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Associations between cervical dilatation on admission and mode of delivery, a cohort study of Norwegian nulliparous women

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ABSTRACT

Objective: To investigate associations between cervical dilatation at hospital admission and mode of delivery.
Methods: A cohort study with data from a cluster-randomised controlled trial, the Labour Progression Study. The study population of 6511 nulliparous women with a singleton fetus in cephalic presentation with spontaneous onset of labour at term, was divided into two groups: <4 cm and ≥ 4 cm cervical dilatation on admission. Binary logistic regression comparing mode of delivery was used to estimate crude and adjusted OR with associated 95% CI.
Results: Of the total study population, 56.7% were admitted with < 4 cm cervical dilatation and 43.3% with ≥ 4 cm. Women admitted with ≥ 4 cm had a significantly higher chance of spontaneous delivery, with adjusted OR of 1.28 (95% CI: 1.14–1.44), and a significantly lower risk of caesarean sections, with an adjusted OR of 0.51 (95% CI: 0.41–0.64). For operative vaginal delivery, there were no significant difference between the study groups. Intrapartum interventions as epidural analgesia and augmentation with oxytocin were lower among women admitted with ≥ 4 cm cervical dilatation.
Conclusion: The study found a significantly higher chance of spontaneous delivery among women admitted with ≥ 4 cm. More research is needed to investigate why so many women are admitted early in labour, and how these women can be better cared for to increase their chances of a spontaneous delivery.

Introduction

The optimal timing for hospital admission of women in labour is an important research and policy question for labouring women, as well as for doctors and midwives. In Norway, women are advised to stay at home until they reach the active phase of labour. However, many seek hospital admission in the latent phase, and several are admitted.

Cervical dilatation is a commonly used parameter in determining a woman's current stage of labour. The definition of active labour recommended in Norwegian Guidelines in Obstetrics is fully effaced cervix, cervical dilatation of 4 cm and the presence of regular contractions [1]. Today's expectations to the cervical dilatation process, and thus the woman's progression in labour date back to the work of Dr Emanuel Friedman in the 1950 s [2]. Based on Friedman's cervicograph, Philpott developed the basis for today's partograph, where active labour and its expected progress were considered to commence at 4 cm cervical dilatation [3]. About 60 years after Friedman presented his work, Zhang et al. presented an alternative curve, where the start of the active phase is 'delayed' until 6 cm dilatation [4].

Worldwide there is no consensus on the optimal definition of active labour. WHO has since 2018 defined active labour as 5 cm cervical dilatation with a substantial degree of cervical effacement and the presence of regular contractions [5]. In the United States, guidelines define active labour at a cervical dilatation of 5–6 cm without any specific mentioning of contractions [6,7]. British guidelines (NICE) define active labour as progressive cervical dilatation from 4 cm with regular painful contractions [8].

Nulliparous women in labour have been found to feel vulnerable and insecure when seeking help in the hospitals [9]. They meet midwives and doctors who are guided by hospital regulations and protocols adapted to limited capacity in the labour wards. Qualitative studies in Scandinavia have shown that this mismatch between women's needs in

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the early stages of labour and what the health care system offer, affects the women's labour experience in a negative way [9,10]. On the other hand, numerous studies have shown significantly higher rates of caesarean sections and more interventions in labours when women are admitted in the latent phase [11–13]. One of the aims stated in the World Health Organisations (WHO) intrapartum guidelines is to avoid unnecessary interventions in labour. It is emphasised that the wide use of interventions in normal labour may interfere with the physiological process of childbirth and undermine women's own capability to give birth [3].

This study is based on a study population of nulliparous women with a singleton fetus in cephalic presentation with spontaneous onset of labour at term. This is an important group to address, as mode of delivery affects future pregnancies and deliveries. Even though previous studies also include nulliparous women, few of them have a homogenous study population of this size [11,13,14]. Also, similar studies have been conducted with data from countries where midwives are not involved as much in the obstetric care as in Scandinavia, such as the United States. Caesarean section rates in countries with similar studies are also not necessarily comparable to Scandinavia, where the rate is lower than many countries globally [15]. This study is based on data from 14 Norwegian hospitals covering all health regions, making results transferable to other countries where midwifery is central in obstetric care.

