smw · swiss medical weekly

Original article | Published 18 November 2025 | doi:https://doi.org/10.57187/s.4546
Cite this as: Swiss Med Wkly. 2025;155:4546

Association between a mismatch of maternal/ neonatal body size and obstetrical interventions in Switzerland in the 1920s: a cross-sectional study

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Summary

INTRODUCTION: Human childbirth remains a complex and risky process for both mothers and infants, even with modern advancements in medical care. This study investigated the prevalence of obstetric interventions, namely caesarean sections, episiotomies, and forceps deliveries, along with the role of maternal-foetal body size mismatch in influencing delivery outcomes.

METHODS: Utilising two datasets from similar archival sources in two Swiss cities (Basel and Lausanne) from the 1920s, we explored the relevance of a mismatch between the body size of the mother and the foetus as a risk factor for obstetrical interventions and the duration of the expulsion phase during delivery.

RESULTS: Over 91% of births (1290/1407 in Basel and 1062/1145 in Lausanne) featured the foetal head in a normal position (either the right or left occiput anterior position). Episiotomies were performed in 8–17% of cases (233/1407 in Basel and 98/1145 in Lausanne) and forceps deliveries in 1–5% (17/1407 in Basel and 54/1145 in Lausanne). Caesarean sections were rare (<1%, 19/1407 in Basel and 6/1145 in Lausanne). Key findings indicated that larger foetal head diameters and narrower pelvic measurements were linked to prolonged expulsion phases and an increased likelihood of intervention. Abnormal head positions and first-time births were also associated with obstetrical interventions. Additionally, rickets was documented in 2% of mothers (23/1145) in Lausanne, correlating with increased forceps use and caesarean section rates.

CONCLUSION: This research provides insights into obstetric practices and maternal health conditions over a century ago, emphasising the significant impact of maternal-foetal body size mismatches on childbirth complications in a historical context.

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Introduction

Human childbirth is a complex process, and despite improved medical care, it is still associated with risks for both the mother and child. In the worst cases, it can be fatal for both. The global burden of maternal morbidity and mortality remains high despite progress in recent decades [1]. An estimated 295,000 maternal deaths occurred worldwide in 2017. The global maternal mortality ratio (MMR) was estimated at 211 per 100,000 live births in 2017, a 38% reduction from 2000, when it was 342 per 100,000 [2]. However, there are important geographical disparities, which have been even more pronounced since the 1990s, as the burden of maternal mortality is very high in developing countries [1]. The UN has therefore explicitly included reducing maternal mortality worldwide in the Sustainable Development Goals (SDG Goal 3.1) [3]. Approximately 73% of maternal deaths between 2003 and 2009 were due to direct obstetric causes (e.g. abortion, embolism, intrapartum haemorrhage, hypertension, and pregnancy-related sepsis) and indirect causes (e.g. pre-existing medical conditions and HIV-related maternal deaths) [4]. Neonatal health (e.g., stillbirths and neonatal morbidities or deaths) is closely related to maternal health and remains a major health problem, particularly in developing countries [5].

The traditional explanation for the uniquely precarious birth process of modern humans compared with that of other mammals is the obstetrical dilemma hypothesis [6]. It describes an evolutionary compromise between the selection pressures for giving birth to a large-brained foetus and our pelvic adaptations for walking upright, which led to a shortened hipbone compared with that of our common ancestor with chimpanzees and bonobos. However, many other explanations have been suggested, and the obstetrical dilemma hypothesis remains debated [7–11]. In general, many factors determine whether a birth is complicated. On the infant's side, factors that can affect delivery include neonatal weight, length, head circumference, position, and gestational age [9, 12]. For example, it is well documented that an infant's birth weight is associated with gestational age and the mother's height and body shape: taller women and those with obesity generally give birth to larger, heavier infants [13–17]. Pelvic dimensions are also major maternal factors that influence the birth process [13, 15–17]. However, the relationship between maternal height and pelvic size is complex. Short women can have large pelvises [18, 19]. In particular, a potential mismatch between the foetus's and the mother's body dimensions in the form of cephalopelvic disproportion is relevant to the course of birth [20]. Depending on geographical region and its exact definition, cephalopelvic disproportion is estimated to affect between 1% and 8% of women giving birth each year [20]. It is more common in heavier neonates (>4000 g) and even more so in infants with larger head sizes [21, 22].

These factors, among others, cause obstructed labour and other birth complications such as shoulder dystocia, and they prompt hospital obstetricians to perform medical interventions such as episiotomy (i.e., a surgical incision of the perineum and the posterior vaginal wall) or caesarean sections to minimise maternal and neonatal risks [23]. According to the Swiss Federal Statistical Office, in 2017, 32.3% of all births in Switzerland were caesarean sections (51.1% planned and 49.9% emergency caesarean sections). Vaginal operative deliveries (mainly using a vacuum cup) were performed in 11.1% of all births. Episiotomies were performed in 17% of all vaginal births, mainly in cases of instrumental births [24]. In caesarean sections, obstructed labour due to maternal pelvic abnormalities was one of the most important reasons (this diagnosis was 72.6 times more common in caesarean sections than in vaginal deliveries) [25].

However, obstetric practice has changed significantly over the past 100 years [26, 27]. At the beginning of the 20th century, fewer than 1% of all births at the Maternity Hospital in Lausanne were caesarean sections, but other interventions were much more common. An important determinant for these interventions was a tight and small pelvis (at the Maternity Hospital in Basel, 9.3% of births between 1895 and 1907 were assessed by contemporary physicians as involving a narrow pelvis) [28]. As late as the mid-20th century, external dimensions of the pelvis were used as indicators of internal dimensions and size of the birth canal, with relatively good agreement [29–31]. A century ago, mean maternal skeletal dimensions, such as stature, were different from today's standards. In Switzerland at the beginning of the 20th century, people were 10–15 cm shorter on average than today. Apart from the lower standard of living, this was due to widespread iodine deficiency and rickets [32–36]. In addition, undernutrition was more common than overnutrition. Whether the body dimensions of infants were also smaller during the late 19th and the first half of the 20th century is unclear in the literature [36–39].

Before the rise in living standards in the 20th century, conditions of scarcity were relatively common in countries that are now considered developed [40]. For some newly developing countries and regions, malnutrition and conditions such as rickets and iodine deficiency remain a problem. In addition, optimal obstetric care is not always available within a reasonable timeframe, especially in remote areas. For settings where caesarean sections are performed only in exceptional emergencies, the knowledge of risk factors related to maternal and infant size disparities is helpful. Historical data from developed countries can provide valuable information. However, few contemporary studies have used this information, despite rich data in European maternity hospital archives from the early 20th century. In this study, we digitised and analysed extensive, nearly complete information on 2500 births collected in the early 1920s in the maternity hospitals of Lausanne and Basel. These two sites were chosen for their wealth of data.

We addressed the following research questions: How common were obstetric interventions such as caesarean sections, episiotomies, and forceps deliveries? Was the mismatch between the mother's body size and the foetus's body size a relevant risk factor for such interventions and for the duration of the expulsion phase during delivery (as a proxy for a complicated birth)? We approached these questions through the lens of historical epidemiology and evolutionary medicine using quantitative methods rather than classical approaches in medical history. Therefore, a comprehensive qualitative text analysis of obstetric textbooks is outside the scope of this paper.

