

# Contemporary Patterns of Spontaneous Labor With Normal Neonatal Outcomes

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**OBJECTIVE:** To use contemporary labor data to examine the labor patterns in a large, modern obstetric population in the United States.

**METHODS:** Data were from the Consortium on Safe Labor, a multicenter retrospective study that abstracted detailed labor and delivery information from electronic medical records in 19 hospitals across the United States. A total of 62,415 parturients were selected who had a singleton term gestation, spontaneous onset of labor, vertex presentation, vaginal delivery, and a normal perinatal outcome. A repeated-measures analysis was used to construct average labor curves by parity. An interval-censored regression was

used to estimate duration of labor, stratified by cervical dilation at admission and centimeter by centimeter.

**RESULTS:** Labor may take more than 6 hours to progress from 4 to 5 cm and more than 3 hours to progress from 5 to 6 cm of dilation. Nulliparous and multiparous women appeared to progress at a similar pace before 6 cm. However, after 6 cm, labor accelerated much faster in multiparous than in nulliparous women. The 95<sup>th</sup> percentiles of the second stage of labor in nulliparous women with and without epidural analgesia were 3.6 and 2.8 hours, respectively. A partogram for nulliparous women is proposed.

**CONCLUSION:** In a large, contemporary population, the rate of cervical dilation accelerated after 6 cm, and progress from 4 cm to 6 cm was far slower than previously described. Allowing labor to continue for a longer period before 6 cm of cervical dilation may reduce the rate of intrapartum and subsequent repeat cesarean deliveries in the United States.

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**LEVEL OF EVIDENCE:** III

Defining normal and abnormal labor progression has been a long-standing challenge. In his landmark publications, Friedman was the first to depict a labor curve and divide the labor process into several stages and phases.<sup>1,2</sup> Abnormal labor progression in the active phase was defined as cervical dilation less than 1.2 cm per hour in nulliparous women and less than 1.5 cm per hour in multiparous women. No appreciable change in cervical dilation in the presence of adequate uterine contraction more than 2 hours was considered as labor arrest.<sup>3</sup> These concepts have come to govern labor management.

However, these criteria created 50 years ago may no longer be applicable to contemporary obstetric

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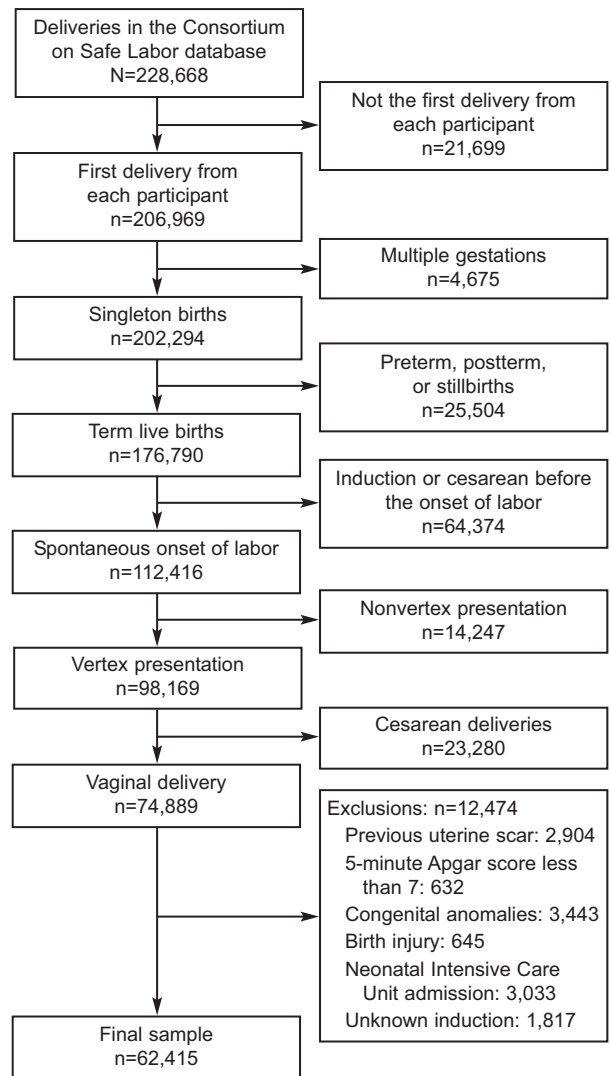


populations and for current obstetric management.<sup>4</sup> Increasing maternal age and maternal and fetal body sizes have made labor a more challenging process. Moreover, frequent obstetric interventions (induction, epidural analgesia, and oxytocin use) may have altered the natural labor process. The purpose of this study was to use contemporary labor data in a large number of parturients with spontaneous onset of labor to examine the labor patterns and estimate duration of labor in the United States.

