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Full length article

# The rate of elective cesarean section after pelvic or hip fracture remains high even after the long-term follow-up: A nationwide register-based study in Finland

Matias Vaajala [a,*], Ilari Kuitunen [b,c], Rasmus Liukkonen [a], Ville Ponkilainen [d], Maiju Kekki [e,f], Ville M. Mattila [a,g]

[a] Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland
[b] Department of Pediatrics, Mikkeli Central Hospital, Mikkeli, Finland
[c] Institute of Clinical Medicine and Department of Pediatrics, University of Eastern Finland, Kuopio, Finland
[d] Department of Surgery, Central Finland Central Hospital Nova, Jyväskylä, Finland
[e] Department of Obstetrics and Gynecology, Tampere University Hospital, Tampere, Finland
[f] Center for Child, Adolescent and Maternal Health Research, Faculty of Medicine and Health Technology, Tampere University, Tampere, Finland
[g] Department of Orthopaedics and Traumatology, Tampere University Hospital Tampere, Finland

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ABSTRACT

*Introduction:* There are only few studies on the effects of pelvic or hip fractures on subsequent delivery outcomes. The aim for this study is to evaluate in a nationwide sample whether the rate of elective CS and emergency CS would decrease during the time after maternal hip and pelvic fracture.

*Material and Methods:* In this nationwide registry-based study, data on all women aged 15–49 years with pelvic or hip fractures leading to hospitalization were retrieved from the Care Register for Health Care for the years 1998–2018. Wrist fractures were used as a control group. The data were linked with data from the National Birth Register, where each first pregnancy during the 14-year follow-up is collected. The delivery outcomes of these pregnancies were analyzed. The results were interpreted with odds ratios (OR), adjusted odds ratios (aOR), and 95 % confidence intervals (CI).

*Results:* A total of 2878 women with pelvic fracture, 1330 women with hip fracture, and 29 580 with wrist fracture found in the Care Register for Health Care. Of these, a total of 586 (20.4 %) women gave birth during the following 14 years after pelvic fracture, 147 (11.0 %) women after hip fracture, and 5255 (17.7 %) women after wrist fracture. Women with pelvic fracture had higher odds for CS during each time period. The aOR for CS was 1.62 (CI 1.22–2.12) during first 5 years, 1.87 (CI 1.33–2.62) during years 5–10, and 1.97 (CI 1.11–3.41) during years 10–14. Women with hip fractures had notably higher odds for CS during first 5 years after fracture (aOR 1.64, CI 1.40–2.67).

*Conclusions:* The results of this study advocate that vaginal delivery is generally possible rather quickly after hip or pelvic fracture. Unplanned CS after hip fractures was more common at the beginning, but the exact reason for this remains unknown and further research should be made on this topic.

## Introduction

Due to numerous strong ligaments, the pelvic ring is a truly stabile structure, making high-energy collisions the most common cause of pelvic traumas [1]. In the younger population, the main cause for hip fractures are also high energy collisions, as the hip fractures caused by weakened bone are common only in an elderly population [2]. The latest nationwide study in Finland found that in fertile-aged women, the incidence of pelvic fractures was ranging between 8.1 and 14.0 per 100 000 person-years and the incidence of hip or thigh fractures was ranging between 7.9 and 12.8 per 100 000 years during years 1998 and 2018 [3].

There are few studies on the effects of pelvic fractures on delivery mode. It seems that even though pelvic fractures may affect the mode of

* Corresponding author.
*E-mail address:* matias.vaajala@tuni.fi (M. Vaajala).

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delivery, vaginal delivery is still possible after pelvic trauma in most cases [4,5]. A study in 1997 found out that patients with a pelvic fracture with over 5 mm dislocation had an increased risk for cesarean section (CS) later [6]. The latest study in Finland found that the rate for elective (CS) is higher, but generally, vaginal delivery appears safe after pelvic fracture [7]. Most concerns in this study were focused on the high rate of elective CS after pelvic fracture. According to a systematic review in 2014, the rate of elective CS was over 40 % after pelvic fractures [8]. However, despite these studies, the literature on this topic is still lacking, and further research is warranted.

The effects of hip fractures on the mode of delivery are poorly studied, mainly because they are too rare for younger population to analyze properly [9]. In addition, women with hip fractures are known to have low birth rate in Finland, making deliveries after hip fractures truly rare events [3]. A study about deliveries after primary total hip arthroplasty found out a high rate of CS as a mode of delivery [10]. In addition, a study in 2019 found out that after total hip replacement (THR), a trial of labor ended up more likely to an emergency CS [11]. There are no studies about the effects of hip fractures occurring before pregnancy on later mode of delivery.