The main objective of this study was to investigate associations between cervical dilatation at hospital admission and mode of delivery. In accordance with the concept that labour is seen as a natural physiological process, spontaneous vaginal delivery is the main focus. The secondary aim was to investigate associations between cervical dilatation at hospital admission and rates of intrapartum interventions and maternal and neonatal outcomes.

Method and materials

Data used in this cohort study originated from a multicentre cluster-randomised controlled trial (RCT), the Labour Progression Study (LaPS) [16]. The aim of that study was to investigate the impact of different labour progression guidelines on intrapartum caesarean section rates. LaPS was conducted in 14 obstetric units in Norway from 2014 to 2017, all of which handled>500 deliveries per year. The LaPS included 7277 women, all classified as group 1 in the Ten Group Classification System (TGCS), also known as the Robson classification. TGCS group 1 refers to nulliparous women with spontaneous onset of labour at term (≥37 weeks of gestational age), with a singleton fetus in cephalic presentation [17]. The first results of the LaPS were presented in 2018 [16]. For more in-depth descriptions of the trial methodology, readers are referred to this article and the LaPS study protocol [18].

Fig. 1 displays a flow chart of the inclusion process for the present study. Women whose cervical status on admission was reported were included in the data material. The study sample was divided into two groups; one including women admitted to hospital with < 4 cm cervical dilatation and one including women admitted with ≥ 4 cm cervical dilatation. The 4 cm cut-off point is based on how Norwegian Guidelines in Obstetrics define the active phase of labour [1]. Fig. 1 also includes cervical dilatation on hospital admission centimetre by centimetre.

Variables and outcomes

Baseline maternal characteristics for the study population were maternal age at onset of active labour, level of education (>12 years), mother being cohabitant/married, reported smoking in the first trimester of pregnancy and maternal body mass index (BMI) early in pregnancy. Neonatal characteristics were birth weight, head circumference and presentation at birth. Maternal age was divided into categories of < 25 years, 25–35 years and > 35 years. BMI (kg/m^2) early in pregnancy was divided into < 18.5 kg/m^2, 18.5–24.9 kg/m^2, 25–29.9 kg/m^2, 30–34.9 kg/m^2 and ≥ 35 kg/m^2. Neonatal birthweight was divided into < 2500 g, 2500–2999 g, 3000–3999 g, 4000–4499 g and ≥ 4500 g. Neonatal head circumference was divided into < 34 cm, 34–36 cm and > 36 cm.

