Heliyon 10 (2024) e27240

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Sub-acute pain after childbirth during COVID-19 pandemic: A secondary analysis of A prospective clinical trial

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A B S T R A C T

Background: COVID-19 pandemic could bring great impact upon the psychological statuses of post-partum women, but no clear evidence was provided yet as to COVID-19 would also affect their pain profile during post-partum period. We determined if pain and psychological vulnerabilities, obstetric factors, and labor analgesia were associated with sub-acute pain after childbirth (SAPC; ongoing pain related to delivery at post-partum 4 weeks or more) during COVID-19 pandemic.

Methods: We included women having a singleton pregnancy of ≥36 gestational weeks. The recruited women were given pre-delivery questionnaires to measure their pain and psychological vulnerabilities. At post-partum 6–10 weeks, an online survey was conducted to collect data on post-partum pain information.

Results: Of the 880 recruited women, 816 completed the post-partum pain survey, with 99 (12.1%) having developed SAPC. Giving birth during COVID-19 pandemic (adjusted odds ratio (aOR) 1.64, 95%CI 1.04 to 2.57), greater pre-delivery central sensitization (aOR 1.02, 95%CI 1.00 to 1.04), greater number of pain relief administered (aOR 1.49, 95%CI 1.18 to 1.89), having had artificial rupture of membrane and oxytocic during labor onset (aOR 3.00, 95%CI 1.66 to 5.40), greater volume of blood loss during delivery (every 100 ml; aOR 1.27, 95%CI 1.11 to 1.44), having had third-degree tear during delivery (aOR 4.40, 95%CI 1.33 to 14.51), and greater infant height (aOR 1.14, 95%CI 1.01 to 1.30) were independently associated with greater risk of SAPC. Having greater general health score was protective against the risk of SAPC (aOR 0.99, 95% CI 0.97 to 0.999) (Area under the curve (AUC) = 0.74).

Conclusions: The generated multivariable association model may help us better understand the shift in pain and psychological aspects of women during COVID-19 pandemic.

1. Introduction

The widespread outbreak of coronavirus disease 2019 (COVID-19) has caught the world unprepared and has led to more than 770 million cases and close to 7 million deaths [1]. The first COVID-19 case in Singapore was reported on Jan 23, 2020, after which a two-months lockdown was implemented from 7 Apr to Jun 1, 2020. Since then, a multi-phased approach was adopted to suppress the number of COVID-19 cases in Singapore [2]; social and economic activities were carefully managed in response of the different SARS-CoV-2 variants, including limited masked-off activities (exercise, dining in, gatherings, entertainment facilities), contact tracing, mask-wearing and social distancing, quarantine, tightened border measures, remote working/studying from home. On Feb 12, 2023, Singapore declared to have entered an endemic phase with most of the restrictions lifted.

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https://doi.org/10.1016/j.heliyon.2024.e27240
Received 20 December 2023; Received in revised form 16 February 2024; Accepted 27 February 2024
Available online 29 February 2024

During the pandemic period, deployment of containment measures would also imply restrictions in major life activities especially within healthcare premises, e.g., delayed/postponed surgery/consultation, limited hospital visits, pre-procedural COVID-19 examination etc. This was especially difficult for a pregnant woman, who was often left alone in delivery wards during this vulnerable period. On top of the adverse effects brought upon COVID-19-infected patients, the virus has also imposed deleterious effects on human general health. Xiong et al. reported higher rates of psychological symptoms (anxiety, depression, post-traumatic stress) in general population during COVID-19 pandemic [3]. The COVID-19 lockdown restrictions have also led to an increase in perceived pain intensity, anxiety, and depressive symptoms in chronic pain patients even in the absence of COVID-19 infection [4]. Similarly, COVID-19 led cancellation of scheduled surgery could significantly increase the pain scores and the subsequent analgesic use especially in female patients [5]. However, it is currently unknown whether catastrophic events, COVID-19 pandemic in this case, would cause an increased pain for the pregnant population especially after giving birth.

Sub-acute pain after childbirth (SAPC), as defined as ongoing pain related to delivery at post-partum 4 weeks or more, is crucial for acute-to-persistent pain transition as it may lead to compromised functional activities and quality of life. There is recent evidence that pain (e.g., inadequate labor analgesia, severe acute post-partum pain), psychological (e.g., anxiety, stress), and obstetric factors (e.g., position of fetal head, blood loss during delivery etc.) could contribute to the development of SAPC [6–8]. As mentioned earlier, previous studies demonstrated that COVID-19 pandemic could bring great impact upon the psychological statuses of post-partum women [3,4], but no clear evidence has been provided on whether COVID-19 will also affect their pain profile during post-partum period. In this secondary analysis of a prospective clinical trial, we hypothesized that giving birth during COVID-19 pandemic would have greater incidence of SAPC as compared with the incidence before COVID-19 pandemic. We also evaluated the pain and psychological vulnerabilities, obstetric factors, labor analgesia and their association with SAPC during COVID-19 pandemic.