## MATERIALS AND METHODS

We used data from the Consortium on Safe Labor, a multicenter, retrospective, observational study that abstracted detailed labor and delivery information from electronic medical records in 12 clinical centers (with 19 hospitals) across nine American College of Obstetricians and Gynecologists U.S. districts from 2002–2008; 87% of births occurred in 2005–2007). Detailed description of the study is provided elsewhere.<sup>5</sup> Briefly, participating institutions extracted detailed information on maternal demographic characteristics, medical history, reproductive and prenatal history, labor and delivery summary, postpartum, and newborn information. Information from the neonatal intensive care unit was linked to the newborn records. Data on labor progression (repeated, time-stamped cervical dilation, station, and effacement) were extracted from the electronic labor database. To make our study population reflect the overall U.S. obstetric population and to minimize the effect of the various number of births from different institutions, we assigned a weight to each patient based on American College of Obstetricians and Gynecologists district, maternal race or ethnicity (non-Hispanic white, non-Hispanic African American, Hispanic, and others), parity (nulliparous compared with multiparous women), and plurality (singleton compared with multiple gestations). We first calculated the probability of each delivery with these four factors according to the 2004 National Natality data. Then, based on the number of patients each hospital contributed to the database, we assigned a weight to each patient.<sup>5</sup> We applied the weight to the current analysis. This project was approved by the Institutional Review Boards of all participating institutions.

There was a total of 228,668 deliveries in the database. A total of 62,415 parturients were selected. Figure 1 depicts the sample selection process for the current analysis. Women were grouped by parity (0, 1, 2+). We used a repeated-measures analysis with eighth-degree polynomial model to construct average labor curves by parity.<sup>6</sup> In this analysis, the starting



**Fig. 1.** Diagram of patient selection.

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point was set at the first time when the dilation reached 10 cm (time=0) and the time was calculated backwards (eg, 60 minutes before the complete dilation, -60 minutes). After the labor curve models had been computed, the x-axis (time) was reverted to a positive value, ie, instead of being -12 → 0 hours, it became 0 → 12 hours.

To estimate duration of labor, we used an interval-censored regression<sup>7</sup> to estimate the distribution of times for progression from one integer centimeter of dilation to the next (called “traverse time”), with an assumption that the labor data are log-normally distributed.<sup>8</sup> The median and 95<sup>th</sup> percentiles were calculated. Because multiparous women tended to be admitted at a more advanced stage labor than nullip-



**Table 1. Characteristics of the Parturients by Parity (Weighted), Consortium on Safe Labor, 2002 to 2008**

	Parity 0	Parity 1	Parity 2+
Unweighted cohort (n)	27,170	17,850	17,395
Weighted cohort (n)	453,693	368,131	311,248
Maternal race			
White	60	55	51
African American	12	12	15
Hispanic	20	26	29
Asian or Pacific Islanders	4	4	2
Others	4	3	3
Maternal age (y)	24.6±5.8	27.7±5.7	30.0±5.4
Body mass index before pregnancy (kg/m <sup>2</sup> )	23.4±4.6	24.2±5.1	25.5±5.6
Body mass index at delivery (kg/m <sup>2</sup> )	29.1±5.0	29.6±5.2	30.5±5.5
Cervical dilation at admission (cm)	4 (1, 7)	4.5 (2, 8)	5 (2, 8)
Effacement at admission (%)	90 (60, 100)	90 (50, 100)	80 (50, 100)
Station at admission	-1 (-3, 0)	-1 (-3, 0)	-2 (-3, 0)
Oxytocin use in spontaneous labor	47	45	45
Epidural analgesia	84	77	71
Total number of vaginal examinations in first stage	5 (1, 9)	4 (1, 7)	4 (1, 7)
Instrumental delivery	12	3	2
Gestational age at delivery (wk)	39.3±1.2	39.2±1.2	39.1±1.1
Birth weight (g)	3,296±406	3,384±421	3,410±428

Data are %, mean±standard deviation, or median (10<sup>th</sup>, 90<sup>th</sup> percentile) unless otherwise specified.

arous women, many multiparous women did not have information on cervical dilation before 4 cm. Therefore, the labor curve for multiparous women started at 5 cm rather than at 4 cm, as for nulliparous women.