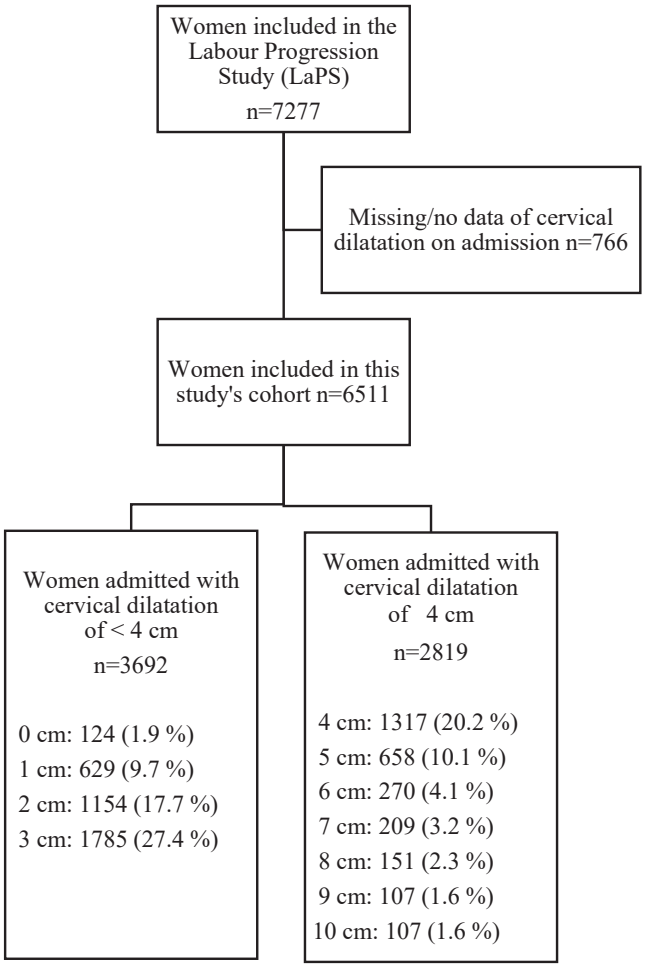

Fig. 1. Flow chart of the inclusion process.

The independent variable in this study was cervical dilatation at hospital admission. Primary outcome was mode of delivery, presented as spontaneous delivery, operative vaginal delivery and caesarean section.

Secondary outcomes were intrapartum interventions, midwifery care during labour, maternal and neonatal outcomes. These variables were customised to the concept of labour as a natural physiological process and are therefore presented as labours *without* interventions and *normal* labour outcomes. Intrapartum interventions included epidural analgesia, artificial rupture of membranes, episiotomy and augmentation with oxytocin during labour. Midwifery care during labour were presented as one-to one care. Normal maternal outcomes were intact anal sphincters after vaginal delivery and normal postpartum haemorrhage, defined as 500 ml or less [19]. Normal neonatal outcomes were Apgar score of ≥ 7 after 5 min, and neonates without admission to neonatal intensive care unit (NICU) lasting > 24 h.

Analyses

Chi-square tests were used to estimate differences in maternal baseline characteristics and neonatal characteristics for the two study groups. For dichotomous variables, p-values were obtained after Yates' Correction for Continuity, as is more accurate [20]. Variables where the differences between the groups were statistically significant (P-values of

< 0.05) were considered to potentially bias the results, and therefore adjusted for in the regression analyses comparing mode of delivery. These were maternal age, level of education, smoking status and BMI early in pregnancy. As the data material in this study originated from a cluster RCT, the original randomisation allocation was also considered a potential bias, and hence adjusted for.

Missing data were found for marital status, smoking during pregnancy, BMI early in pregnancy and neonatal head circumference, and are presented in detail in Table 1. The low number of missing data were considered not significant for the results of the analyses; hence, imputation considered not necessary. Interventions such as the use of oxytocin, epidural analgesia and diagnosed labour dystocia in the active phase were identified as effect modifiers. These were not included in the regression analyses. No colliders were identified.

To investigate the associations between cervical dilatation on admission and mode of delivery, binary logistic regression was used to estimate crude and adjusted odds ratios (OR) with associated 95% confidence intervals (CI). Secondary outcomes are presented as descriptive statistics.

IBM SPSS version 26.0 was used to analyse the data.

Ethical considerations

The LaPS was approved by the Regional Committee for Medical and Health Research Ethics South East (no. 2013/1862/REK), and the study protocol was registered in www.clinicaltrials.gov NCT02221427. All women enrolled the study provided signed informed consent for participation. The dataset used in this study was de-identified before the analyses were carried out, and results cannot be traced back to the original respondents.

Table 1
Baseline maternal characteristics of included participants and neonatal characteristics divided into two groups based on cervical dilatation on hospital admission.