2. Methods

2.1. Ethics

This study is a secondary analysis of a larger clinical trial investigating the association between the use of labor epidural analgesia and post-partum depression at post-partum 6–10 weeks (primary study), conducted between June 2017 and July 2021 at kK Women's and Children's Hospital, Singapore [9]. The primary study and the secondary analysis were approved by the SingHealth Centralized Institutional Review Board (reference number 2017/2090; approved on March 25, 2017) and registered on Clinicaltrials.gov (NCT03167905; registration date May 30, 2017). Written informed consent were obtained from all participants on the primary study, and patients were notified on the further analysis of their data in the consent document. This secondary analysis was conducted in accordance with the Declaration of Helsinki and adheres to the applicable Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

2.2. Recruitment

Patients from antenatal clinics, wards or the delivery suites were invited to participate in the study, with written informed consent obtained before any study procedure was conducted. We included nulliparous or multiparous pregnant women who were of age 21 years old and above, with an American Society of Anesthesiologists (ASA) physical status II and a single fetus for $\geq$36 gestational weeks. Patients were excluded if they had multiple pregnancies, non-cephalic fetal presentations, uncontrolled obstetric/medical complications (e.g. pre-eclampsia, premature rupture of membrane (PROM) for more than 48 h, gestational diabetes on insulin, pregnancy-induced hypertension on medication), or an elective cesarean delivery. As the study involved the use of validated instruments in English language, those who could not read nor understand English were also excluded from the study.

2.3. Data collection

Upon informed consent, patients would fill in a set of questionnaires before their delivery, which comprised questions on labor pain and psychological vulnerability that were validated and used in Singaporean pregnant women [10,11], including the following.

1. Edinburgh Postnatal Depression Scale (EPDS): A self-reporting scale consisting of 10 items of antenatal and postnatal depression with a score ranging from 0 to 30 [12]. The EPDS is shown to be moderately correlated with Beck's Depression Inventory (Spearman correlation = 0.78, $P < 0.001$). It has been validated in the antenatal and postnatal population of Singapore with a sensitivity of 81.8% and specificity of 67.4% using a cut-off score of 9/10 [13]. In this study, a cut-off of 10 was used to identify probable post-partum depression [14];
2. Pain Catastrophizing Scale (PCS): A self-reporting scale to evaluate negative thought processes that may occur when experiencing actual or perceived pain, and/or exposure to painful experiences, with subscales on helplessness, magnification, and rumination [15]. The PCS has been shown to have excellent internal consistency, with a coefficient alpha of 0.87[15];
3. Central Sensitization Inventory (CSI): A psychometric instrument that identifies key somatic and emotional complaints associated with pain hypersensitivity/expansion and/or prolonged pain once the stimulus is removed [16];
4. Fear-Avoidance Components Scale (FACS): A patient-reported measure designed to evaluate pain-related fear avoidance in patients with painful medical conditions [17]. It has been shown to have high internal consistency with a Cronbach's alpha of 0.92 [17];

5. State Trait Anxiety Inventory (STAI): A 40-item self-report scale that assesses situational anxiety (STAI-State) and dispositional anxiety (STAI-Trait) [18]. The use of STAI has been validated in women during late pregnancy and post-partum period [19];
6. Perceived Stress Scale (PSS): A 10-item instrument to measure an individual's perception of stress, as well as the degree to which situations in an individual's life are seen as stressful [20];
7. Angle Labor Pain Questionnaire (A-LPQ): A condition-specific, multidimensional psychometric instrument used to assess women's pain experiences during labor and delivery process of childbirth [21];
8. EuroQol five-dimensional-three-level (EQ-5D-3L): A widely used instrument to measure health-related quality of life [22].