Based on our hypothesis, the fears and unawareness of the capability to give birth after pelvic and hip fracture might increase the elective CS rates especially, when there is little time passed from the fracture. In addition, recent pelvic and hip fractures might lower the threshold to convert attempted vaginal delivery to an unplanned CS. The aim for this study is to evaluate in a nationwide sample whether the rate of elective CS and emergency CS would decrease during the time after maternal hip and pelvic fracture.

## Materials and methods

In this nationwide retrospective register-based cohort study, data were retrieved from the Care Register for Health Care and combined with data retrieved from the National Medical Birth Register (MBR). Both registers are maintained by the Finnish Institute for Health and Welfare. The study period was from January 1, 1998 through December 31, 2018. The coverage and quality of both registers is high [12–14].

All fertile-aged (15–49 years) women with a pelvic or hip fracture diagnosis before pregnancy during the study period were retrieved from the Care Register for Health Care. Pelvic or hip fracture was defined as a hospitalisation period based on ICD-10 (International Classification of Diseases 10th revision) codes. We used women who were hospitalized with fracture of the wrist as a reference group. Women with fractures of the wrist were chosen as a reference group because we expected these women to be similar in background and risk-taking behaviour to those women in the major trauma groups than women in the general population without any injuries. In addition, as wrist fractures generally heal quickly, we did not expect them to have a major impact on fertility, and therefore they formed a comparable reference group. The exact ICD-10 codes with definitions for pelvic, hip, and wrist fractures are shown in supplementary Table 1. Only first pelvic, hip, or wrist fracture for each woman were obtained from the Care Register for Health Care, as the identification of new fractures is challenging due to register-based study design.

Data retrieved from the Care Register for Health Care were combined with data from the MBR using the pseudonymised identification number of the mother. The MBR contains information on all pregnancies, delivery statistics and the perinatal outcomes of births with a birthweight of $\geq$500 g or a gestational age $\geq$22 + 0. It contains information on a total of 628 908 women with 1 192 825 deliveries during our study period. Each first pregnancy occurring in 14 years after pelvic, hip, or wrist fracture were collected from the MBR. The 14-year time period was chosen, as the majority of patients who decided to get pregnant did it during this 14-year period (96.4 % of women with hip, or pelvic fracture). Time difference between fracture and pregnancy were calculated and the details on these subsequent pregnancies were collected from the MBR. Pregnancies with multiple fetuses were excluded from the analysis, as the nature of multiple pregnancies differs from singleton pregnancies. Also, fractures occurring during pregnancy were not included in this study. Formation of study groups is shown as a flowchart in Fig. 1. In the MBR, CS was classified as elective or urgent until 2004, and in order to have uniform coding throughout the study period we used this instead of the current three-stage classification (elective, urgent and emergency). Therefore, our current report considers each emergency and urgent CS as an unplanned CS. The results of this study are reported according to the STROBE guidelines [15].

**Table 1**
Background characteristics of deliveries in the pelvic fracture group, hip fracture group, and wrist fracture group.

| | Pelvic fracture group | | Hip fracture group | | Wrist fracture group | |
|---|---|---|---|---|---|---|
| Total number of patients | 586 | | 147 | | 5255 | |
| | n | % | n | % | n | % |
| Age during fracture (mean, sd) | 22.8 (6.1) | | 23.9 (6.12) | | 24.8 (6.2) | |
| Age during delivery (mean, sd) | 27.9 (5.5) | | 29.0 (6.3) | | 29.7 (5.6) | |
| Smoking status during pregnancy | | | | | | |
| confirmed smoker* | 166 | 28.3 | 45 | 30.6 | 1197 | 22.8 |
| unknown | 19 | 3.2 | 4 | 2.7 | 135 | 2.6 |
| Nulliparous | 448 | 76.5 | 116 | 78.9 | 3851 | 73.3 |
| Previous CS** | 35 | 6.0 | 5 | 3.4 | 296 | 5.6 |
| Gestational diabetes | 52 | 8.9 | 13 | 8.8 | 650 | 12.4 |
| Time difference between fracture and pregnancy (months) | | | | | | |
| mean (sd) | 63.1 (39.9) | | 61.8 (39.7) | | 58.8 (39.8) | |
| Mode of delivery | | | | | | |
| elective CS | 80 | 13.7 | 15 | 10.2 | 379 | 7.2 |
| unplanned CS | 87 | 14.8 | 24 | 16.3 | 705 | 13.4 |
| vaginal delivery | 419 | 71.5 | 108 | 73.5 | 4171 | 79.4 |

*Confirmed smoker contains women with smoking during only 1st trimester and/or on later trimesters.
**CS = Cesarean section.

