | 110 (60) | 4.12 (±3.38) | 6 (±2) | 37 (±27) |
| >501 | 12 (3) | 8.18 (±3.26) | 9 (±3) | 60 (±49) | 7 (4) | 6.34 (±3.46) | 6 (±2) | 40 (±21) |
| Epidural | | | | | | | | |
| Yes | 171 (47) | 8.37 (±4.68) | 7 (±3) | 60 (±43) | 114 (63) | 4.22 (±3.15) | 6 (±3) | 33 (±23) |
| No | 192 (53) | 6.23 (±5.81) | 6 (±3) | 56 (±39) | 68 (37) | 3.49 (±3.49) | 5 (±3) | 35 (±27) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Birth weight (g) | | | | | | | | |
| <3999 | 337 (93) | 7.13 (±5.37) | 6 (±3) | 56 (±38) | 164 (90) | 3.81 (±3.05) | 6 (±3) | 35 (±26) |
| ≥4000 | 26 (7) | 8.69 (±4.92) | 7 (±3) | 80 (±67) | 18 (10) | 5.18 (±4.98) | 6 (±3) | 29 (±13) |

* only vaginal deliveries were included

In both units, the cumulative dose of oxytocin administered was considerably higher when labour was induced ($p<0.05$). Women that underwent induction of labour, on average received, 7.3µg (±5.9) of oxytocin, while women during augmented labour received 3.9µg (±3.2). The total amount of oxytocin administered until childbirth and after birth to women during labour was 17.5µg (±7.6) for induction of labour and 14.8µg (±6.6) for augmentation of labour, a statistically significant difference ($p<0.05$).

Without exception, the oxytocin infusion was continued after 5 cm cervical dilatation following induction of labour and discontinued only after the baby's birth.

The minimum escalation rate was 1 millilitre per hour (ml/h) and maximum was 35 ml/h [median 5.6 ml/h, average 6.2 ml/h]. The minimum interval was 2 min, and a maximum of 480 min (median 43.3 min, average 54.1 min).

The cumulative dose of oxytocin related to maternal characteristics and different obstetric outcome shown in Table 3.

Table 3**.** The cumulative dose oxytocin related to maternal characteristics and different obstetric outcome.

| | n (%) | cumulative dose oxytocin (mean ±SD) | p-value |
|---|---|---|---|
| Age (years) | | | p=0.087 |
| ≤24 | 36 (7) | 4.87 (±3.29) | |
| 25-34 | 384 (70) | 6.50 (±5.01) | |
| ≥ 35 | 125 (23) | 5.62 (±6.69) | |
| Gestational age (weeks) | | | p=0.016* |
| 37-39 | 294 (54) | 6.61 (±5.05) | |
| >40 | 251 (46) | 5.82 (±5.71) | |
| Parity | | | p=0.000* |
| Nulliparous | 375 (69) | 7.08 (±5.17) | |
| Multiparous | 170 (31) | 4.24 (±5.29) | |
| Type of delivery | | | p=0.358 |
| Vaginal delivery | 456 (84) | 5.99 (±5.11) | |
| Cesarean sections | 89 (16 ) | 7.20 (±6.49) | |
| Oxytocin (reason) | | | p=0.000* |
| Induction | 363 (67) | 7.33 (±5.84) | |
| Augmentation | 182 (33) | 3.95 (±5.71) | |
| Postpartum blood loss (ml) | | | p=0.472 |
| <300 | 213 (39) | 5.98 (±5.24) | |
| 301-500 | 313 (57) | 6.25 (±5.58) | |
| >501 | 19 (4) | 7.51 (±3.36) | |
| Epidural | | | p=0.007* |
| Yes | 286 (53) | 6.81 (±5.96) | |
| No | 259 (47) | 5.52 (±4.55) | |
| Birth weight | | | p=0.122 |
| >4000 | 501 (92) | | |
| ≥4000 | 44 (8) | | |

*p-value (p<0.05)

There is a  negative correlation between the cumulative dose of oxytocin administered during labour and parity (R Spearman = -0.4087, p<0.05), and a weak correlation with duration of pregnancy (R Spearman = -0.138, p<0.05). There was no statistically significant correlation between the amount of oxytocin administered and maternal age (p=0.2669).