Baseline patient demographics (age, ethnicity, marital status, personal history of mental illness, etc.), obstetric (durations of stage of labor, mode of labor onset, mode of delivery, etc.) and neonatal characteristics (height, weight, apgar scores) were collected accordingly. In the primary study, patients might request for pain relief (epidural, Entonox, pethidine, remifentanil) upon experiencing labor pain, and the number of pain relief administered implying the number of pain relief being given to the patients were also documented. An online survey was conducted subsequently at post-partum 6–10 weeks to collect data on post-partum pain (SAPC, pain scores). To avoid attribution bias and minimize the loss to follow-up, the study team also sent regular reminders to the patients' mobile

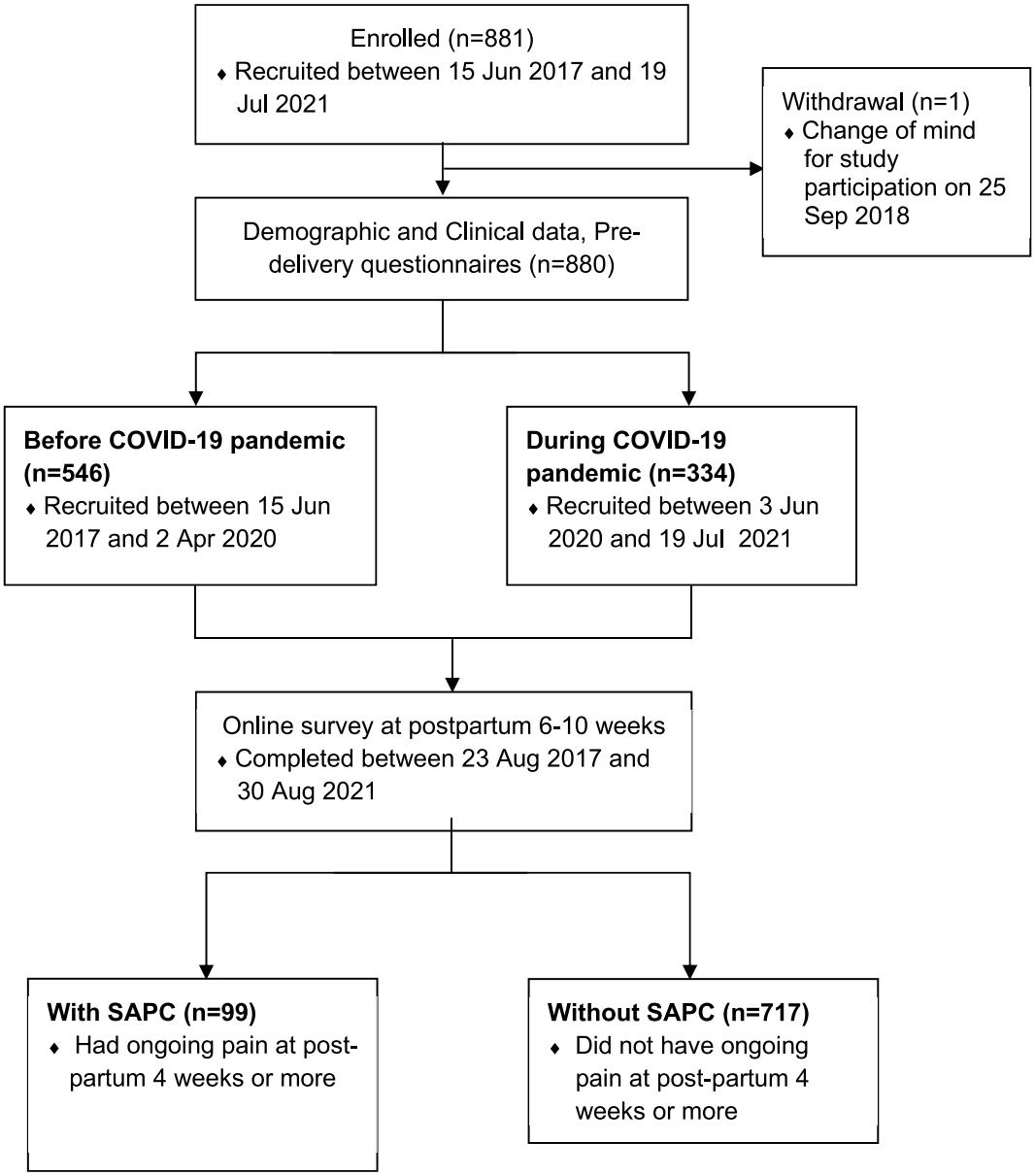

Fig. 1. Study flow diagram.

number to encourage uptake of the online survey. Questionnaires taken from all time points with missing data or doubts would be followed up with patients for further clarification to minimize measurement bias.