### *Statistics*

Continuous variables were interpreted as mean with standard deviation or as median with interquartile range based on variable distribution. Categorised variables were presented as absolute numbers and percentages. Student's *t*-test, Mann-Whitney *U* test and Chi squared tests were used for group comparisons. P-value under 0.05 was considered statistically significant in all analyses. The rate of CSs and attempted vaginal deliveries were examined in a longitudinal setting by the number of elective CSs as numerator and attempted vaginal deliveries as denominator. The rate of unplanned CSs and attempted vaginal deliveries were examined by the number of unplanned CS as numerator and successful vaginal deliveries as denominator.

Time-stratified multivariable logistic regression was used to assess the pregnancy outcomes during different time periods. The model was used in time periods of 0–5 years, 5–10 years, and 10–14 years. Maternal smoking during pregnancy, age of the mother during fracture, gestational diabetes, and previous CS were used as adjusting variables. Odds ratios (OR) and adjusted odds ratios (AOR) with 95 % confidence

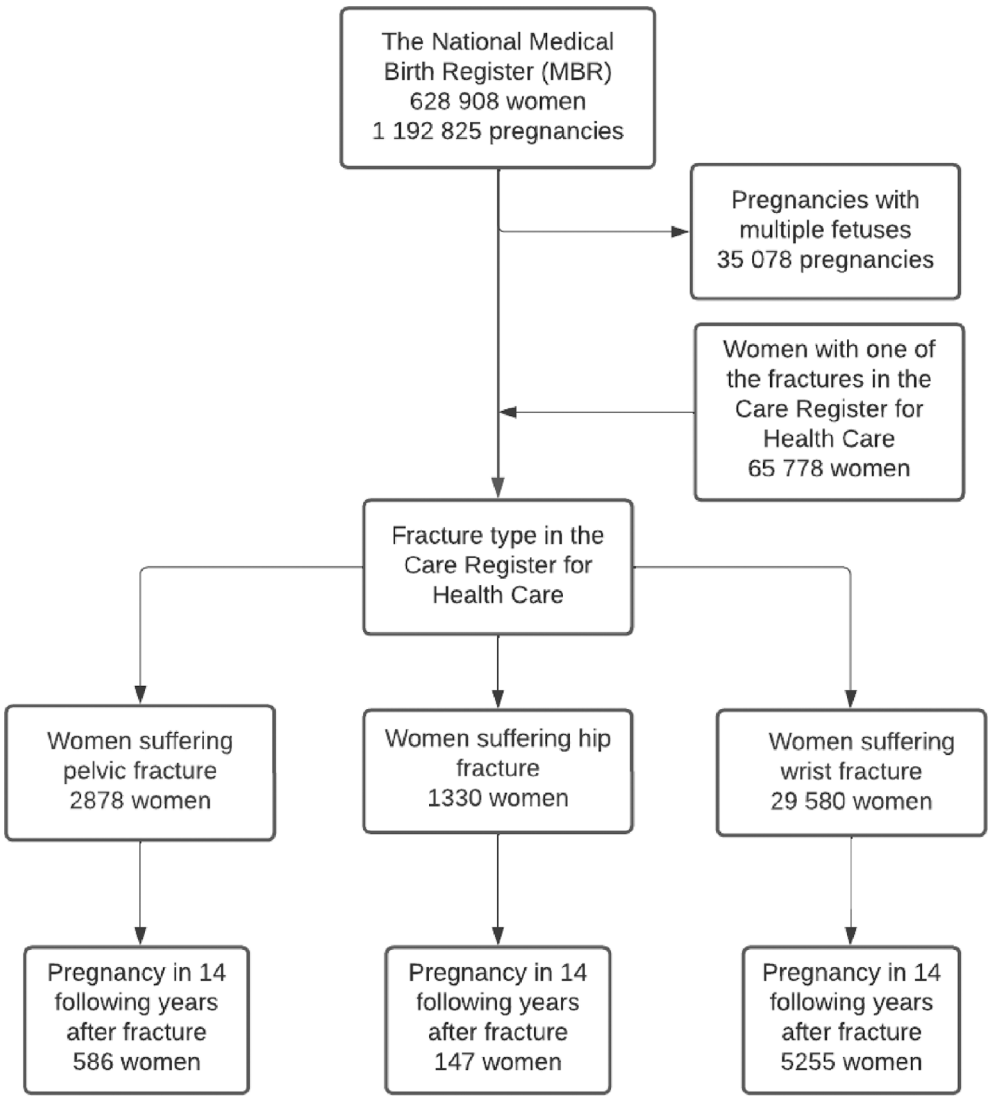


**Fig. 1.** Flowchart of the study population. Data from the MBR were combined with data on the diagnosed pelvic, hip, and wrist fractures in the Care Register for Health Care.

intervals (CI) were calculated for the main outcomes. Adjustments were made by choosing the variables for a multivariate model using directed acyclic graphs (DAGs) constructed using the free online software DAGitty (dagitty.net). The variables included in the DAG were chosen based on known risk factors and by hypothesised causal pathways [18,19]. DAG is presented in Fig. 2. Statistical analysis was performed using R version 4.0.3.

*Ethics*