With the increasing cumulative dose of oxytocin, the use of epidural anaesthesia increased slightly (Estimate=0.04908, Pr(>|z|)=0.005876).

There was no statistically significant correlation between the cumulative dose of oxytocin administered and the rate of emergency CS (p=0.05926), forceps-assisted (p=0.3884) or vacuum-assisted births (p=0.7281), immediate postpartum blood loss (p=0.7609), Apgar scores (p=0.8908) and birth weight (p=0.2015). Similarly, there were no statistically significant differences between the units in the total amount of oxytocin administrated to women.

In most instances (93.6%), the actual administration of oxytocin did not comply with the PSOG guidelines due to continuation of infusion after achieving effective uterine contractions and beginning of the active phase of labour (dilatation > 5 cm) (Table 4). In regard of the start dose, escalation dose and interval the protocol was followed in 18.9% (n=103) of labours: 18.4% (n=100) followed the low-dose protocol (start dose 0.5-2 mU/min, escalation rate 1-2 mU/min, interval 15-40 mins) and only 0.6% (n=3) followed the high-dose protocol (start dose 6mU/min, escalation rate 3-6mU/min, interval 15-40 mins). In cases of inconsistencies in escalation rates and intervals, most often the escalation rate increased, and intervals extended.

Table. 4: Accordance with oxytocin national administration protocol (N=545).

| | VARIABLES OF ACCORDANCE WITH NATIONAL PROTOCOL | | | | | |
|---|---|---|---|---|---|---|
| | Medium (n=545) | Start dose* (n=509) | Escalation rate (n=545) | Interval (n=545) | Continuation of infusion after established labour was achieved** (n=363) | All variables of accordance present (n=545) |
| In accordance | n=545 (100%) | n=130 (26%) | n=131 (24%) | n=192 (35%) | n= 4 (1%) | n=35 (6%) |
| Discordant | n=0 (0%) | n=379 (74%) | n=414 (76%) | n=353 (65%) | n= 541 (99%) | n= 510 (94%) |

*36 patients had previously administered oxytocin – start dose not available

** only induced labours

# Discussion

The mean cumulative dose of oxytocin administrated to women in our study was 3.9 μg following augmentation and 7.3 μg following induction of labour and the total amount of oxytocin was 17.5 μg for induction of labour and 14.8 μg for augmentation of labour. Roloff et al. obtained similar results in stimulated labour. The mean cumulative oxytocin dose was 2.3 U (3.9 μg). Selin *et al.* (2019) reported the amount administrated to women from begining of labour until delivery in low and high-dose oxytocin augmentation schemes [21]. In low-dose regimens, women received 5.7 μg and while women in high-dose regimens received 7.9 μg [21], higher than the total amount found in our study. In studies assessing the relationship between oxytocin and BMI (Body mass index). The amount supplied from beginning of labour until delivery depending on BMI was 3.0-4.7 μg [11], 4.3-8.4 μg [14], 1.7-5.0 μg [12]. Similar to our findings, Frey *et al.* (2015) found that induction was associated with higher maximum oxytocin doses [22]. The fact that higher amounts of oxytocin were administrated to women following induction of labour is understandable, given that the infusion is likely to be continued for a more extended period.

Furthermore, there was a correlation between the mean cumulative dose of oxytocin infused, parity and duration of pregnancy. Multiparous women, on average, received lower the mean cumulative dose of oxytocin compared to nulliparous women. A longer duration of pregnancy was associated with a smaller amount of oxytocin being administered, i.e., women whose labours were induced at 40 weeks' gestation, on average, received less oxytocin than women whose labours were induced at 39 weeks' gestation. Similar correlations between parity were reported by Oscarssona *et al*. (2006). Multiparous women were less likely than nulliparous women to receive intrapartum oxytocin [23].