	Cervix < 4 cm n = 3692	Cervix ≥ 4 cm n = 2819	P-value
Maternal characteristics			
Age on admission			
< 25 years	936 (25.4%)	646 (22.9%)	0.040
25–34 years	2469 (66.9%)	1968 (69.8%)	
≥ 35–years	287 (7.8%)	205 (7.3%)	
Is cohabitant or married*	3470 (94.8%)	2681 (95.9%)	0.052
Higher education (>12 years)	2173 (58.9%)	1778 (63.1%)	0.001
Smoking during first trimester**	243 (6.7%)	150 (5.4%)	0.036
BMI (kg/m2) early in pregnancy ***			
<18.5	153 (4.2%)	124 (4.4%)	0.036
18.5–24.9	2427 (66.0%)	1946 (69.2%)	
25–29.9	786 (21.4%)	518 (18.4%)	
30–34.9	235 (6.4%)	165 (5.9%)	
≥35	77 (2.1%)	59 (2.1%)	
Neonatal characteristics			
Birth weight			
< 2500 g	13 (0.4%)	14 (0.5%)	0.184
2500–2999 g	308 (8.3%)	274 (9.7%)	
3000–3999 g	2866 (77.6%)	2181 (77.4%)	
4000–4499 g	449 (12.2%)	313 (11.1%)	
≥ 4500 g	45 (1.5%)	37 (1.3%)	
Head circumference			
< 34 cm	459 (12.4%)	378 (13.4%)	0.335
34–36 cm	2675 (72.5%)	2041(72.4%)	
> 36 cm	558 (15.1%)	399 (14.2%)	
Presenting as occiput anterior at birth	3426 (92.8%)	2626 (93.2%)	0.609
Original LaPS allocation (WHO partograph / Zhang guideline)			
Zhang guideline	1874 (50.8%)	1679 (59.6%)	<0.001

All data are n (%).
Missing data: * 53 of 6511 (n = 6458), ** 63 of 6511 (n = 6448), *** 21 of 6511 (n = 6490), **** 1 of 6511 (n=6510).

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Results

Of the 6511 women included, 3692 (56.7%) were admitted to hospital with < 4 cm cervical dilatation and 2819 (43.3%) with ≥ 4 cm.

A larger proportion of women with < 4 cm cervical dilatation on admission was found in the group aged 25–34 years, while women admitted with ≥ 4 cm had higher representation in the groups < 25 years and ≥ 35 years. Women admitted with ≥ 4 cm cervical dilatation were more likely to have higher education and less likely to be obese. A smaller proportion of the group admitted with ≥ 4 cm cervical dilatation reported smoking during pregnancy's first trimester. Mother's status as cohabitant/married as well as the neonatal characteristics showed no significant differences between the groups (Table 1).

Results from the analyses regarding cervical dilatation and mode of delivery are presented in Table 2. Women admitted with ≥ 4 cm had a significantly higher chance of spontaneous delivery than women admitted with < 4 cm cervical dilatation, with adjusted OR of 1.28 (95% CI: 1.14–1.44), and a significantly lower risk of caesarean sections than women admitted with < 4 cm cervical dilatation, with adjusted OR of 0.51 (95% CI: 0.41–0.64). For operative vaginal delivery, no significant differences between the groups were found.

The secondary outcomes, intrapartum interventions, midwifery care during labour, normal maternal and neonatal outcomes, are shown in Table 3. The clearest differences between the groups were found in the intrapartum interventions of epidural analgesia and augmentation with oxytocin. Women admitted with ≥ 4 cm cervical dilatation tended to have more labours without epidural analgesia (66.9%) compared to women admitted with < 4 cm (39.7%). Women admitted with ≥ 4 cm cervical dilatation also tended to have more labours without augmentation with oxytocin (64.5%) compared to women admitted with < 4 cm (50.5 %). Women admitted with ≥ 4 cm cervical dilatation had more one to one care in active phase of labour (87.6%) compared to women admitted with < 4 cm (83.0%). Differences was also found for normal post-partum haemorrhage, where women admitted with ≥ 4 cm cervical dilatation tended to have more normal haemorrhages (84.4%) compared to women admitted with < 4 cm (82.5%).

Discussion

The aim of this study was to investigate associations between cervical dilatation on admission and mode of delivery. Women admitted with ≥ 4 cm cervical dilatation had a significantly higher chance of spontaneous delivery than women admitted with < 4 cm, as demonstrated also in previous studies [11–13]. This study does not, however, identify why women admitted with a cervical dilatation < 4 cm had a reduced chance of spontaneous delivery. There might be many underlying causes, such as long and painful latent phase, psychosocial background, ability to cope with pain and personality.