Both the MBR and the Care Register for Health Care have the same unique pseudonymised identification number for each patient. The pseudonymisation was made by the Finnish data authority Findata. The authors did not have access to the pseudonymisation key, as it was maintained by Findata. In accordance with Finnish regulations, no informed written consent was required because of the retrospective register-based study design and because the patients were not contacted. Permission for use of this data was granted by Findata after evaluation of the study protocol (Permission number: THL/1756/14.02.00/2020).

## Results

During our study period, there was a total of 2878 women with pelvic fracture, 1330 women with hip fracture, and 29 580 with wrist fracture found in the Care Register for Health Care.

Of these, a total of 586 (20.4 %) women gave birth during the following 14 years after pelvic fracture, 147 (11.0 %) women after hip fracture, and 5255 (17.7 %) women after wrist fracture. Notably higher rate of women smoked during pregnancy in pelvic (28.3 %) and hip (30.6 %) fracture groups than in wrist fracture group (22.8 %, $p < 0.001$). Elective CS was more common in pelvic fracture group (13.7 %) and hip fracture group (10.2 %), when compared to wrist fracture group (7.2 %, $p < 0.001$ for both). Women in hip fracture group had highest rate for unplanned CS (16.3 %) (Table 1).

Women with pelvic fracture had highest proportion of elective CS throughout the study period; the ratio to attempted vaginal deliveries increased up to 0.16 in around three years and stayed there the whole 14-year period. The ratio between elective CS and attempted vaginal deliveries was approximately 0.08–0.09 throughout the whole 14 years in wrist fracture group. Women with hip fractures had slightly lower ratio between elective CS and attempted vaginal delivery than women with pelvic fractures, ranging mostly between 0.08 and 0.14. (Fig. 2).

After excluding elective CS, women with pelvic fractures had similar ratio between unplanned CS and successful vaginal deliver with wrist fractures, ranging between 0.15 and 0.20 for both groups during the whole time. Women with hip fractures had high ratio between