We also found a correlation between the mean cumulative dose of oxytocin administrated during labour and the use of epidural anaesthesia. Other studies have reported similar findings, both in terms of more frequent use of oxytocin administration after the epidural anaesthesia commenced [24,25] and in the more frequent use of epidural anaesthesia following oxytocin augmentation of labour. [26,27]. This may be explained, in part, by the more painful nature of oxytocin-stimulated contractions and restrictions in movement that many women face when continuous electronic fetal monitoring is required during labour induction or augmentation [28].

Although some studies have reported negative associations between intrapartum oxytocin administration and neonatal outcomes [23,29], we did not find any correlation between the the mean cumulative dose of oxytocin administrated Apgar scores and neonatal weight. However, using a more sensitive indicator of neonatal wellbeing, such as pH values in neonates, may lead to different results.

In our study, 84% of women birthed vaginally following labour augmentation, similar to the proportion of 87% found in a Danish study [29] but considerable higher than the 51% reported in Bugg *et al*.'s (2005) study with nulliparous women [30].

We did not find any correlation between the mean cumulative dose of oxytocin administrated to women before birth and the mode of delivery. In other words, women who received large amounts of oxytocin during labour were as likely as women who received small quantities to have an emergency CS. Similar findings were reported in studies comparing the high, and low-dose augmentation, where the higher doses of oxytocin administrated did not lower the risk of CS [21]. A systematic review concluded that early administration of oxytocin did not affect the mode of birth [8]. However, some studies have demonstrated a correlation between oxytocin administration and mode of delivery, including a lower risk of CS when compared to expectant management [27] but overall higher risk of intrapartum interventions [23,26,30]. Systematic reviews show that high-dose inductions and high-dose stimulations did not affect cesarean section rates. [7], [31] We were unable to find any other study reporting on the correlation between the cumulative dose of oxytocin administered and mode of birth.

Ours findings show that the majority of hospitals in Warsaw did not have written protocols on intrapartum oxytocin administration for induction or augmentation of labour. Even in units where protocols were available and compliant with the national guidelines, the actual administration of oxytocin did not follow the recommended regimen in 94 % of labours.

While one study conducted in Germany found that 69% of participating units had protocols on oxytocin administration [3], they did not explore actual adherence to the protocol. In a study by Jackson establishing of a collaboration to build a consensus-driven, evidence-based approach to the use of oxytocin resulted within seven years in accordance with the guidelines in 73% to 100% [6]. Studies show that the use of oxytocin in accordance with guidelines was associated with several significant clinical outcomes, including a decrease in cesarean births for fetal distress based on electronic fetal monitoring, decreases in length of first stage labour, and decreases in maximum dose of oxytocin. [32]

With few exceptions, the oxytocin infusion was continued in all the observed labours, despite the national guidelines,[5] and information in Summary of Product Characteristics for oxytocin,[33] stating that the infusion may be discontinued when labour becomes established, i.e., when cervical dilatation reaches 5 cm. In the light of the latest reports that show the benefit of discontinuing the infusion once established labour is achieved [34,35], observed practices require further analysis. Since too few women in our test group had oxytocin disconnected after reaching active labor, we could not compare this group with the rest. In Poland, we also do not have data on the percentage of cesarean sections in the group of women who received oxytocin during delivery, but only data on the overall percentage of cesarean sections.

The guidelines for the supply of oxytocin proposed by PSOGO do not apply to particular situations such as twin pregnancies, pregnancies with previous caesarean section, pregnancies in obese women. They also lack information on the dose of oxytocin that should be set after disruption of infusion for the time epidural anaesthesia provision.

Even assuming that there were situations in our study group that required non-standard behaviour, it seems unlikely that this would apply to over 90% of those surveyed.