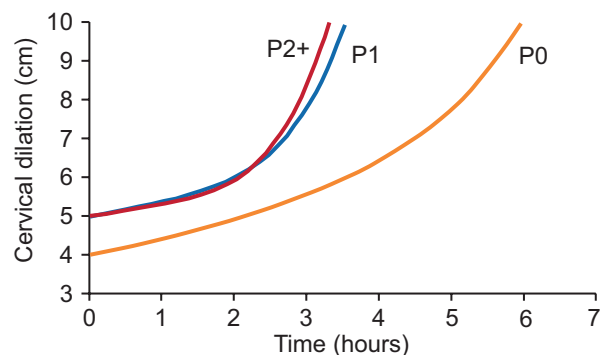
Finally, to address the clinical experience wherein a woman is first observed at a given dilation and then measured periodically, we calculated cumulative duration of labor from admission to any given dilation up to the first 10 cm in nulliparous women. The same interval-censored regression approach was used. We provide the estimates according to the dilation at admission (2.0 or 2.5 cm, 3.0 or 3.5 cm, 4.0 or 4.5 cm, and 5.0 or 5.5 cm) because women admitted at different dilation levels may have different patterns of labor progression. We then plotted the 95<sup>th</sup> percentiles of the duration of labor from admission as a partogram. All statistical analyses were performed using SAS 9.1 (PROC MIXED for the repeated-measures analysis and PROC LIFEREG for interval censored regression). Because the objective of this article is to describe labor patterns and estimate duration of labor without comparing among various groups, no statistical tests were performed.

## RESULTS

Table 1 presents the baseline characteristics of women by parity. With increasing parity, both maternal age and body mass increased. The median cervical dilation at admission was 4 cm, 4.5 cm, and 5 cm for parity 0, 1, and 2+, respectively, whereas the

median effacement was 90%, 90%, and 80%, respectively. Oxytocin for augmentation was used in nearly half of the women. Approximately 80% of women used epidural analgesia for labor pain. The median number of vaginal examinations from admission to the first 10 cm was five for nulliparous women and four for multiparous women. The majority of women had a spontaneous vaginal delivery.

Figure 2 depicts the labor curves for various parities. In multiparous women, labor appears to accelerate after 6 cm of cervical dilation. Parity 2+ entered the active phase earlier than parity 1. In



**Fig. 2.** Average labor curves by parity in singleton term pregnancies with spontaneous onset of labor, vaginal delivery, and normal neonatal outcomes. P0, nulliparous women; P1, women of parity 1; P2+, women of parity 2 or higher.

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**Table 2. Duration of Labor in Hours by Parity in Spontaneous Onset of Labor**

Cervical Dilation (cm)	Parity 0 (n=25,624)	Parity 1 (n=16,755)	Parity 2+ (n=16,219)
3-4	1.8 (8.1)	—	—
4-5	1.3 (6.4)	1.4 (7.3)	1.4 (7.0)
5-6	0.8 (3.2)	0.8 (3.4)	0.8 (3.4)
6-7	0.6 (2.2)	0.5 (1.9)	0.5 (1.8)
7-8	0.5 (1.6)	0.4 (1.3)	0.4 (1.2)
8-9	0.5 (1.4)	0.3 (1.0)	0.3 (0.9)
9-10	0.5 (1.8)	0.3 (0.9)	0.3 (0.8)
Second stage with epidural analgesia	1.1 (3.6)	0.4 (2.0)	0.3 (1.6)
Second stage without epidural analgesia	0.6 (2.8)	0.2 (1.3)	0.1 (1.1)

Data are median (95<sup>th</sup> percentile).

contrast, the average labor curve for nulliparous women did not show a clear inflection point.

Table 2 shows the duration of labor from one centimeter of dilation to the next. The 95<sup>th</sup> percentiles indicate that at 4 cm, it could take more than 6 hours to progress to 5 cm, whereas at 5 cm, it may take more than 3 hours to progress to 6 cm. Surprisingly, the medians and 95<sup>th</sup> percentiles of duration of labor before 6 cm were similar between nulliparous and multiparous women. Only after 6 cm did multiparous women show faster labor than nulliparous women, which is consistent with the labor curves. Table 2 also suggests that at 6 cm or more, almost all women who had vaginal delivery and normal neonatal outcomes had a 95<sup>th</sup> percentile of first stage of labor of less than 2 hours, particularly in multiparous women. In the second stage of labor, the 95<sup>th</sup> percentiles for nulliparous women with and without epidural analgesia were 3.6 hours and 2.8 hours, respectively. The duration of the second stage was much shorter in multiparous women.