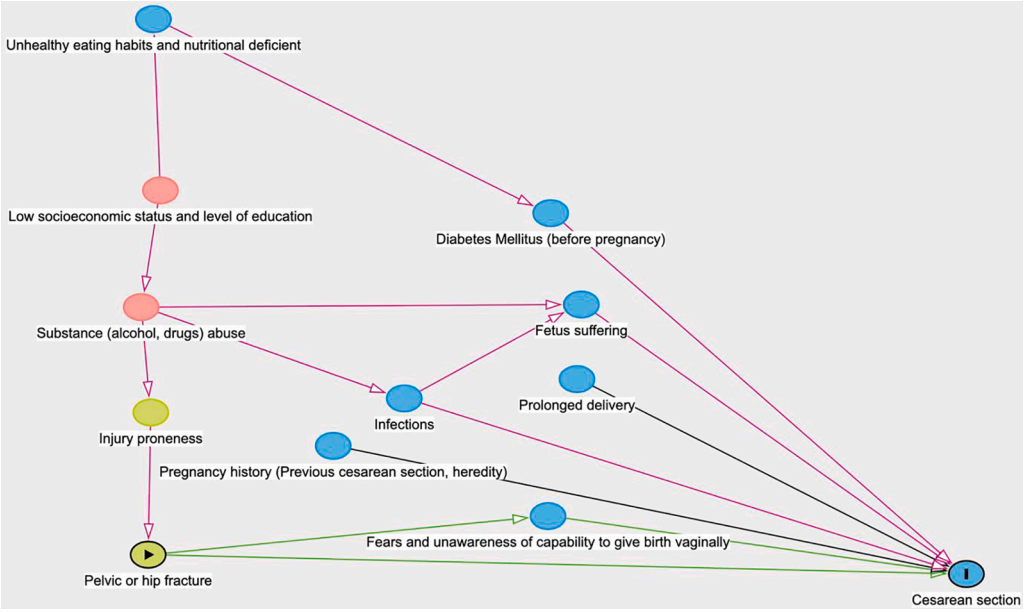


**Fig. 2.** DAG, risk for cesarean section as a dependent variable and pelvic or hip fracture as an exposure variable.

unplanned CS and successful vaginal deliveries during first 20 months, ranging between 2.1 and 0.6. However, after this period the ratio decreased between 0.2 and 0.3, which was still higher than in wrist fracture group (0.15–0.20). (Fig. 3).

When compared to wrist fractures, women with pelvic fracture had higher odds for cesarean section during each time period. The aOR for CS was 1.62 (CI 1.22–2.12) during first 5 years, 1.87 (CI 1.33–2.62) during years 5–10, and 1.97 (CI 1.11–3.41) during years 10–14. Women with hip fractures had notably higher odds for CS during first 5 years after fracture (aOR 1.64, CI 1.40–2.67). (Table 2).

Among pelvic and hip fracture patients included in this study, women with multiple fractures of lumbar spine or pelvic (S72.0) had highest rate of elective CS (18.9 %). Women with fractures of ilium had lowest rate of unplanned CS (4.3 %) pertrochanteric hip fractures had highest rate of unplanned CS (27.6 %). (Table 3).