In this study some baseline characteristics of women in the two groups differed. In the group admitted with < 4 cm cervical dilatation, more women reported smoking during the first trimester, had a higher BMI prior to pregnancy, they were younger, and fewer of them had higher education. All these factors are socially gradient factors, indicating that social vulnerability during pregnancy can affect when a woman is admitted to hospital in labour. Close follow-up during pregnancy and thorough birth preparations could be valuable to improve these women's chances of spontaneous vaginal deliveries.

Norwegian Guidelines in Obstetrics recommend that labouring women should be admitted when in active labour [1]. However, maternal and/or fetal conditions, as well as practical matters, such as travelling distance to the hospital, are important to consider in the admission process. These factors may influence the decision to admit a woman in early labour. More than half of the women in this study were

Table 2
Associations between cervical dilatation on admission and mode of delivery.

	Total	Cervix <4 cm (n = 3692)	Cervix ≥4 cm (n = 2819)	Crude OR (95% CI)	P-value	Adjusted[2] OR (95% CI)	P-value
Spontaneous delivery	4847 (74.4%)	2682 (72.6%)	2165 (76.8%)	1.25 (1.11–1.37)	<0.001	1.28 (1.14–1.44)	<0.001
Operative vaginal delivery [12]	1253 (19.2%)	718 (19.4%)	535 (19.0%)	0.97 (0.86–1.10)	0.634	0.94 (0.83–1.07)	0.364
Caesarean section	411 (6.3%)	292 (7.9%)	119 (4.2%)	0.51 (0.41–0.64)	<0.001	0.51 (0.41–0.64)	<0.001

Numbers are presented as n (%).
Crude and adjusted OR's for mode of delivery, with associated 95% CI.
[1] Vacuum or forceps-assisted delivery.
[2] OR adjusted for mothers age, smoking during pregnancy, pre-pregnant BMI, higher education (≤/>12 years) and original LaPS allocation.

Table 3
Secondary outcomes – interventions during labour, maternal and neonatal outcomes.

	Cervix < 4 cm n = 3692	Cervix ≥ 4 cm n = 2819	P-value
Interventions during labour			
Delivering without epidural analgesia	1465 (39.7%)	1885 (66.9%)	<0.001
Labour without artificial rupture of the membranes	2237 (60.6%)	1729 (61.3%)	0.560
No augmentation with oxytocin during labour	1856 (50.3%)	1818 (64.5%)	<0.001
Delivery without episiotomy[3]	2407 (70.8%)	1904 (70.5%)	0.836
Midwifery care during labour			
One to one care in active phase of labour	3066 (83.0%)	2470 (87.6%)	<0.001
Maternal outcomes			
Intact anal sphincter after delivery[3]	3317 (97.6%)	2618 (97.0%)	0.178
Normal postpartum haemorrhage (≤500 ml)	3045 (82.5%)	2378 (84.4%)	0.047
Neonatal outcomes			
Apgar score > 7 after 5 min	3644 (98.7%)	2788 (98.9%)	0.537
Neonates not admitted to NICU > 24 h	3567 (96.6%)	2747 (97.4%)	0.062

All data are n (%).
[3] Of 6100 women with vaginal deliveries assessed (spontaneous and operative vaginal).

admitted with<4 cm cervical dilatation. As shown in Fig. 1, women admitted at 8 cm and more, accounts for 5.5 % of the total study population.

In Norway, labour is monitored with the use of the WHO partograph, and documented accordingly. The partograph is based on an expected progress of 1 cm cervical dilatation per hour with a four-hour delay between the alert- and action line. The partograph is started when active labour is defined. However, recent studies have shown that the expected 1 cm/hour is not relevant until the woman have reached 5 cm dilatation [21]. This suggests that expectations towards nulliparous women's progression in the earlier stages of labour might be unrealistic. Both the WHO [5] and US guidelines [6] were recently revised, "delaying" the onset of active labour from 4 to 5 or 6 cm cervical dilatation. Further research will need to demonstrate whether such changes will affect the timing of admission, interventions in labour and women's mode of delivery. However, regardless of definition, early admission to the hospital represents a risk of defining active labour too soon and reinforce the already unrealistic expectations of labour progression. The misinterpretation of commencement of active labour might be a contributing factor for the association between cervical dilatation on admission and mode of delivery.