Data and methods

Historical context of the data

The early 1920s marked a transitional phase after the crisis years at the end of the First World War and the 1918–19 influenza pandemic ("Spanish flu"). Switzerland was not directly involved in WWI but was affected by major economic disruptions. Although the socioeconomic conditions during the final years of the war (1917 and 1918) were not severe enough to cause famine (as in Russia), adverse effects on nutritional status in general and neonatal health were evident. The 1918–19 influenza pandemic likely exacerbated these effects [14, 38, 41]. In a longer-term context, Switzerland was already one of the wealthiest countries in Europe in terms of gross domestic product (GDP) at the beginning of the 20th century [42]. This article focuses on two medium-to-large cities in southwest and northwest Switzerland: French-speaking Lausanne (70,000 inhabitants in 1925) and German-speaking Basel (145,000 inhabitants in 1925). Other indicators of the standard of living also showed an upward trend during this period: overall mortality rates, particularly infant and child mortality, declined. Life expectancy increased, and the health burden due to infectious diseases declined [42–45]. Using average height as an indicator of the standard of living, Switzerland approximately corresponded to the central European average at the beginning of the 20th century. Comparable sources for this paper present data from women born between 1890 and 1899 with an average height of 158–162 cm [33].

The maternity hospitals in Lausanne and Basel

This study takes advantage of the fact that all births in large Swiss maternity hospitals were carefully documented and preserved in the early 20th century. At that time, Switzerland had only a handful of maternity hospitals. The hospitals in Lausanne and Basel, the two with the most data, were included. In both cities, the cantonal maternity hospitals were the only maternity hospitals in the city. Both hospitals' birth registers include births to women from the upper and lower socioeconomic classes and both complicated and uncomplicated births.

The cantonal hospital of Lausanne became a university hospital with the opening of the medical faculty of the University of Lausanne in 1890 [46–50]. Since the 1890s, there have been no specific restrictions on admissions [51]. Over the years, an increasing proportion of all births in the city took place in this hospital. Most of these births were to parents from the city and its immediate surroundings. A comparison of the number of births in the registers with the official birth statistics shows that in 1910, 37% of all births in the city of Lausanne took place in this hospital, and in 1920, the proportion increased to 66% [52]. In Basel, the Chair of Gynaecology and Obstetrics was established at the university in 1887. Most patients (>85%) were residents of the city of Basel. Around 1920, 60% of all births in Basel took place at the university hospital [14].

This study combines two similar datasets from identical archival sources to address the research questions. For the Lausanne dataset, individual data were transcribed from the birth records of the Canton of Vaud Maternity Hospital (Archives cantonales vaudoises, K VIII e 256–262, 1922). This series of archives covers full calendar years. In the books, each birth record extends over four pages and contains much precise information about the mother, the infant, and the birth itself. A total of 1145 cases were used from the archive books in 1922 (excluding non-birth-related cases, miscarriages, and multiple births). Individual data from Basel were extracted from the birth records of the Canton of Basel City University Maternity Hospital (kept at the State Archives Basel City, Sanität X29), where births have been recorded in detail since 1896. The Basel archive series covers about one-third of each calendar year (3–4 months). An individual birth record extends over five pages and contains detailed information on the mother, the birth, and the infant. Incomplete records are scarce [38]. Data from three years for Basel were combined to approximate the size of the dataset from Lausanne: 1921 (covering August to December, n = 510), 1922 (January to March, n = 423), and 1923 (May to July, n = 474). In total, the Basel dataset contained 1407 births.

The demographic data included the mother's date of birth, place of residence, occupation, marital status, age, height (cm), general and skeletal condition (signs of rickets or not), waist circumference just before delivery (cm), and age at menarche. Obstetric measurements (all in cm) included the interspinous distance (the distance between the two anterior superior iliac spines), the intercristal distance (the widest distance between the two iliac cristae), and the conjugata externa (the distance from the upper edge of the symphysis to the processus spinosus of the fifth lumbar vertebra) (appendix figure S1). Solid evidence indicates that external pelvic measurements correlate well with internal measurements [53, 54]. Parity and date of last menstruation were also recorded. Maternal mortality was recorded, as well as the number of obstetric interventions performed (caesarean section, episiotomy, forceps delivery, and extraction). Because forceps deliveries and caesarean sections were relatively uncommon, these two interventions were classified together as the next stage of intervention after episiotomy. During birth, the dilation, expulsion, and postpartum phases were recorded for each birth. The two most common vertex presentations that are generally associated with the least risk were categorised as normal. These are the left occipito-anterior (LOA) and right occipito-anterior (ROA) positions, which were recorded in Lausanne with the French terms OIGA (Occipito-lliaque Gauche Antérieure) and OIDA (Occipito-lliaque Droite Antérieure), respectively, and in Basel with the German terms "erste vordere Hinterhauptslage" (HHL I) and "zweite vordere Hinterhauptslage" (HHL II), respectively. All other head positions and foetal presentations were classified as abnormal. For the infant, the vital status at birth and in the first days after birth (early neonatal mortality), date of birth, gestational age in weeks, and sex were recorded. Anthropometric data included birthweight, head circumference, length, placental weight and size, and postnatal weight after several days during the hospital stay (infant weight loss).

Ethics statement

This study was approved by the Cantonal Ethics Committee of the Canton of Zurich (BASEC number 2021-00628). Approval meant that informed consent was not required, as the study was based on historical data from the 1920s. Data collection was performed between 01.07.2021 and 31.07.2024. In the archives, the study team had access to non-anonymised personal information in the historical medical records, but in agreement with the ethics committee, the data were fully anonymised in the course of the study.

Statistical methods

Logistic regression models were used to estimate the risk of episiotomy (yes or no) or caesarean section/forceps delivery (yes or no) in the presence of several explanatory variables. For episiotomy, the following explanatory variables were included: sex, parity, head position, maternal height, birthweight, the ratio of the conjugata externa to head circumference (3 groups: normal; large vs small [3rd tercile conjugata externa vs 1st tercile head circumference], and small vs large [1st tercile conjugata externa vs 3rd tercile head circumference]), and the duration of the expulsion phase (3 groups: terciles). Because of the low number of females who underwent caesarean section or forceps delivery (Lausanne: n = 60, Basel: n = 35), the model only included sex, parity, head position, head circumference (continuous in cm), and conjugata externa (continuous in cm) as explanatory variables. To make the expulsion phase comparable in both data sets, the duration of the phase was z-transformed and modelled using a linear regression model, including sex, parity, head position, maternal height, birth weight, and the ratio of the conjugata externa to head circumference as explanatory variables. Because maternal height and pelvic breadth measurements (crests) are strongly correlated, we only used maternal height as an explanatory variable in the model for the episiotomy and expulsion phases. However, a sensitivity analysis with crests is shown in the supplementary material. In addition, a sensitivity analysis was performed for these two models (the number of births for caesarean section/forceps was too low), including only primiparous women. Because of the multicollinearity between gestational age and head circumference, gestational age was only controlled for in sensitivity analyses (a univariable analysis including gestational age is shown in the supplementary material). For the Lausanne dataset, additional information was available on the maternal body morphology (normal, thin, or obese) and whether the mother had rickets; for Basel, additional information included socioeconomic position (SEP) based on the partner's occupation. Univariable analyses were performed for these additional variables. Model assumptions regarding multicollinearity, homoscedasticity, and independence were fulfilled for all models. The assumption of normally distributed residuals was not completely fulfilled for the dependent variable "expulsion time", but evidence shows that Gaussian models are robust even when this assumption is violated [55]. The sample size is relatively large; in addition, the predictors are relatively normally distributed or only slightly skewed, so the results are assumed to be robust (appendix figure S2).

All statistical analyses were performed using R version 4.3.2.