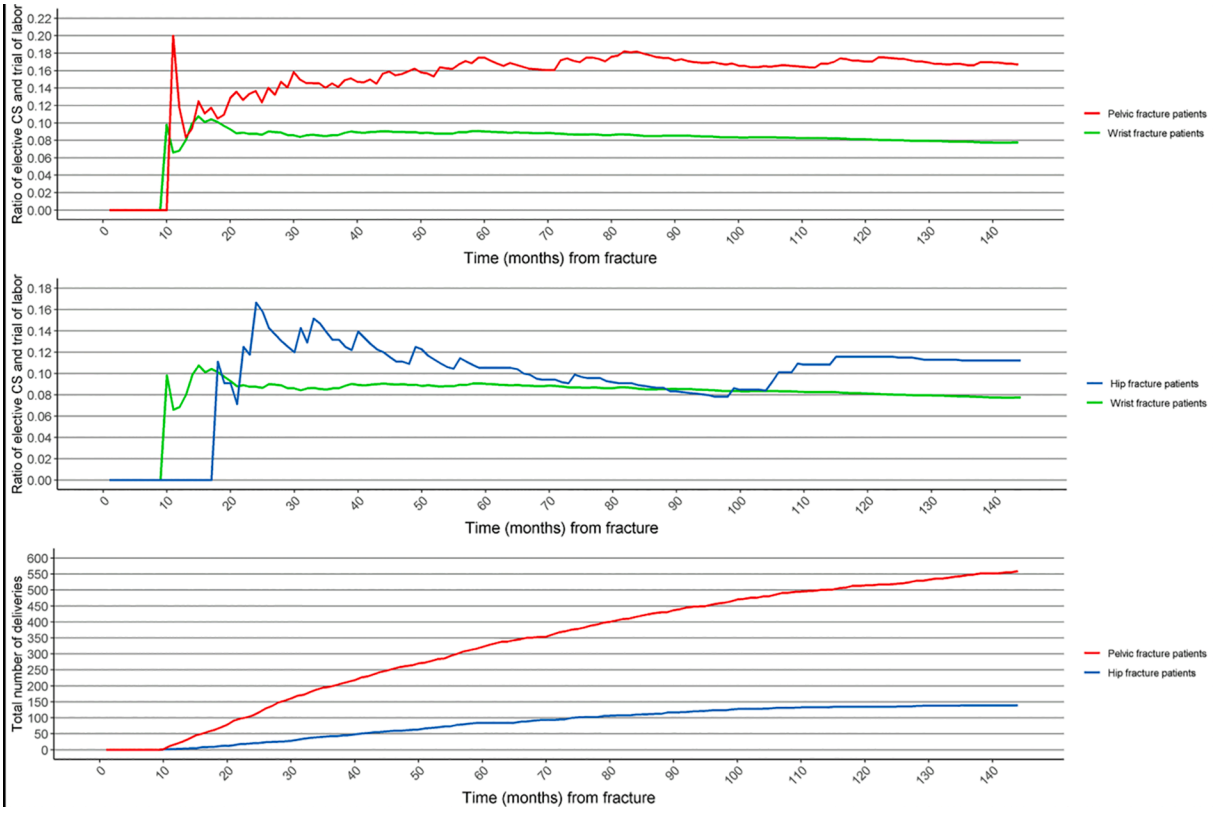


**Fig. 3.** Monthly ratio between elective cesarean section (CS) and attempted vaginal delivery (number of elective CSs as numerator and attempted vaginal deliveries as denominator) and total number of deliveries as a time function. Pelvic and hip fracture patients were compared to wrist fracture patients.

**Table 2**
Time-stratified univariable and adjusted odds ratios (OR) with confidence intervals (CI) for all (elective + unplanned) cesarean section (CS) after fracture. Pelvic and hip fractures were compared to wrist fractures. Models were adjusted with maternal smoking during pregnancy, age of the mother during fracture, gestational diabetes, and previous CS.

| | Pelvic fracture group | | Hip fracture group | |
|---|---|---|---|---|
| | Odds ratio (CI) | | Odds ratio (CI) | |
| Time period | Univariable | Adjusted | Univariable | Adjusted OR |
| 0–4 years | 1.42 (1.09–1.83) | 1.62 (1.22–2.12) | 1.44 (0.87–2.31) | 1.64 (1.40–2.67) |
| 5–9 years | 1.75 (1.24–2.43) | 1.87 (1.33–2.62) | 1.36 (0.69–2.52) | 1.52 (0.76–2.86) |
| 10–14 years | 1.71 (0.97–2.91) | 1.97 (1.11–3.41) | 1.21 (0.27–4.14) | 1.22 (0.26–4.31) |
| Total | 1.39 (1.28–1.87) | 1.73 (1.42–2.11) | 1.39 (0.97–2.00) | 1.54 (1.15–2.24) |

## Discussion

The main finding of this study was that women with previous pelvic fractures had a higher rate for elective CS throughout the follow-up, but the rate for unplanned CS was on a similar level already in the beginning with wrist fractures. In addition, the high rate of unplanned CSs during first years after hip fractures was observed (Fig 4).

The rate for CS after pelvic fracture was higher in each period. The rate for elective CS was higher since the beginning and didn't decrease by time. This is an important finding, as the rate for unplanned CS had reached the same level around two years after the pelvic fracture. Also, it is good to notice, that the low number of patients giving birth during the first two years might be the cause for higher rate of unplanned CS at the beginning. A previous nationwide study in Finland, found that vaginal delivery appears to be possible delivery method after pelvic fractures and only minority of patients ended up in unplanned CS, which is in line with the results of this study [7]. In addition, the same study found that vaginal delivery was generally possible even after multiple pelvic fractures. However, in that study, the pregnancy outcomes were examined only generally, and the effects of time were not taken into account. Our results confirm that vaginal delivery appears to be generally possible even after short period from the pelvic fracture.

Generally, CS is safe and possibly even lifesaving operation for many mothers and neonates. However, the downsides of CS for the neonate are the increased risk for asthma, obesity, and poorer cardiorespiratory health in later life than those born vaginally [20,21]. Additionally, breastfeeding duration is shorter after elective CS [22]. In addition, CS may cause pregnancy-related complications in future pregnancies [23]. Therefore, as CS is known to have numerous downsides, the necessity of CS should always be considered carefully and results like these found on the possibility of vaginal delivery after pelvic fractures, should be utilized, when considering the possibility of vaginal delivery between patient and obstetrician. The rate of CS in Finland is one of the lowest in Europe (16–17 %), and it has remained stable for the past two decades [24,25]. Even though elective CS was more common during the whole 14-year period in this study, the rate is still lower than in other countries. In a previous systematic review concerning level-1 trauma centers, the rate of elective CS was over 40 % after pelvic fractures [8] which is over twofold increase to CS rate in Finland. Our results suggest, that generally pelvic fracture should not be a reason to not try vaginal delivery after the fracture.