We then calculated cumulative duration of labor from admission to the first 10 cm in nulliparous

women. Table 3 presents the median and 95<sup>th</sup> percentile of duration of the first stage of labor. The 95<sup>th</sup> percentiles are also plotted as connected staircase lines in Figure 3. Each specific dilation at admission (2, 3, 4, or 5 cm) has its own corresponding line. At any time in the first stage, if a woman's labor crosses her corresponding 95<sup>th</sup> limit to the right side of the curve, then her labor may be considered as protracted. Figure 4 illustrates three cases. Each letter represents a pelvic examination for the corresponding patient. Patient A was admitted at 2 cm. Her labor progressed to 10 cm without crossing the corresponding 95<sup>th</sup> percentile boundary. Patient B was admitted at 4 cm. Her labor progressed to 6 cm and then stopped despite oxytocin augmentation. After 10 hours from admission, she passed the 95<sup>th</sup> percentile and may be considered as having labor arrest. Patient C was admitted at 5 cm. She reached 9 cm after 13 hours but passed the 95<sup>th</sup> percentile.

## DISCUSSION

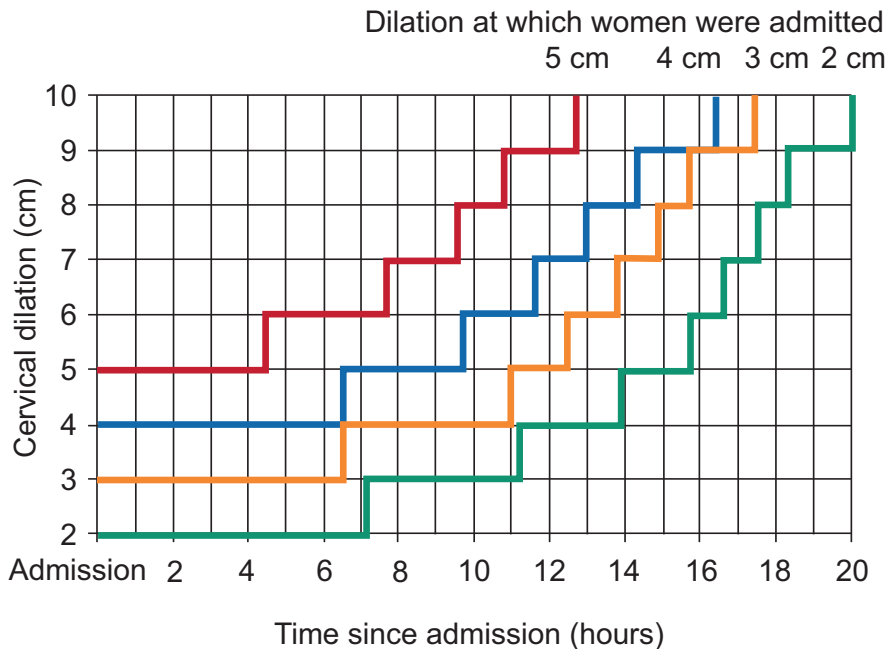
The definitions of “normal labor” and “labor arrest” have profound effects on labor management and cesarean delivery rate. Our study used data from a large number of contemporary parturients across the United States who had a singleton term pregnancy with spontaneous onset of labor, a vertex fetal presentation, vaginal delivery, and normal neonatal outcomes. We found that labor may take more than 6 hours to progress from 4 to 5 cm and more than 3 hours to progress from 5 to 6 cm of dilation. Nulliparous and multiparous women appeared to progress at a similar pace before 6 cm. However, after 6 cm, labor accelerated much faster in multiparous than in nulliparous women. The 95<sup>th</sup> percentiles of the second stage of labor in nulliparous women with and without epidural analgesia were 3.6 and 2.8 hours, respectively. Utilizing data from this