2.4. Statistical analyses

Demographic, pre-delivery pain and psychological vulnerabilities, analgesic, obstetric and neonatal characteristics were summarized based on exposures i.e. the two periods when patients were admitted for delivery: those recruited between Jun 15, 2017 and Apr 2, 2020 (before COVID-19 pandemic or non-exposed), and those recruited between Jun 3, 2020 and Jul 19, 2021 (during COVID-19 pandemic or exposed). All continuous and categorical variables were summarized as mean (standard deviation (SD)) or median (interquartile range (IQR)), whichever appropriate and frequency (percentages) respectively. Chi-square and two sample independent tests or Mann-Whitney U – test, whichever appropriate, were used for categorical and continuous variables respectively to compare the difference between two periods.

The primary objective of the study was to determine whether there was a difference in incidence of SAPC before and during COVID-19 pandemic. The outcome of SAPC was defined as binary data with categories '*SAPC present*' or '*SAPC absent*' at post-partum 6–10 weeks. At this time point patients were asked whether they had had ongoing pain at post-partum 4 weeks or more (no/yes) and whether they had current pain relating to their delivery (no/yes). Answering 'yes' to either of these two questions would be considered

Table 1
Demographic characteristics.

Variable	During COVID-19 pandemic (n = 334)	Before COVID-19 pandemic (n = 546)	P-value
Age (years), mean (SD)	30.9 (3.88)	31.0 (4.07)	0.6639
Ethnicity, n (%)			0.0843
Chinese	190 (58.1)	277 (51.0)	–
Malay	76 (23.2)	166 (30.6)	–
Indian	19 (5.8)	38 (7.0)	–
Others	42 (12.8)	62 (11.4)	–
Marital status, n (%)			0.1021
Single	10 (3.1)	8 (1.5)	–
Married	311 (96.0)	530 (98.0)	–
Divorced/separated	1 (0.3)	3 (0.6)	–
Others	2 (0.6)	0	–
Occupation, n (%)			0.0030
Homemaker/unemployed	42 (13.3)	97 (18.8)	–
Self-employed	17 (5.4)	17 (3.3)	–
Professional	138 (43.8)	178 (34.5)	–
Service/sales	25 (7.9)	64 (12.4)	–
Management	25 (7.9)	26 (5.0)	–
Others	68 (21.6)	134 (26.0)	–
Highest education, n (%)			<0.0001
Primary or below	1 (0.3)	7 (1.4)	–
Secondary/high school	33 (10.6)	113 (22.2)	–
University/polytechnic	217 (70.0)	330 (64.8)	–
Post-graduate	59 (19.0)	59 (11.6)	–
Number of biological children before this pregnancy, n (%)	0.3 (0.7)	0.6 (0.9)	<0.0001
Age at first menstrual period (years), mean (SD)	13.0 (2.9)	12.8 (2.2)	0.2722
Mood changes during menstrual period, n (%)			0.6356
Always	51 (16.2)	66 (13.1)	–
Sometimes	177 (56.4)	291 (57.7)	–
Rarely	67 (21.3)	112 (22.2)	–
Never	19 (6.1)	35 (6.9)	–
Cramps during menstrual period, n (%)			0.4579
Always	82 (26.1)	144 (28.5)	–
Sometimes	127 (40.4)	194 (38.4)	–
Rarely	84 (26.8)	121 (24.0)	–
Never	21 (6.7)	46 (9.1)	–
Diarrhea during menstrual period, n (%)			0.7875
Always	18 (5.7)	26 (5.1)	–
Sometimes	84 (26.8)	121 (24.0)	–
Rarely	83 (26.4)	142 (28.1)	–
Never	129 (41.1)	216 (42.8)	–
Previous peri-partum depression, n (%)	0	4 (0.8)	0.1141
Personal history, n (%)			
Depression	8 (2.4)	13 (2.4)	0.9893
Other mood disorder	0	1 (0.2)	0.4339
Others	1 (0.3)	0	0.1857

Before COVID-19 pandemic is defined as the recruitment period that falls between Jun 15, 2017 and Apr 2, 2020; whereas during COVID-19 pandemic is the recruitment period lying between Jun 3, 2020 and Jul 19, 2021.
P values are based on two sample independent T-test and Chi-square test respectively for continuous and categorical variables respectively.

as "SAPC present'.

Univariate and multivariable logistic regression models were used to find associated factors for the development of SAPC. Quantitative association from logistic regression analysis were expressed as odds ratios (OR) with 95% confidence intervals (95% CI). Stepwise variable selection method was used to finalize the multivariable model after incorporating clinically relevant variables with p-value <0.10 in univariate logistic regression analyses. Area under the curve (AUC) from the receiver operating characteristic curve was also reported. All statistical tests were two-sided with statistical significance levels set at 5%. Analyses were performed using SAS version 9.4 (SAS Institute; Cary, North Carolina, USA).