Results

Data from 1407 births in Basel and 1145 births in Lausanne between 1921 and 1923 were included in the analysis. Episiotomy was performed in 16.6% of births in Basel and 8.6% of births in Lausanne (8.0% difference, 95% confidence interval (CI) 5.4 to 10.6, p <0.001) (table 1). In Basel, however, forceps delivery was performed in 1.2% of the births, compared with 4.7% in Lausanne (3.5% difference, 95% CI 2.1 to 4.9, p <0.001). In Basel, 19 caesarean sections were performed, and in Lausanne, 6 were performed (1.4% vs 0.5% of all births, difference not significant). The foetal head position was normal in over 90% of births (the difference between Basel and Lausanne was not significant). In Basel, the mothers were slightly older on average than in Lausanne (28.7 years vs 28.0 years, p = 0.003). They were marginally taller (158.0 cm vs 156.5 cm, p <0.001) and had a slightly larger conjugata externa (19.9 cm vs 19.6 cm, p <0.001). Their infants were slightly heavier (3282.0 g vs 3205.9 g, p <0.001) with a larger head circumference (34.7 cm vs 34.5 cm, p = 0.001). The mean expulsion phase was longer in Basel than in Lausanne (52.2 min vs 33.1 min, p <0.001), and there were more first births in Basel than in Lausanne (51.7% vs 36.9%, p <0.001). By contrast, no significant difference was observed in the rate of premature births (<37 weeks), number of stillbirths, the proportion of female neonates, or the mean intercristal distance. The distribution plots in figure S2 show that most continuous body dimensions tended towards symmetry.

Regarding the duration of the expulsion phase (figure 1), a very large infant head circumference in combination with a small maternal conjugata externa led to a significantly prolonged expulsion phase (z = 0.37 [95% CI 0.12–0.62] for Basel and z = 0.29 [95% CI 0.06–0.52] for Lausanne, expressed in z-values). Of the other co-factors, a higher parity led to a significantly shorter expulsion phase, and an abnormal foetal position led to a considerably longer expulsion phase in Basel and Lausanne. These factors were significant in both the univariable and multivariable models. The significant association between the ratio of the conjugata externa to head circumference remained when the model was reduced to first births, when the maternal intercristal distance was included in the model instead of maternal height, and when the model was additionally adjusted for SEP in Basel and for the health or rickets status of the mother in Lausanne (appendix figures S3A, S4A, S5A, S6A, and S7A).

The risk of performing an episiotomy was lower for female infants (significant in Lausanne) and with increased parity (figure 2). A large head circumference combined with a small conjugata externa significantly increased the risk of episiotomy in Basel (odds ratio (OR) 2.03, 95% CI 1.04–3.80), and the trend was the same but not significant in Lausanne (OR 1.35, 95% CI 0.58–2.91). When the expulsion phase was particularly long (3^{rd} tercile), the risk of an episiotomy was also higher. The effect of the pelvis-to-head circumference ratio became somewhat less pronounced when the model was reduced to first births, when the intercristal distance was used in the model instead of maternal height, and when the model was additionally adjusted for SEP in Basel and for the health status of the mother in Lausanne in the sensitivity analyses (appendix figures S3B, S4B, S5B, S6B, and S7B).

An abnormal foetal position and a higher head circumference were associated with forceps use or caesarean section in the simplified models (not fully adjusted for all cofactors) (figure 3). By contrast, the risk was lower with a longer conjugata externa and a higher parity. In general, physician-recorded maternal rickets was not associated with the duration of the expulsion phase or with episiotomy, but it was associated with a higher risk of forceps use or caesarean section (OR 6.98, 95% CI 2.44–17.5). However, overall maternal health status and maternal body shape (thin or obese), as assessed by a physician, did not have a significant effect in any model in Lausanne (appendix figures S5C, S6C, and S7C).

Discussion

Using historical data sets from the 1920s from Basel and Lausanne, which each had only one maternity hospital, we showed that in over 90% of births, the position of the foetal head was either right occiput anterior or left occiput anterior (i.e., considered normal); episiotomy was performed in 8–17% of births and forceps delivery was performed in 1–5%, while caesarean sections were rarely performed (<1% of all births). Regarding the primary exposure variable, a large foetal head diameter and a short conjugata externa (as an indicator of an anteroposteriorly narrow pelvis), either alone or in combination with each other, tended to prolong the expulsion phase and increase the risk of intervention. Abnormal head position and first births were also associated with prolonged expulsion phase and increased intervention risk. Rickets (noted by physicians in 2% of Lausanne mothers) increased the risk of forceps delivery or caesarean section.

We are unaware of similar modern studies that have analysed comparable historical datasets from maternity hospitals, so we cannot compare our results with other studies of historical data. While traditional external pelvic measurements such as interspinous, intercristal, and conjugata externa provide valuable insights into pelvic dimensions, their routine use has declined with the advent of advanced imaging technologies. These modern methods,

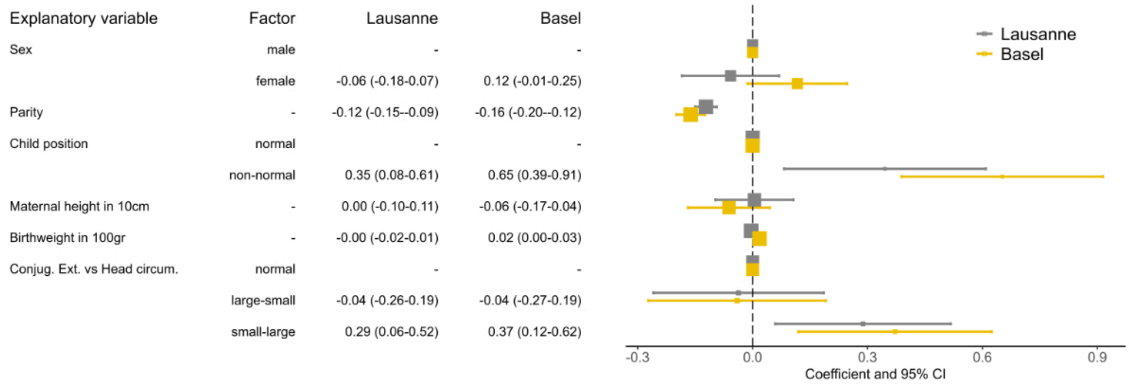
Table 1:
Summary of the two samples from Lausanne and Basel for outcomes/interventions and all co-factors, continuous variables (including individual body measurements and ratios), and categorical variables. SD: Standard deviation; CI: Confidence interval.