**Table 3. Duration of Labor in Hours in Nulliparous Women With Spontaneous Onset of Labor**

Cervical Dilation (cm)	Admitted at 2 or 2.5 cm (n=4,247)	Admitted at 3 or 3.5 cm (n=6,096)	Admitted at 4 or 4.5 cm (n=5,550)	Admitted at 5 or 5.5 cm (n=2,764)
Admitted to 3	0.9 (7.1)	NA	NA	NA
Admitted to 4	3.2 (11.2)	1.0 (6.5)	NA	NA
Admitted to 5	5.0 (13.9)	2.9 (11.0)	0.9 (6.5)	NA
Admitted to 6	6.0 (15.7)	4.2 (12.5)	2.2 (9.7)	0.6 (4.5)
Admitted to 7	6.6 (16.6)	5.0 (13.8)	3.2 (11.6)	1.5 (7.7)
Admitted to 8	7.1 (17.5)	5.6 (14.9)	3.9 (13.0)	2.4 (9.6)
Admitted to 9	7.6 (18.3)	6.1 (15.7)	4.5 (14.3)	3.0 (10.8)
Admitted to 10	8.4 (20.0)	6.9 (17.4)	5.3 (16.4)	3.8 (12.7)

NA, not applicable.  
Data are median (95<sup>th</sup> percentile).





**Fig. 3.** The 95<sup>th</sup> percentiles of cumulative duration of labor from admission among singleton term nulliparous women with spontaneous onset of labor, vaginal delivery, and normal neonatal outcomes.

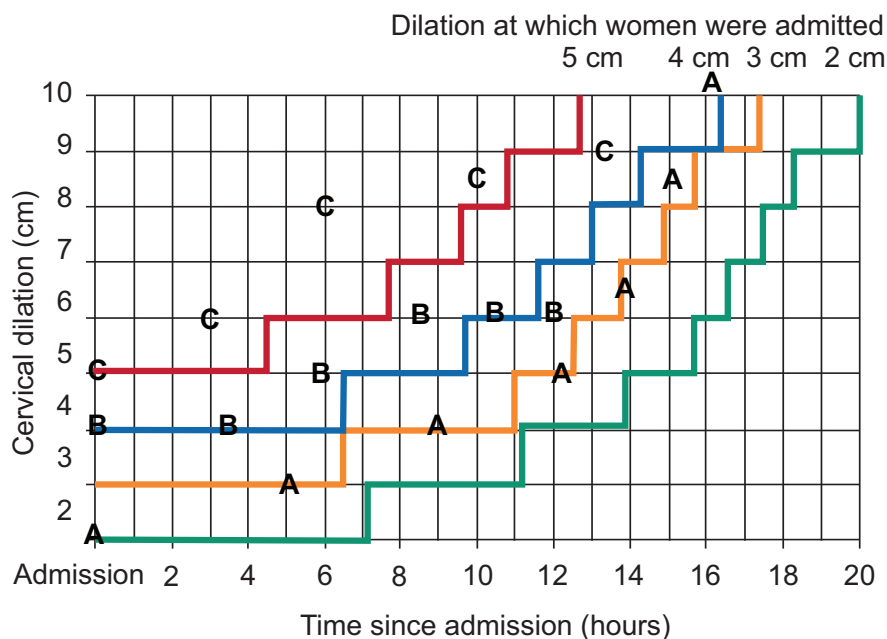
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study, we produced a partogram for contemporary nulliparous women.

Labor curves and normal values in labor progression are still largely based on the work by Dr. Emanuel Friedman several decades ago.<sup>2,3</sup> However, our study with a contemporary population observed several important differences from the classic Friedman curve.<sup>2</sup> First, after having plotted a large number of labor curves, it became clear that there are a

substantial number of parturients who may not have a consistent pattern of the active phase of labor, particularly in nulliparous women. Labor may progress more gradually but still achieve vaginal delivery.

Second, even in women who had an active phase characterized by precipitous cervical dilation in the late first stage, the active phase often did not start until 6 cm or more. This seems to differ materially from prevailing concepts that the active phase starts before 4 cm<sup>2,3</sup> and



**Fig. 4.** Labor progression in three patients (A, B, C). Each letter represents a pelvic examination for the corresponding patient. The stair lines are the 95<sup>th</sup> percentiles of cumulative duration of labor from admission at 2, 3, 4, and 5 cm of cervical dilation, respectively.