3. Results

3.1. Study recruitment and demographics based on before/during COVID-19 pandemic

All patients from the primary study (n = 881) were included for this secondary analysis, with one patient withdrawn from the study due to a change of mind for study participation (Fig. 1). Among the 880 patients, 546 (62.0%) and 334 (37.9%) patients were from before and during COVID-19 pandemic. There was no significant difference in demographic characteristics before and during COVID-19 pandemic except education, occupation, and number of biological children before this pregnancy (Table 1).

3.2. Psychological, analgesic, obstetric, and neonatal characteristics based on before/during COVID-19 pandemic

The associations of the two periods (before and during COVID-19 pandemic) and pre-delivery psychological measures are shown in Table 2. None of the pre-delivery psychological measures were significantly different between before and during COVID-19 pandemic. The mean (SD) A-LPQ total score was higher during COVID-19 pandemic (130.2 (49.3)) as compared with before COVID-19 pandemic (126.1 (49.9)) but failed to reach statistical significance (p = 0.2493). Interestingly, mean (SD) A-LPQ subscale of fear/anxiety was significantly higher during COVID-19 pandemic (24.1 (10.3)) as compared with before COVID-19 pandemic (21.9 (11.2)) (p = 0.0052).

Association of patients' analgesic, obstetric, and neonatal characteristics with the two periods were shown in Table 3. The gravida, having received epidural as labor analgesia, having had artificial rupture of membrane (ARM) and oxytocic or induction during labor onset, the duration of second stage of labor without post-partum obstetric complications, and having had emergency/crash lower segment cesarean section (LSCS) were significantly different between before and during COVID-19 pandemic. A total of 816 patients (92.6%) responded to the online survey at post-partum 6–10 weeks. The overall incidence of SAPC in this cohort was 12.1% (95%CI 10.0%–14.6%), with a higher incidence of 15.8% (95%CI 11.9%–20.2%) among the cohort during COVID-19 pandemic as compared with those patients giving birth before COVID-19 pandemic (9.8%, 95%CI 7.3%–12.8%) (p = 0.0111). The information on pain scores and pain descriptors of those with SAPC at post-partum 6–10 weeks is listed in Appendix 1.

Table 2
Pain and psychological vulnerabilities.

Pre-delivery Variable	During COVID-19 pandemic (n = 334)	Before COVID-19 pandemic (n = 546)	P-value
EPDS (0–30)	7.3 (4.3)	7.9 (4.3)	0.0788
EPDS ≥10, n (%)	90 (27.7)	168 (31.5)	0.2426
PCS Helplessness (0–24)	7.6 (5.3)	7.5 (5.3)	0.7313
PCS Magnification (0–12)	4.2 (2.8)	4.0 (2.8)	0.3464
PCS Rumination (0–16)	7.1 (4.5)	7.1 (4.3)	0.9827
PCS Total score (0–52)	18.9 (11.5)	18.6 (11.4)	0.7360
CSI (0–100)	53.9 (12.7)	52.9 (12.4)	0.2762
FACS Activity avoidance (0–45)	21.2 (10.0)	21.4 (9.7)	0.7397
FACS Pain related anxiety (0–40)	13.3 (8.7)	13.1 (8.0)	0.7883
FACS Victimization (0–15)	3.3 (3.1)	3.6 (3.1)	0.1312
FACS Total score (0–100)	37.4 (19.0)	38.1 (17.8)	0.5878
STAI State anxiety (20–80)	39.3 (10.7)	39.6 (11.6)	0.6469
STAI Trait anxiety (20–80)	38.3 (9.6)	38.6 (9.2)	0.6000
STAI Total score (40–160)	77.5 (18.8)	78.3 (19.2)	0.5963
PSS Total Score (0–40)	15.7 (6.3)	16.5 (5.9)	0.0602
A-LPQ Uterine contraction pain (0–40)	26.4 (9.6)	25.3 (10.9)	0.1274
A-LPQ Fear/anxiety (0–40)	24.1 (10.3)	21.9 (11.2)	0.0052
A-LPQ Back Pain/long haul (0–50)	31.0 (14.5)	29.6 (14.2)	0.1772
A-LPQ Birthing pain (0–40)	20.9 (13.8)	21.9 (13.2)	0.2649
A-LPQ The enormity of the pain (0–50)	28.5 (15.5)	26.8 (15.5)	0.1429
A-LPQ Total Score (0–220)	130.2 (49.3)	126.1 (49.9)	0.2493
EQ-5D-3L VAS (0–100)	74.8 (15.9)	73.0 (17.1)	0.1324

Data are all expressed as mean (SD).
Before COVID-19 pandemic is defined as the recruitment period that falls between Jun 15, 2017 and Apr 2, 2020; whereas during COVID-19 pandemic is the recruitment period lying between Jun 3, 2020 and Jul 19, 2021.
P values are based on two sample independent T-test and Chi-square test respectively for continuous and categorical variables respectively.