		Basel		Lausanne		Difference (Basel vs Lausanne)		
		n/value	%	n/value	%	Difference	95% CI	p
Year	1921	510						
	1922	423		1145				
	1923	474						
	Total	1407		1145				
Episiotomy	No	1174	83.4	1047	91.4			
	Yes	233	16.6	98	8.6	8.0	5.4 to 10.6	p <0.001
	Missing	0	0.0	0	0.0			
	Total	1407	100.0	1145	100.0			
Forceps	No	1390	98.8	1091	95.3			
	Yes	17	1.2	54	4.7	−3.5	2.1 to 4.9	p <0.001
	Missing	0	0.0	0	0.0			
	Total	1407	100.0	1145	100.0			
Caesarean section	No	1388	98.6	1139	99.5			
	Yes	19	1.4	6	0.5	0.8	0.0 to 1.6	p = 0.056
	Missing	0	0.0	0	0.0			
	Total	1407	100.0	1145	100.0			
Foetal position	Abnormal	117	8.3	83	7.2	1.1	−1.1 to 3.2	p = 0.356
	Normal	1290	91.7	1062	92.8			
	Missing	0	0.0	0	0.0			
	Total	1407	100.0	1145	100.0			
Maternal height (cm)	n	949		1102				
	Mean	158.0		156.5		1.5	0.9 to 2.1	p <0.001
	SD	6.3		6.5				
	Missing	458	32.6	43	3.8			
Sex of neonate	Female	690	49.0	580	50.7	−1.6	−5.6 to 2.3	p = 0.440
	Male	712	50.6	555	48.5			
	Missing	5	0.4	10	0.9			
	Total	1407	100.0	1145	100.0			
Stillbirth	No	1343	95.5	1107	96.7			
	Yes	61	4.3	35	3.1	1.3	−0.3 to 2.8	p = 0.113
	Missing	3	0.2	3	0.3			
	Total	1407	100.0	1145	100.0			
Birthweight (g)	n	1399		1139				
	Mean	3282.0		3205.9		76.2	33.2 to 119.0	p <0.001
	SD	551.4		544.3				
	Missing	8	0.6	6	0.5			
Head circumference (cm)	n	1365		1114				
	Mean	34.7		34.5		0.2	0.1 to 0.3	p = 0.001
	SD	1.6		1.5				
	Missing	42	3	31	2.7			
Maternal age (years)	n	1407		1133				
	Mean	28.7		28.0		0.7	0.2 to 1.6	p = 0.003
	SD	5.8		5.9				
	Missing	0	0	12	1			
Intercristal distance (cm)	n	1237		1120				
	Mean	28.5		28.6		−0.1	−0.2 to 0.1	p = 0.118
	SD	1.5		1.6				
	Missing	170	12.1	25	2.2			
Conjugata externa (cm)	n	1231		1056				
	Mean	19.9		19.6		0.3	0.2 to 0.4	p <0.001
	SD	1.3		1.6				
	Missing	176	12.5	89	7.8			
Duration of expulsion phase (min)	n	1348		1073				
	Mean	52.2		33.1		19.0	14.2 to 24.0	p <0.001
	SD	71.8		44.1				
	Missing	59	4.2	72	6.3			
Gestational age (weeks)	n	1194		1141				
	Mean	39.8		40.1		−0.2	−0.5 to −0.1	p <0.001
	SD	2.5		2.7				

	Missing	213	15.1	4	0.3			
Gestational age categories (weeks)	<37	83	5.9	74	6.5	−0.6	−2.5 to 1.4	p = 0.612
	37 to 41	795	56.5	709	61.9			
	≥41	315	22.4	358	31.3			
	Missing	214	15.2	4	0.3			
	Total	1407	100.0	1145	100.0			
Parity	1	727	51.7	423	36.9	14.7	10.8 to 18.6	p <0.001
	2	358	25.4	279	24.4			
	≥3	322	22.9	421	36.8			
	Missing	0	0.0	22	1.9			
	Total	1407	100.0	1145	100.0			
Maternal socioeconomic position background	Low	331	23.5					
	Medium	728	51.7					
	High	318	22.6					
	Housewives	21	1.5					
	Missing	9	0.6					
	Total	1407	100.0					
Maternal obesity	Yes			41	3.6			
	No			1081	94.4			
	Missing			23	2.0			
	Total			1145	100.0			
Maternal undernutrition	Yes			23	2.0			
	No			1099	96.0			
	Missing			23	2.0			
	Total			1145	100.0			
Maternal goitre	Yes			47	4.1			
	No			1075	93.9			
	Missing			23	2.0			
	Total			1145	100.0			
Maternal rickets	Yes			23	2.0			
	No			1122	98.0			
	Missing			23	2.0			
	Total			1145	100.0			

particularly MRI pelvimetry, offer more accurate and detailed assessments, improving the prediction of labour outcomes and management of childbirth. However, despite their superior precision, advanced imaging techniques are mainly reserved for specific circumstances due to their availability and cost, such as in cases of breech or twin pregnancies. Moreover, most pelvimetric studies have concluded that the sensitivity of such simple linear dimensions to predict the risk of dystocia in births with cephalic presentations was too low to be clinically relevant [56, 57]. However, traditional clinical pelvimetry remains vital in settings where advanced imaging is inaccessible [54]. At the population level, studies have suggested that clinical pelvimetry can offer valuable predictive information, especially when combined with other maternal and foetal factors. Moreover, the transition from clinical to imaging-based pelvimetry reflects broader trends in obstetric practice, where technological advancements continually reshape clinical decision-making. These developments underscore the importance of integrating both traditional and

Figure 1: Expulsion time coefficients and 95% confidence intervals (CIs) from the linear regression model. All explanatory variables were mutually adjusted. The models were performed separately for Lausanne and Basel. To make the expulsion phase comparable between Basel and Lausanne, the expulsion time was z-transformed. “Conjug. Ext vs Head circum” shows the ratio of the conjugata externa to head circumference (3 groups: normal; large vs small [3rd tercile conjugata externa vs 1st tercile head circumference]; and small vs large [1st tercile conjugata externa vs 3rd tercile head circumference]).



modern approaches to optimise maternal and foetal outcomes [53].

Our study has several limitations. First, sample selection bias may have affected the two datasets. Although around two-thirds of all births in the two cities occurred at these hospitals at the beginning of the 1920s, it is unclear whether our results are generalisable to the remaining home births. Interventions and abnormal births may have been more common among hospital births than among all births. Second, medical interventions during labour are often stepwise when complications arise. Although the birth registers analysed may allow a precise reconstruction of all birth sequences and the reasons behind interventions, this detailed analysis was not possible for our dataset of around 2500 births due to time and effort constraints. More in-depth medical-historical analyses should be conducted. Third, the elasticity of the soft tissue plays a major role in the processes under consideration, in addition to the bony shape of the maternal pelvis. Unfortunately, we were unable to include these soft tissue factors in our analysis. In addition, maternal body mass index and weight gain during pregnancy, which might affect the weight of the infant, as well as any pathological process, were not available. Fourth, it is immediately apparent from examining the birth registers that both hospitals worked according to precise internal and obstetric guidelines. Unfortunately, despite intensive archive research, these guidelines could not be reconstructed. The two hospitals may have measured and documented the variables of interest differently, which could explain specific differences observed in our data. Obstetric textbooks and literature from this period should be consulted in a more in-depth medical-historical analysis to gain a better understanding of the use of these interventions. Finally, the observed differences may also reflect differences in patient populations between French-speaking southern Switzerland and German-speaking northern Switzerland, with potentially varying socioeconomic and cultural differences.

Conclusion

Our study provides insights into the health situation and obstetric practice over 100 years ago, when obstetric processes were precisely documented in the maternity hospitals. At that time, maternal body shape and health differed considerably due to living conditions, and modern obstetric methods were not yet widely used. Under these conditions, the mismatch between maternal body shape and the foetus was an important factor in complicated births.

Data sharing statement

The data are available in a public, open-access repository at https://doi.org/10.5281/zenodo.15576871, and the statis-

Figure 2: Episiotomy odds ratios (ORs) and 95% confidence intervals (CIs) from the logistic regression model. All explanatory variables were mutually adjusted. The models were performed separately for Lausanne and Basel. “Conjug. Ext vs Head circum” shows the ratio of the conjugata externa to head circumference (3 groups: normal; large vs small [3rd tercile conjugata externa vs 1st tercile head circumference]; and small vs large [1st tercile conjugata externa vs 3rd tercile head circumference]).

Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	0.49 (0.30-0.81)	0.70 (0.47-1.05)
Parity	-	0.70 (0.52-0.88)	0.52 (0.35-0.72)
Child position	normal	-	-
	non-normal	0.29 (0.05-1.02)	0.81 (0.32-1.82)
Maternal height in 10cm	-	1.32 (0.89-2.00)	1.30 (0.94-1.82)
Birthweight in 100gr	-	1.02 (0.97-1.08)	1.03 (0.99-1.08)
Conjug. Ext. vs Head circum.	normal	-	-
	large-small	0.92 (0.33-2.20)	0.60 (0.24-1.31)
	small-large	1.35 (0.58-2.91)	2.03 (1.04-3.80)
Expulsion phase	1st tercile	-	-
	2nd tercile	2.47 (1.13-5.72)	0.66 (0.34-1.29)
	3rd tercile	8.06 (3.92-18.0)	1.63 (0.87-3.09)

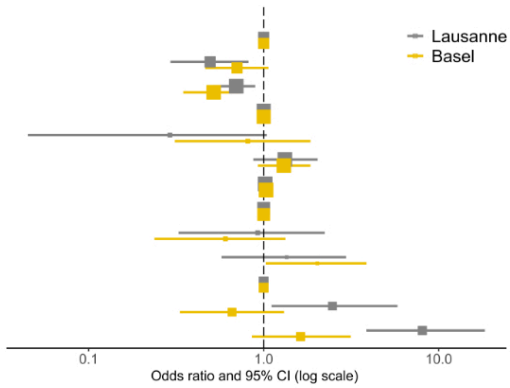
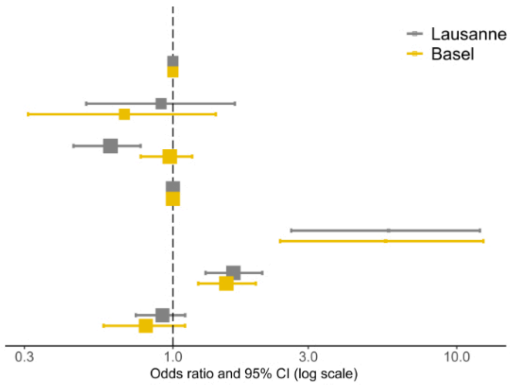


Figure 3: Forceps and caesarean section odds ratios (OR) and 95% confidence intervals (CIs) from the logistic regression model. All explanatory variables were mutually adjusted. The models were performed separately for Lausanne and Basel.

Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	0.91 (0.49-1.65)	0.67 (0.31-1.42)
Parity	-	0.60 (0.45-0.77)	0.98 (0.77-1.17)
Child position	normal	-	-
	non-normal	5.75 (2.61-12.0)	5.62 (2.39-12.4)
Head circumference in cm	-	1.63 (1.30-2.06)	1.54 (1.23-1.96)
Conjugata Externa in cm	-	0.92 (0.74-1.10)	0.80 (0.57-1.10)



tical codes can be found at https://github.com/KaMatthes/Obstetrical_interventions_1922.

Acknowledgments

The authors would like to thank Lukas Helm, Joël Floris, Kaspar Pohl, Laura Grogg, Nikola Koepke, and Ulrich Woitek for their help in collecting and preparing the data and for previous collaborations. They also express gratitude to the staff of the Basel-Stadt and Vaud State Archives for their help and support.

Financial disclosure

Swiss National Science Foundation (Project-No. 156683, Project-No. 197305 & Project-No. 310030_212984).

Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. – *AVJ* received grants from Swiss National Science Foundation and support for attending meetings and/or travel from the University of Zurich. – *MH* received grants from Swiss National Science Foundation 310030_212984. – No other potential conflict of interest related to the content of this manuscript was disclosed.

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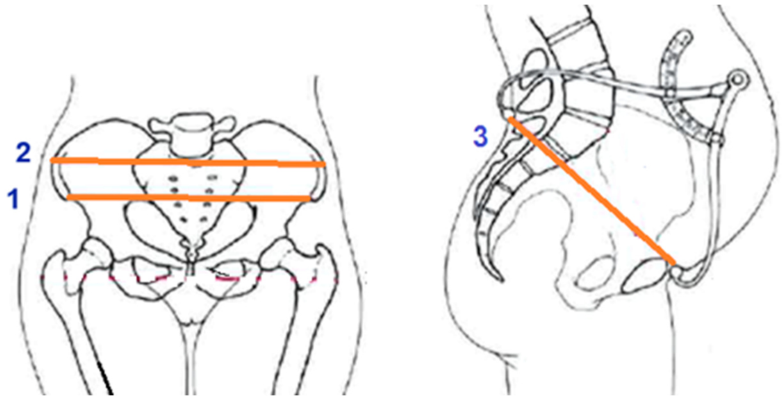
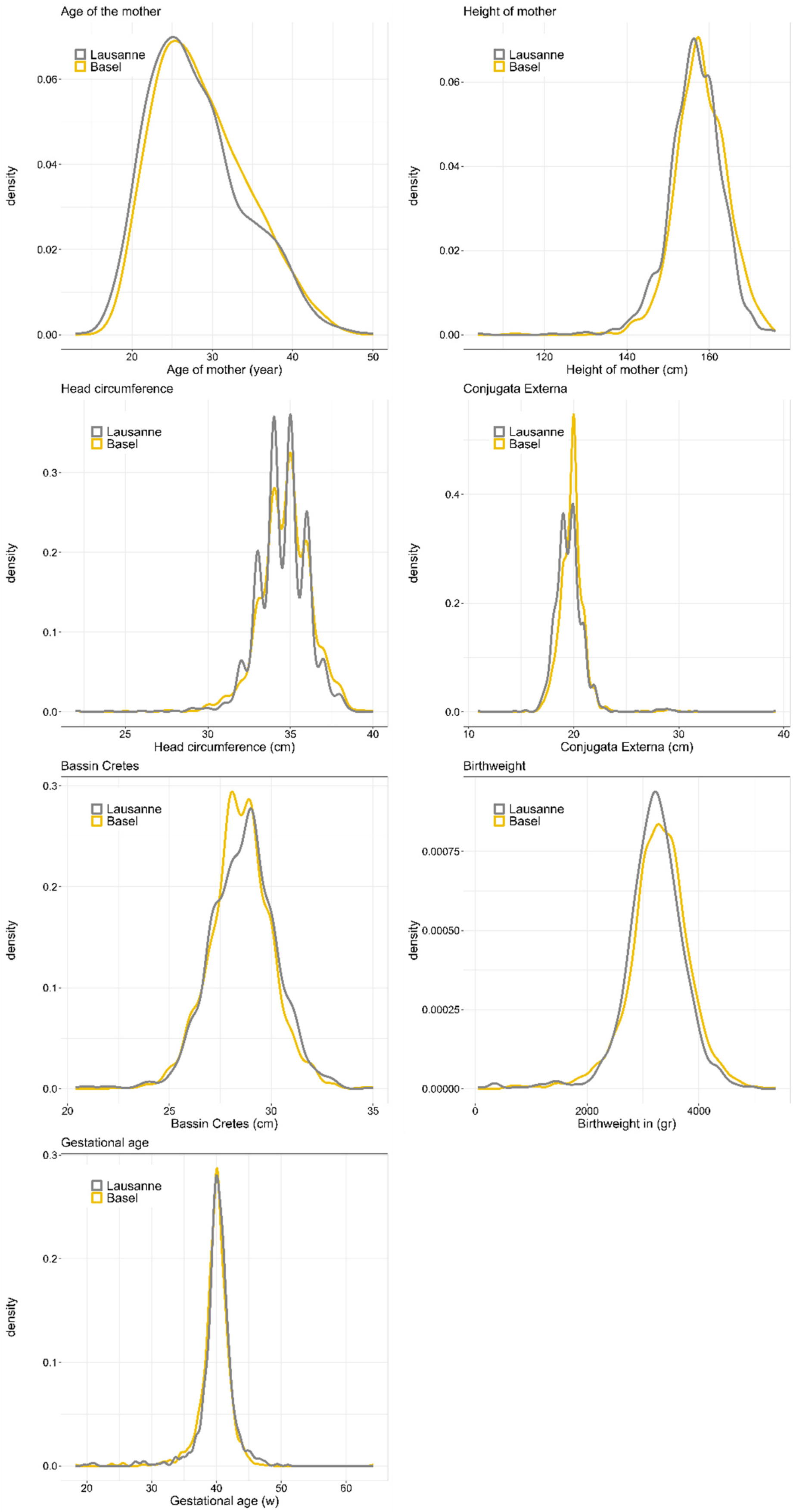
Appendix

Supplementary Figure S1: The three obstetric measurements recorded in the sources: 1) Interspinous distance (distance between the two anterior superior iliac spines); 2) Intercristal distance (most comprehensive distance between the two iliac cristae); 3) Conjugata externa (distance from the upper edge of the symphysis to the processus spinosus of the fifth lumbar vertebra).