Notably lower rate of women with hip fracture got pregnant after the fracture. In addition, the time difference on average between fracture and the following pregnancy was longer than in wrist fracture group, indicating to the fact that the healing from hip fracture is a longer process than for example, after pelvic fractures. According to previous literature, the functional recovery after hip fractures may last up to 9 months, women being included in the group with poor recovery [26], whereas the functional recovery after pelvic fracture takes only up to 12 to 22 weeks [27].

The latest nationwide study in Finland found out, that women with hip fractures had low birth rate during 5 years after fracture, which is in line with these results [3].

Interestingly, the rate for unplanned CS was high during first years after hip fracture. The reason for this remains unknown and the low number of patients in this group might cause imprecision. However, even after 18 months (and after a total of 11 deliveries), there was more unplanned CS than successful vaginal deliveries, which is truly high proportion compared to the rate after 14 years. Also, based on our results over quarter of attempted vaginal deliveries after pertrochanteric fracture ended up to an unplanned CS. There is not much previous literature on this topic. A study with 47 patients giving birth after primary THR found out that 36 % of these had CS as a mode of delivery. The main reasons for CS in this study were delay in labour, hypertension induced by pregnancy and a breech presentation [10]. In addition, a

**Table 3**
Absolute number and percentages on planned mode of delivery and mode of delivery among pelvic and hip fracture patients based on fracture ICD-10 diagnoses.

| ICD-10 | Definition | Planned mode of delivery | | | Mode of delivery | | |
|---|---|---|---|---|---|---|---|
| | | | n | % | | n | % |
| Pelvic fractures | | | | | | | |
| S32.1 | Fracture of sacrum | Total number | 129 | | Total number * | 109 | |
| | | elective CS | 20 | 15.5 | unplanned CS | 20 | 18.3 |
| S32.3 | Fracture of ilium | Total number | 51 | | Total number * | 46 | |
| | | elective CS | 5 | 9.8 | unplanned CS | 2 | 4.3 |
| S32.4 | Fracture of acetabulum | Total number | 69 | | Total number * | 61 | |
| | | elective CS | 8 | 11.6 | unplanned CS | 11 | 18.0 |
| S32.5 | Fracture of pubis | Total number | 116 | | Total number * | 106 | |
| | | elective CS | 10 | 8.6 | unplanned CS | 18 | 17.0 |
| S32.7 | Multiple fractures of lumbar spine and pelvis | Total number | 127 | | Total number * | 103 | |
| | | elective CS | 24 | 18.9 | unplanned CS | 24 | 23.3 |
| S32.8 | Fracture of other parts of pelvis | Total number | 94 | | Total number * | 81 | |
| | | elective CS | 13 | 13.8 | unplanned CS | 12 | 14.8 |
| Hip fractures | | | | | | | |
| S72.0 | Fracture of head and neck of femur | Total number | 114 | | Total number * | 103 | |
| | | elective CS | 11 | 9.6 | unplanned CS | 16 | 15.5 |
| S72.1 | Pertrochanteric fracture | Total number | 33 | | Total number * | 29 | |
| | | elective CS | 4 | 12.1 | unplanned CS | 8 | 27.6 |

*Total number of attempted vaginal deliveries.