Table 3
Analgesic, obstetric, and neonatal characteristics.

	During COVID-19 pandemic (n = 334)	Before COVID-19 pandemic (n = 546)	P-value
Gravida, mean (SD)	1.7 (1.0)	2.0 (1.3)	0.0003
Gestation (weeks), mean (SD)	39.1 (0.9)	39.1 (1.1)	0.9420
Analgesia received, n (%)			
Epidural	288 (89.7)	417 (80.3)	0.0003
Entonox	200 (62.3)	356 (68.6)	0.0612
Pethidine	64 (19.9)	89 (17.1)	0.3088
Remifentanil	2 (0.6)	7 (1.3)	0.3209
Number of pain relief requests, mean (SD)	1.7 (0.9)	1.8 (0.9)	0.6515
Number of pain relief administered, mean (SD)	1.7 (0.9)	1.8 (0.9)	0.6723
Mode of labor onset, n (%)			
Spontaneous	5 (1.5)	17 (3.1)	0.1361
Cesarean, not in labor	1 (0.3)	1 (0.2)	0.7253
ARM without oxytocic	4 (1.2)	12 (2.2)	0.2812
Oxytocic without ARM	6 (1.8)	9 (1.6)	0.8692
ARM and oxytocic	47 (14.1)	47 (8.6)	0.0109
Spontaneous and oxytocic	2 (0.6)	4 (0.7)	0.8149
Prostin induction	95 (28.4)	290 (53.1)	<0.0001
Emergency/crash LSCS	33 (9.9)	51 (9.3)	0.7915
Others	192 (57.5)	180 (33.0)	<0.0001
Duration of second stage of labor (mins), mean (SD)	75.1 (61.4)	59.1 (58.8)	0.0010
Volume of blood loss during delivery (ml), mean (SD)	278.8 (128.1)	277.9 (160.1)	0.9294
Third degree tear, n (%)	5 (1.5)	10 (1.8)	0.7074
Mode of delivery, n (%)			0.7055
Vaginal delivery	208 (62.3)	356 (65.2)	–
Instrumental delivery	45 (13.5)	64 (11.7)	–
Emergency/crash LSCS	81 (24.3)	126 (23.1)	–
Position of fetal head, n (%)			0.8975
OA	242 (72.7)	404 (74.3)	–
OP	9 (2.7)	12 (2.2)	–
Other cephalic (e.g., face)	80 (24.0)	126 (23.2)	–
Others (e.g., breech)	2 (0.6)	2 (0.4)	–
Infant weight (g), mean (SD)	3204.6 (355.6)	3184.5 (372.0)	0.4240
Infant height (cm), mean (SD)	49.3 (1.8)	49.1 (1.9)	0.2072
Infant head circumference (cm), mean (SD)	33.9 (1.2)	33.9 (1.3)	0.9224
Apgar 1' (0–10), median (IQR)	9.0 (0.0)	9.0 (0.0)	0.1525
Apgar 5' (0–10), median (IQR)	9.0 (0.0)	9.0 (0.0)	0.9216
Infant resuscitation, n (%)	144 (43.2)	210 (38.9)	0.2110
Post-partum obstetric complications, n (%)			
None	285 (87.7)	429 (80.0)	0.0038
Prolonged labor	19 (5.7)	44 (8.1)	0.1857
Emergency/crash LSCS	10 (3.0)	69 (12.6)	<0.0001
Failed anesthesia for LSCS	1 (0.3)	0	–
Post-partum hemorrhage	2 (0.6)	3 (0.5)	0.2008
Others	14 (4.2)	10 (1.8)	0.9247
Incidence of SAPC, n (%)	50 (15.8)	49 (9.8)	0.0111

Data are all expressed as mean (SD).
Before COVID-19 pandemic is defined as the recruitment period that falls between Jun 15, 2017 and Apr 2, 2020; whereas during COVID-19 pandemic is the recruitment period lying between Jun 3, 2020 and Jul 19, 2021.
P values are based on two sample independent T-test and Chi-square test for continuous and categorical variables respectively.