Supplementary Figure S2: Density function of the explanatory variables.

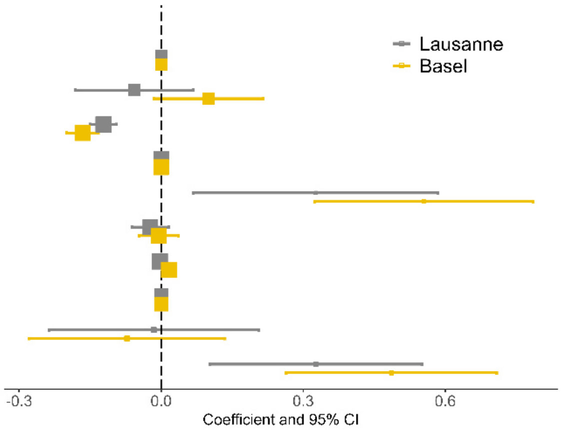


Supplementary Figure S3: Sensitivity analysis – adjusted for bassin cretes instead of maternal height. All explanatory variables were mutually adjusted. A) Expulsion time - Coefficient and 95% Confidence Interval (CI) from the linear regression model. B) Episiotomy - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model.

A) Expulsion time

Bassin Cretes - Expulsion phase in z-values: Coefficient (95% CI)

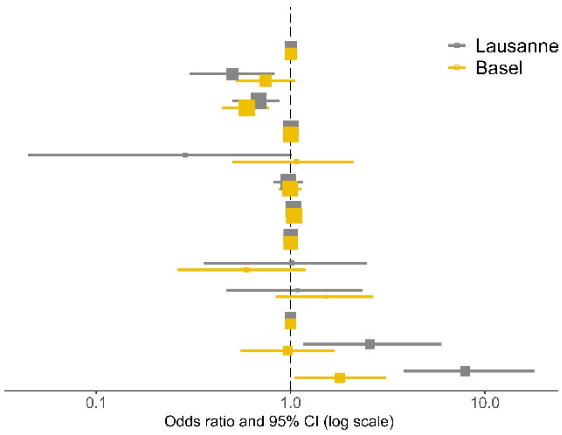
Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	-0.06 (-0.18-0.07)	0.10 (-0.02-0.22)
Parity	-	-0.12 (-0.15--0.09)	-0.17 (-0.20--0.13)
Child position	normal	-	-
	non-normal	0.33 (0.07-0.58)	0.55 (0.32-0.78)
Bassin Cretes in cm	-	-0.02 (-0.06-0.02)	-0.01 (-0.05-0.04)
Birthweight in 100gr	-	-0.00 (-0.02-0.01)	0.02 (0.00-0.03)
Conjug. Ext. vs Head circum.	normal	-	-
	large-small	-0.02 (-0.24-0.21)	-0.07 (-0.28-0.13)
	small-large	0.33 (0.10-0.55)	0.49 (0.26-0.71)



B) Episiotomy

Bassin Cretes - Episiotomy: OR (95% CI)

Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	0.50 (0.31-0.82)	0.74 (0.53-1.04)
Parity	-	0.68 (0.51-0.87)	0.60 (0.45-0.76)
Child position	normal	-	-
	non-normal	0.29 (0.05-0.99)	1.07 (0.51-2.09)
Bassin Cretes in cm	-	0.97 (0.83-1.14)	0.99 (0.88-1.12)
Birthweight in 100gr	-	1.03 (0.98-1.09)	1.04 (1.01-1.08)
Conjug. Ext. vs Head circum.	normal	-	-
	large-small	1.01 (0.36-2.42)	0.59 (0.27-1.18)
	small-large	1.09 (0.47-2.31)	1.52 (0.86-2.62)
Expulsion phase	1st tercile	-	-
	2nd tercile	2.55 (1.18-5.89)	0.96 (0.56-1.66)
	3rd tercile	7.92 (3.86-17.6)	1.79 (1.06-3.07)

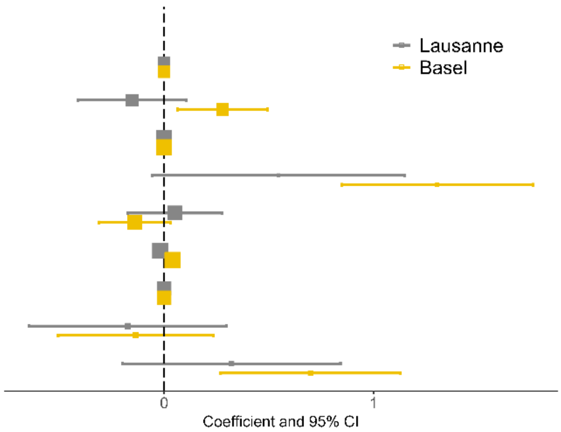


Supplementary Figure S4: Sensitivity analysis – only first parity is included. All explanatory variables were mutually adjusted. A) Expulsion time - Coefficient and 95% Confidence Interval (CI) from the linear regression model. B) Episiotomy - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model.

A) Expulsion phase

Only 1st parity - Expulsion phase in z-values: Coefficient (95% CI)

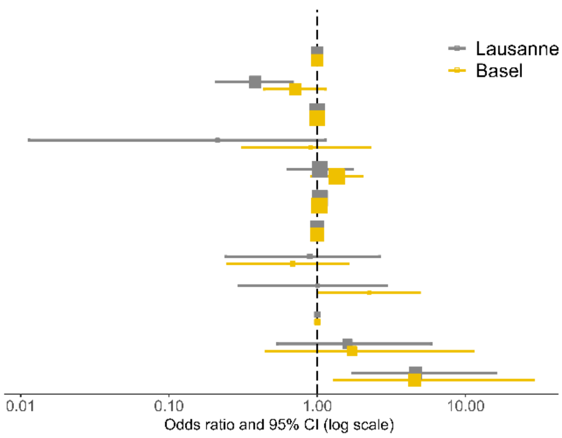
Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	-0.15 (-0.41-0.10)	0.28 (0.06-0.49)
Child position	normal	-	-
	non-normal	0.55 (-0.06-1.15)	1.30 (0.85-1.76)
Maternal height in 10cm	-	0.05 (-0.17-0.28)	-0.14 (-0.31-0.03)
Birthweight in 100gr	-	-0.02 (-0.05-0.01)	0.04 (0.01-0.07)
Conjug. Ext. vs Head circum.	normal	-	-
	large-small	-0.17 (-0.65-0.30)	-0.14 (-0.51-0.23)
	small-large	0.32 (-0.20-0.84)	0.70 (0.27-1.13)



B) Episiotomy

Only 1st parity - Episiotomy: OR (95% CI)