Research has shown that a possible explanation for the higher caesarean section rates among women admitted early in labour is that they will receive more interventions, such as epidural analgesia and augmentation with oxytocin [11–13,22]. It may well be that these women need epidural due to unmeasurable reasons, and different baseline characteristics and social gradient factors may play a role.

These results may raise questions why so many women are admitted at an early stage of labour and when the 'correct' time to admit women in spontaneous labour, with a normal labouring process, is. The study shows that there might be an association between early admission and mode of delivery, but the reason is complex and not necessarily because of the admission itself. Women may have predisposing factors that necessitates early admission, or complications may arise in the early stage of labour.

Research shows that nulliparous women with an previous spontaneous vaginal delivery have approximately 95% chance of vaginal delivery in their subsequent pregnancy [23]. It has been found that in maternity care and obstetric research, focus is mainly directed towards risk factors and adverse outcomes [24]. A shift in focus to investigate factors that facilitate spontaneous deliveries is crucial. To avoid unnecessary interventions, care throughout pregnancy, labour and delivery should be focused on labour as a physiological process. One-to-one care should be a priority [5]. Further research is needed to investigate why so many women are admitted early in labour. At the same time, care for women admitted early must be improved so that it is provided without reducing their chances of a spontaneous delivery.

Strengths and limitations

One of the strengths of this study is the large and homogenous study population of 6511 women in TGCS group 1. The TGCS group 1 accounts for approximately 26% of annual births in Norway [25].

Furthermore, this study is strengthened by the data being collected at 14 obstetric units in all four health regions of Norway. Possible geographical and socio-cultural differences in practice are thus captured in the data material. However, units handling<500 deliveries annually were not included in the LaPS, and findings may therefore have limited applicability to such units.

The data collection in the LaPS was thoroughly implemented, with low rates of missing data among the included participants. This is considered a strength also in this study. However, the pre-defined variables in the LaPS might omit underlying factors of importance for interventions and outcome and, hence, represent a limitation according to our research question. For example, the traveling distance to the hospital might affect time for admittance. It would also be interesting to include length of the latent phase prior to admission. Prior research has shown that women admitted early in labour might have undocumented underlying conditions affecting mode of delivery [13,22]. Data regarding this were unfortunately unavailable for this study but should be investigated in future research.

Dichotomization of the study population might reduce potential diversities. The choice to dichotomize, was based on the fact that performing centimetre analyses, increases the risk that each finding would be given more weight and potentially add more uncertainty to the results. The reliability of cervical examination can be questioned, as it is based on subjective findings by doctors and midwives [14]. Centimetre by centimetre analysis could potentially give statistically significant findings, still the clinical relevance could be rather uncertain. By dividing the population into the two groups, results were considered to have greater transfer value to practice.

It is also worth noting that cervical dilatation on admission does not in itself inform the decision to admit a woman to hospital or not. Contractions, fetal heart rate, colour of amniotic fluid, bleeding, mothers' well-being and travelling distance to hospital are only some of the factors that contribute to an overall assessment for each individual woman [22]. A limitation of this study is that these factors are not addressed in the current analyses.

In the study period of LaPS, the rate of intrapartum caesarean section (ICS) was reduced by 37.8% in the control group and by 26.5% in the intervention group. The reduction in ICS may have had implications for the results of this study.

Conclusion

This study showed associations between cervical dilatation on admission to hospital and mode of delivery among women in TGCS group 1. Women admitted with $\geq$ 4 cm cervical dilatation had a significantly higher chance of spontaneous delivery and a significantly lower chance of caesarean section than women admitted with $<$ 4 cm. However, the underlying cause of these differences cannot be answered in this study. >50% of all women included were admitted before they reached 4 cm cervical dilatation. Further research is needed to investigate why so many women are admitted so early, and how care can be improved in order to increase their chance of spontaneous delivery.

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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