3.3. Univariate and multivariable logistic regression based on SAPC outcomes

Univariate and multivariable logistic regression model to find the associated factors of SAPC are shown in Table 4. Incidence of SAPC were significantly higher in during COVID-19 pandemic with OR of 1.72 (95%CI 1.13 to 2.62, p = 0.0118). Univariate logistic regression analyses showed that higher value of pre-delivery factors including CSI, FACS subscale on activity avoidance, A-LPQ subscale on fear/anxiety, A-LPQ subscale on back pain/long haul, A-LPQ subscale on the enormity of the pain, A-LPQ total score and lower EQ-5D-3L VAS score were increasingly associated with incidence of SAPC. It also showed that greater number of pain relief requests and pain relief administered, greater volume of blood loss during delivery and having had third-degree tear during delivery were associated with greater incidence of SAPC. Having received epidural and pethidine as labor analgesia, and having had ARM and oxytocic during labor onset were significantly associated with higher incidence of SAPC. Infants with greater birth height was also positively associated with incidence of SAPC.

Multivariable model showed that giving birth during COVID-19 pandemic, greater pre-delivery CSI score, greater number of pain relief administered, having had ARM and oxytocic during labor onset, greater volume of blood loss during delivery, having had third-degree tear during delivery, and greater infant height were independently associated with increased odds of developing SAPC. Having greater general health score was protective against the risk of SAPC. The area under the curve (AUC) for the multivariable model was

Table 4
Univariate and multivariable logistic regression model for SAPC.

Variables	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Period (During COVID-19 pandemic versus Before COVID-19 pandemic)	1.72 (1.13–2.62)	0.0118	1.64 (1.04–2.57)	0.0330
Ethnicity (Ref: Chinese)		0.0594+	–	–
Malay	1.50 (0.60–3.76)	0.3857	–	–
Indian	1.90 (1.18–3.06)	0.0083	–	–
Others	1.65 (0.86–3.16)	0.1338	–	–
Diarrhea during menstrual period (Rarely/Never versus Always/Sometimes)	0.56 (0.36–0.87)	0.0096	–	–
Pre-delivery CSI	1.03 (1.01–1.04)	0.0018	1.02 (1.00–1.04)	0.0154
Pre-delivery FACS Activity avoidance	1.03 (1.01–1.05)	0.0072	–	–
Pre-delivery FACS Total score	1.01 (1.00–1.02)	0.0455	–	–
Pre-delivery A-LPQ Uterine contraction pain	1.02 (1.00–1.05)	0.0534	–	–
Pre-delivery A-LPQ Fear/anxiety	1.02 (1.00–1.05)	0.0308	–	–
Pre-delivery A-LPQ Back Pain/long haul	1.02 (1.00–1.04)	0.0141	–	–
Pre-delivery A-LPQ The enormity of the pain	1.02 (1.00–1.03)	0.0225	–	–
Pre-delivery A-LPQ Total Score	1.01 (1.00–1.01)	0.0166	–	–
Pre-delivery EQ-5D-3L VAS	0.98 (0.97–0.99)	0.0006	0.99 (0.97–0.999)	0.0396
Analgesia received: Epidural	2.67 (1.21–5.91)	0.0154	–	–
Analgesia received: Pethidine	1.99 (1.22–3.24)	0.0059	–	–
Number of pain relief requests	1.47 (1.18–1.83)	0.0007	–	–
Number of pain relief administered	1.47 (1.18–1.84)	0.0006	1.49 (1.18–1.89)	0.0008
Mode of Labor Onset: ARM and oxytocic	2.34 (1.35–4.05)	0.0024	3.00 (1.66–5.40)	0.0003
Mode of Labor Onset: Prostin induction	0.40 (0.25–0.64)	0.0002	–	–
Mode of Labor Onset: Others	1.93 (1.26–2.95)	0.0024	–	–
Volume of blood loss during delivery every 100 ml	1.29 (1.14–1.45)	<0.0001	1.27 (1.11–1.44)	0.001
Third-degree tear during delivery	4.18 (1.37–12.73)	0.0119	4.40 (1.33–14.51)	0.015
Mode of Delivery (Ref: Vaginal delivery)		0.0046+	–	–
Instrumental	2.29 (1.28–4.08)	0.0051	–	–
Emergency/crash LSCS	1.85 (1.14–3.01)	0.0134	–	–
Position of fetal head (Ref: OA)		0.0217+	–	–
OP	2.86 (1.01–8.14)	0.0486	–	–
Others	1.69 (1.06–2.68)	0.0279	–	–
Infant height	1.17 (1.05–1.31)	0.005	1.14 (1.01–1.30)	0.0349
Infant weight	1.001 (1.000–1.001)	0.0203	–	–
Infant resuscitation	1.45 (0.95–2.20)	0.0876	–	–
Post-partum obstetric complications: Prolonged labor	2.01 (1.03–3.95)	0.0419	–	–

Before COVID-19 pandemic is defined as the recruitment period that falls between Jun 15, 2017 and Apr 2, 2020; whereas during COVID-19 pandemic is the recruitment period lying between Jun 3, 2020 and Jul 19, 2021. + refers to type 3 or overall p value.