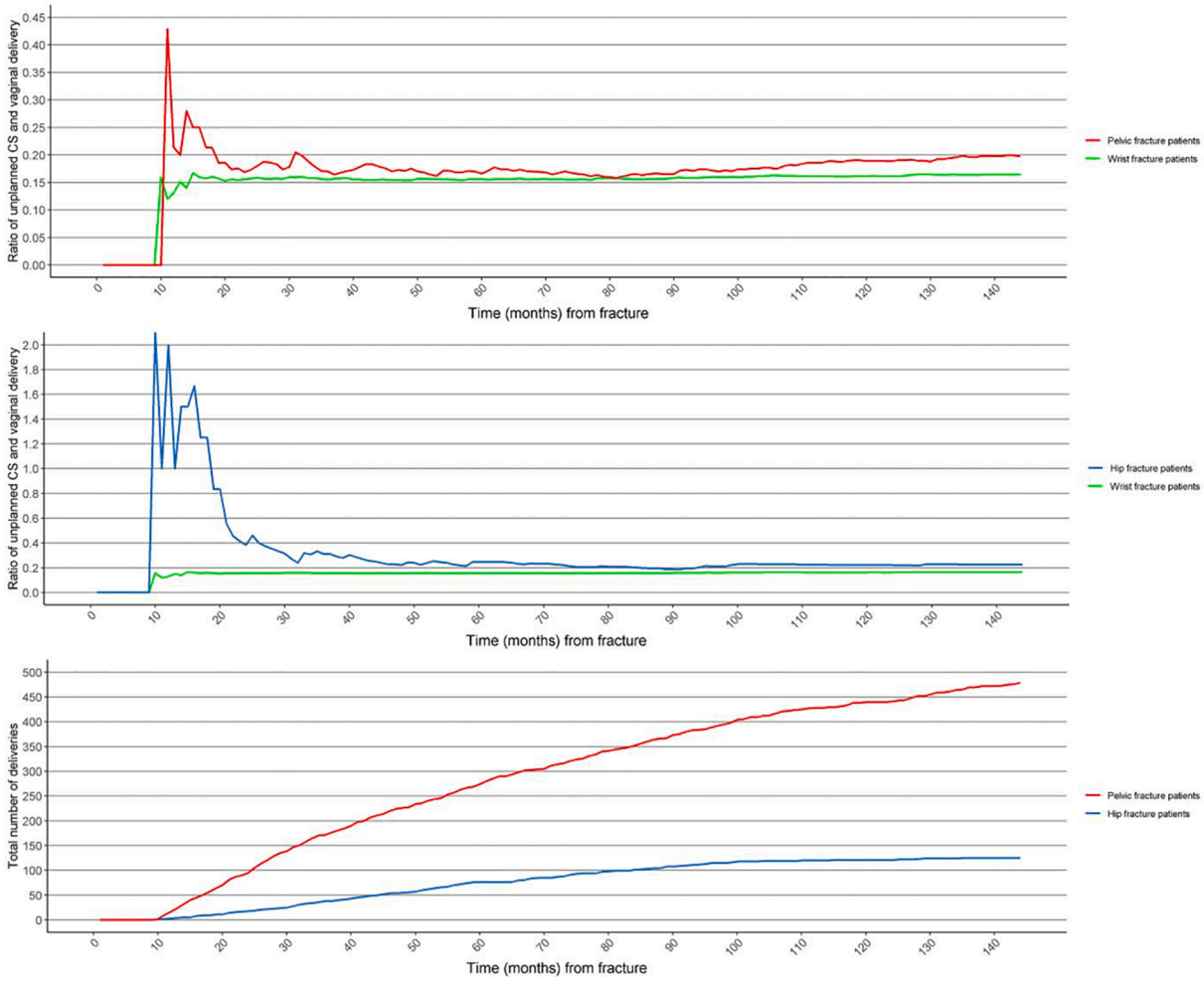


**Fig. 4.** Monthly ratio between unplanned cesarean section (CS) and successful vaginal delivery (number of unplanned CS as numerator and successful vaginal deliveries as denominator). Pelvic and hip fracture patients were compared to wrist fracture patients.

study in 2019 found out that after THR, trial of labor ended up more likely to an emergency CS [11]. However, as the exact reason behind unplanned CS stays unknown based on our data, and the number of patients giving birth after hip fractures is relatively low, further research could be made on this topic.

The strength of our study is the large nationwide study population with a long study period, enabling the proper analysis of such rare events. The register data used in our study are routinely collected using structured forms with nationwide instructions, which ensures the good coverage and reduces possible reporting and selection bias [28]. Therefore, the coverage and validity of both registers included in this study are high [12,14]. The advantage of our study compared to previous studies is the large national research material in a country with uniform delivery-related guidelines and attitudes.

The main limitation of our study is the missing clinical data on injuries (i.e., radiological findings). As this information is not recorded to the registers, we could only use ICD-10 coding. In addition, the number of patients, especially in the hip fracture group is relatively small and therefore, these findings should be further researched in the future using larger registers. Furthermore, since cases of CS were classified as elective or urgent prior to 2004, we have used the same classifications in the present study instead of the elective, urgent and emergency classifications. Also, the indications behind CS are not registered in the MBR, which means that the indications for elective CS, such as had the patient planned an elective CS or attempted vaginal delivery before unplanned CS, remain unknown.

## Conclusions

The results of this study advocate that vaginal delivery is generally possible rather quickly after hip or pelvic fracture, but the possibility should always be evaluated by the gynecologist. Unplanned CS after hip fractures was more common at the beginning, but the exact reason for this remains unknown and further research should be made on this topic.

## 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.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejogrb.2022.08.013.

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