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that 4 cm is a commonly used milestone.<sup>9</sup> Rouse et al<sup>10,11</sup> defined the active phase in induced labor as cervical dilation at 4 cm with 90% or more effacement or 5 cm dilation regardless of effacement. However, Peisner and Rosen<sup>12</sup> found that among women who had no active phase arrest, 50% of them entered active phase by 4 cm dilation, 74% entered active phase by 5 cm, and 89% entered active phase by 6 cm. These findings point to the importance of separating an average starting point of active phase from a clinical diagnosis of labor arrest. Judging whether a woman is having labor protraction and arrest should not be based on a research definition of an average starting point or average duration of labor. Instead, an upper limit of what is considered “normal labor” should be used in patient management. As long as the labor is within a normal range and other maternal and fetal conditions are reassuring, a woman should be allowed to continue the labor process. Our study suggests that in the contemporary population, 6 cm rather than 4 cm of cervical dilation may be a more appropriate landmark for the start of the active phase.

Finally, consistent with clinical experience, our data demonstrate that cervical dilation often accelerates as labor advances. No appreciable change in dilation for 4 hours may be normal in early labor but is probably too long after 6 cm (Table 2). This nonlinear relationship should be reflected in the definition of labor arrest.

For a more objective evaluation of labor protraction and arrest, a partogram may be a useful tool. Such a tool was originally utilized to prevent prolonged and obstructed labor in developing countries.<sup>13,14</sup> The central feature of the partogram recommended by the World Health Organization consists of two straight, diagonal, parallel lines based on the phase of maximum slope in the Friedman curve. The alert line starts at 4 cm of cervical dilatation to the point of expected full dilatation at the rate of 1 cm per hour,<sup>15</sup> indicating that attention is needed if cervical dilation is slower than 1 cm per hour starting at 4 cm. The action line is parallel, and 4 hours is to the right of the alert line. Several studies,<sup>14–16</sup> but not all,<sup>17</sup> have shown that the partogram reduces the risk of prolonged labor, cesarean deliveries, and perinatal mortality in developing countries.

Our partogram differs from the one by the World Health Organization<sup>15</sup> in that: 1) we do not consider the alert line necessary in the United States because most women give birth in a hospital setting; 2) our 95<sup>th</sup> percentile lines, equivalent to the action line, are exponential-like stair lines rather than straight lines because cervical dilation is not recorded as a continuous measure. The progression patterns (exponential)

are more consistent with the physiology of dilation acceleration in the late first stage; and 3) our partogram allows much slower labor progression before 6 cm of dilation but much shorter duration than 4 hours after 6 cm. Finally, in contrast to the purpose of the World Health Organization partogram, our partogram is intended to prevent premature cesarean delivery. Its validity and usefulness have yet to be confirmed.

The limitations of the current study are worth mentioning. First, defining “normal labor” remains a challenge. To best define this process, we examined labor patterns in women who had spontaneous onset of labor, vaginal delivery, and normal neonatal outcomes. Second, given the very high frequency of obstetric intervention (induction and prelabor cesarean delivery) in contemporary practice, only one-third of all births in our large population comprised women who were at term, had spontaneous onset of labor, and had vaginal deliveries. Third, because intrapartum cesarean deliveries were performed according to the prevailing definition of labor arrest, some cesarean deliveries may be performed too soon (before 6 cm), which can cause early censoring of observation. This censoring may have resulted in a bias toward a shorter labor, particularly at the 95<sup>th</sup> percentiles. Fourth, nearly half of the parturients included in our analysis were administered oxytocin for augmentation, which may have altered the natural labor progression. Thus, findings from our study must be interpreted within the context of current obstetric practice. Finally, we recognize that assessment of cervical dilation is inherently somewhat subjective. The inaccuracy of cervical dilation is likely caused by random error, which increases standard error but does not necessarily bias the point estimate. Given the large number of patients in our study, our point estimates (the average labor curve, median, and 95<sup>th</sup> percentile) are stable.

The differences in study population and obstetric practice may partly explain why the contemporary labor curves differ substantially from those from 50 years ago,<sup>18</sup> even though exactly the same statistical method was used. Women are older and heavier, and these factors are known to affect labor progress and duration. Labor appears to progress more slowly now than before, even though more labors are being treated with oxytocin for augmentation. The current study observed that the inflection point between latent and active phases on the labor curve emerges at a more advanced cervical dilation. For instance, the inflection point in multiparous women previously was described as occurring at 5 or 5.5 cm 50 years ago,<sup>18</sup>



but our data show that now it is at 6 or 6.5 cm. These findings indicate that the labor process in contemporary obstetric populations needs to be reevaluated and the definitions of “normal” and “abnormal” labor need to be re-examined. Avoiding cesarean delivery before the active phase of labor is established may reduce the rate of cesarean delivery (intrapartum and subsequent repeat cesarean deliveries).

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