Explanatory variable	Factor	Lausanne	Basel
Sex	male	-	-
	female	0.38 (0.21-0.68)	0.71 (0.44-1.13)
Child position	normal	-	-
	non-normal	0.21 (0.01-1.14)	0.90 (0.31-2.26)
Maternal height in 10cm	-	1.04 (0.63-1.72)	1.35 (0.92-2.02)
Birthweight in 100gr	-	1.04 (0.98-1.12)	1.03 (0.98-1.09)
Conjug. Ext. vs Head circum.	normal	-	-
	large-small	0.89 (0.24-2.62)	0.68 (0.25-1.61)
	small-large	1.01 (0.30-2.93)	2.25 (1.01-4.89)
Expulsion phase	1st tercile	-	-
	2nd tercile	1.60 (0.54-5.89)	1.71 (0.45-11.2)
	3rd tercile	4.61 (1.73-16.0)	4.54 (1.31-28.6)

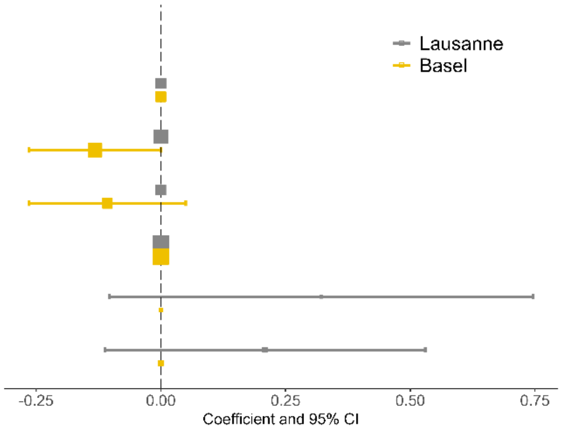


Supplementary Figure S5: Analysis including SEP for Basel and maternal body for Lausanne. A) Expulsion time - Coefficient and 95% Confidence Interval (CI) from the linear regression model. B) Episiotomy - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model. C) Forceps and caesarean section - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model.

A) Expulsion phase

SEP and Maternal body - Expulsion phase in z-values: Coefficient (95% CI)

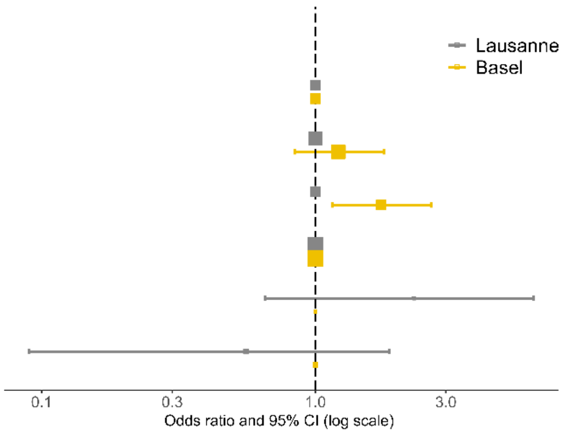
Explanatory variable	Factor	Lausanne	Basel
Socioeconomic position	low	-	-
	medium	-	-0.13 (-0.26-0.00)
	high	-	-0.11 (-0.26-0.05)
Maternal body	normal	-	-
	thin	0.32 (-0.10-0.75)	-
	obese	0.21 (-0.11-0.53)	-



B) Episiotomy

SEP and Maternal body - Episiotomy: OR (95% CI)

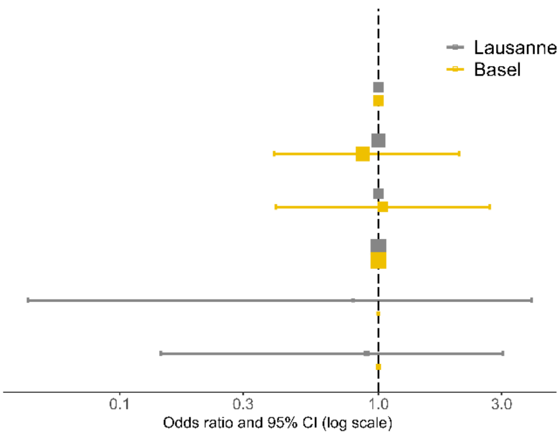
Explanatory variable	Factor	Lausanne	Basel
Socioeconomic position	low	-	-
	medium	-	1.21 (0.84-1.78)
	high	-	1.74 (1.15-2.65)
Maternal body	normal	-	-
	thin	2.29 (0.65-6.26)	-
	obese	0.56 (0.09-1.86)	-



C) Forceps and caesarean section

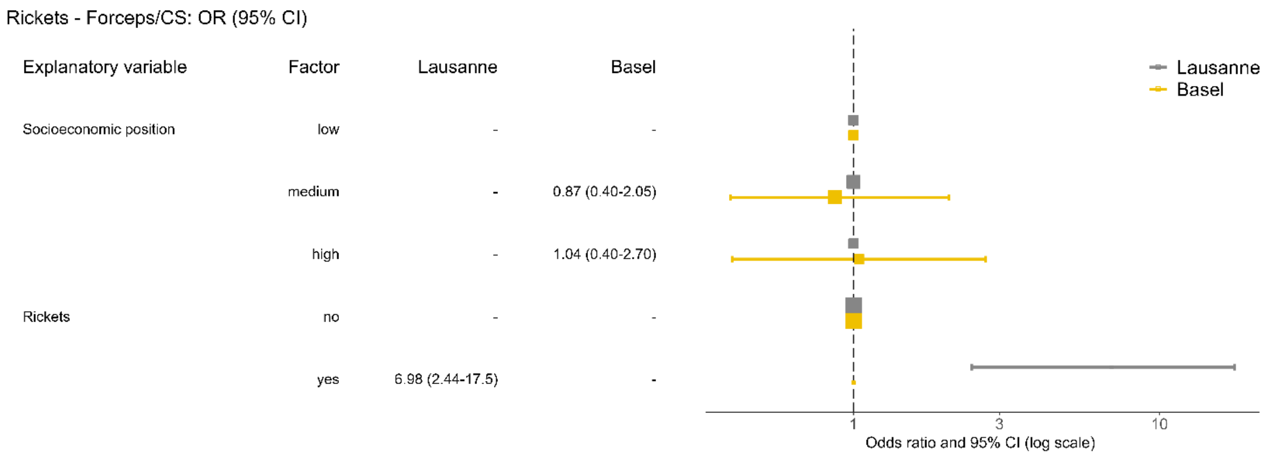
SEP and Maternal body - Forceps/CS: OR (95% CI)

Explanatory variable	Factor	Lausanne	Basel
Socioeconomic position	low	-	-
	medium	-	0.87 (0.40-2.05)
	high	-	1.04 (0.40-2.70)
Maternal body	normal	-	-
	thin	0.80 (0.04-3.91)	-
	obese	0.90 (0.14-3.04)	-