Jackson et al. showed that the lack of oxytocin protocols was primarily due to insufficient consensus between those taking care of the mother (midwives and doctors), between providers and the relevant literature regarding specific, restrictive dosing of oxytocin. When midwives and doctors work together to write a guideline, it has a higher likelihood of being successfully followed [36]. This was not our case, because national guidelines for oxytocin administration in Poland were formed by a group of expert obstetricians.

Typically, deviations from the protocol for stimulation have been associated with increasing time interval to dose escalation. This may be due to the burden being placed on staff when caring for several labouring women at a time and the inability to increase the dose at an exact interval. Investigating the cause of this condition, however, requires detailed research.

The Jackson study found that increasing compliance was associated with a statistically significant reduction in the amount of oxytocin used during labour and a reduction in the time between initiating oxytocin administration and the birth of the child [6].

The two maternity units selected for this study, despite having similar protocols on oxytocin administration, differed considerably in the rates of labour induction and augmentation, as well as the rates of vaginal births after labour induction. Similar discrepancies among units were reported in studies from Sweden and the UK, suggesting that care offered in different units is based on clinicians' attitudes and preferences rather than on scientific research [23,27]. As stated previously, the oxytocin administration regimens were not followed in 510 (93.6%) of the labours observed during our study. Although there is no scientific consensus on the optimal oxytocin administration dose or regimen, clinicians should follow their unit's guidelines unless exceptional circumstances are present.

### Limitations

One of the limitations of our study was the inability to access and analyse data from all women undergoing induction or augmentation of labour. Analysis of data from all women may have resulted in different outcomes.

We conducted the study in tertiary-level urban units providing specialist care to women who may have had complicated medical and obstetric history. Recruitment bias may have affected the rates of therapeutic interventions, including induction and augmentation rates, and it would be beneficial to conduct a similar study in units catering mostly for healthy women.

## Conclusions

We did not observe any effect of the mean cumulative oxytocin dose on short-term perinatal outcomes. It is worth assessing the impact of oxytocin on long-term outcomes. Oxytocin supply in most deliveries was incompatible with oxytocin supply protocols proposed by national experts. A thorough analysis should be performed to find out the reasons for the continuation of oxytocin infusion after achieving established labour. This should also be an essential part of the labour ward staff training. Hospitals with similar protocols did not differ significantly in terms of total oxytocin, induction and augmentation rates. Still, they differed in mode of the delivery—qualitative research explaining what makes this difference would be significant. The observations from our study can be subject to several generalisations. Following guidelines improves the quality of care and increases the safety of those giving birth. In countries with low compliance of practices with standards, measures should be taken to investigate the reasons for such a situation, as well as efforts to support their implementation.

# Abbreviations

CS – Caesarean section

mU – milliUnits

IU – International Units

mU/min – milliUnits per minute

ml/min - Mililiter per minute

ml/h – Mililiter per hour

# Declarations

### Ethics approval and consent to participate

The Bio-ethical Commission approved the study of the Medical University of Warsaw (reference number AKB/226/2018). According to Polish law, non-interventional observational studies do not require patient consent.

### Consent for publication

Not applicable

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors have no conflicts of interest to disclose.

### Funding

The study was sponsored by a grant from the Foundation for St. Sophia Specialist Hospital in Warsaw (number 3B/GF/2018). The grant funded data collection, database construction and statistical analysis.

### Authors' Contributions

BB: Conceptualisation, Data curation, Formal analysis, Methodology, Project administration; Funding acquisition, Writing- original draft, Writing- review&editing;

AK: Conceptualisation, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration; Writing- original draft, Writing- review&editing;

IK: Conceptualisation, Data curation, Formal analysis, Methodology, Project administration, Funding acquisition, Writing- original draft, Writing- review&editing

DS: Conceptualisation, Methodology, Project administration; Writing- review&editing

UTP: Formal analysis, Writing- review&edting;

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MR: Conceptualisation, Methodology, Writing- review&edting;

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**Acknowledgement**

None

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"Observation chart for recording oxytocin administration"

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