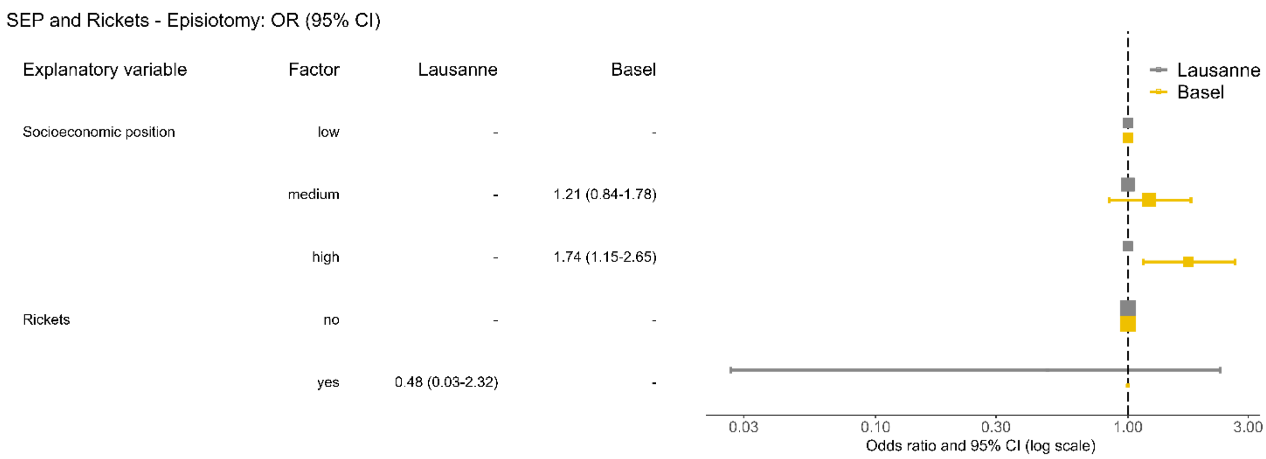


Supplementary Figure S6: Analysis including SEP for Basel and rickets for Lausanne. A) Expulsion time - Coefficient and 95% Confidence Interval (CI) from the linear regression model. B) Episiotomy - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model. C) Forceps and caesarean section - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model.

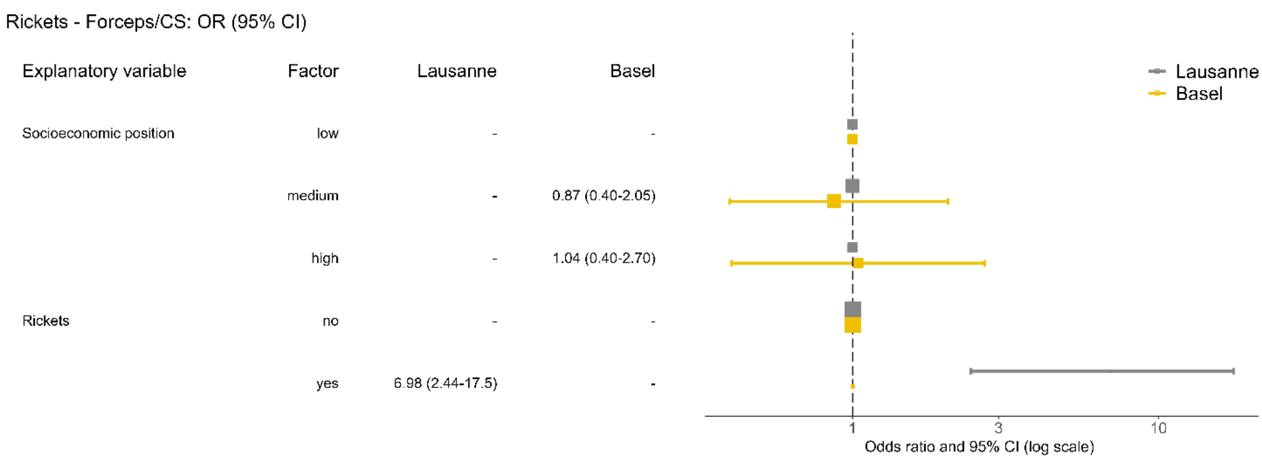
A) Expulsion phase



B) Episiotomy

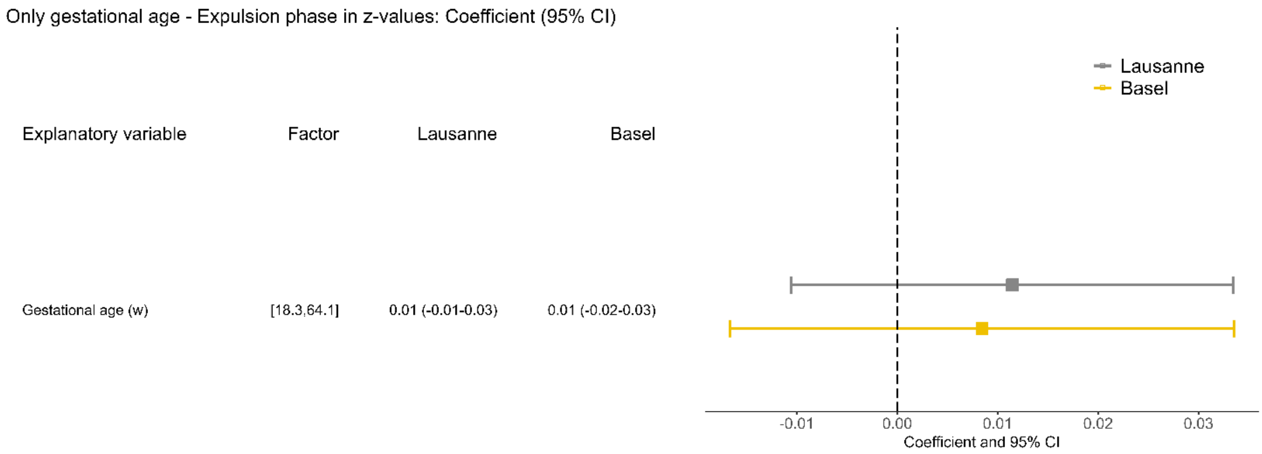


C) Forceps and caesarean section

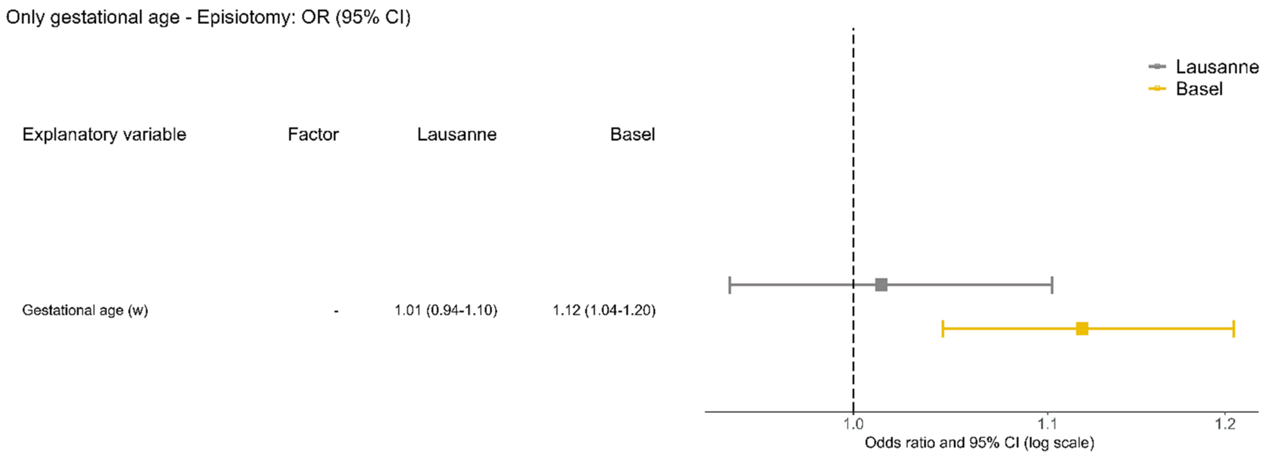


Supplementary Figure S7: Univariable analysis - only gestational age. A) Expulsion time - Coefficient and 95% Confidence Interval (CI) from the linear regression model. B) Episiotomy - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model. C) Forceps and caesarean section - Odds ratio (OR) and 95% Confidence Interval (CI) from the logistic regression model.

A) Expulsion phase



B) Episiotomy



C) Forceps and caesarean section