0.74 (95% CI 0.69 to 0.80).

4. Discussion

In this study, we investigated how the two different periods (before and during COVID-19 pandemic) would affect the evolution of SAPC, and showed that giving birth during COVID-19 pandemic, greater pre-delivery central sensitization, greater number of pain relief administered, having had ARM and oxytocic during labor onset, greater volume of blood loss during delivery, having had third-degree tear during delivery, and greater infant height were independently associated with greater risk of SAPC. Conversely, having greater general health score was protective against the risk of SAPC.

Our current data demonstrated a 12.1% overall incidence of SAPC, which is similar to our previous published study [6]. Due to the scarcity of evidence on SAPC, we set to understand how different association factors could impact post-partum women especially given the current situation of COVID-19 pandemic. Our findings revealed that those who gave birth during COVID-19 pandemic (June 2020 to July 2021) had increased odds of SAPC as compare with the period before the COVID-19 lockdown in Apr 2020. As compared with other countries, Singapore has a relatively low rate of COVID-19 infection [23]; thus, this allows us to focus on the aspects of mental health arising from COVID-19 related restrictions without being confounded by the physical health issues due to the disease. For instance, a recently published study reported an increased rate of gestational hypertensions and chorioamnionitis in pregnant women who delivered during the lockdown period, albeit the birth rate of very-pre-term and very-low-birth weight infants was lower as compared with the period before COVID-19 pandemic [24]. Having a greater general health score (i.e., better general health) contributes to the reduced risk of SAPC development in our study, yet we found no significant difference in general health before and during COVID-19 pandemic.

On the other hand, the COVID-19 preventive measures have significantly impacted the mental health in pregnant women, manifesting in heightened stress and anxiety, of which were shown to be independent predictors of SAPC in patients receiving epidural analgesia [6]. A Denmark study investigating pregnant women's opinions during lockdown period revealed that the majority of the women were isolated at home most of the time, with many worrying about the risk of acquiring the infection and access to prenatal care amidst the overwhelmed healthcare systems and border closure [25]. It is also likely that pregnant women were adversely affected by information relating to COVID-19 leading to development of psychological vulnerabilities, which may be further amplified by the

frequent exposure to social media especially misinformation and fake news [26]. Nevertheless, the investigated psychological vulnerabilities (anxiety, stress, depression) were not found to be independently associated with SAPC nor COVID-19 period, suggesting that other possible psychological factors (e.g., trauma, resilience, emotional exhaustion etc.), together with the limited medical access, could mediate the development of SAPC during COVID-19 pandemic [27–29].

The term central sensitization is a pathophysiologic process that involves the central amplification of pain with symptoms including hyperalgesia, allodynia, expanded pain distribution, and prolonged pain following removal of the stimulus [16]. It is postulated that the relationship between central sensitization and the co-morbidity of pain and depression is mediated by abnormal hypothalamo-pituitary-adrenal axis and monoamine activities [30,31]. Recent study further demonstrated that Spanish patients with central sensitization pain syndromes could be at greater risk of acquiring psychological vulnerabilities (depression, anxiety, stress) during the COVID-19 lockdown, however there was no baseline data before COVID-19 pandemic to make further comparison [32]. In pregnant population, a positive association between central sensitization and the development of sub-acute pain was reported after cesarean delivery [33]. As far as we know, this is the first report on the pre-delivery central sensitization in patients after undergoing labor and delivery process. Nevertheless, our findings showed no significant difference in central sensitization between the two periods (before and during COVID-19 pandemic), suggesting that further research are required to confirm the role of sensitization during COVID-19 pandemic.

An earlier study has suggested that the development of SAPC could be linked to multiple analgesic factors (use of meperidine prior to neuraxial procedure, mean procedural time and attempts, presence of breakthrough pain), however these factors are largely limited to that relating to labor epidural analgesia [6]. Here we reported the findings that increased number of pain relief administered was independently associated with greater risk of SAPC. Inadequate labor pain control is recognized as a cause of development of acute postpartum pain [34], which in turn predicts the persistent pain after childbirth [8]. We did not investigate whether poor birthing experience or satisfaction as attributed to labor pain is involved in SAPC development. However, but it is undeniable that tissue trauma plays a vital role in SAPC development, considering the significant associations observed in infant height, greater volume of blood loss and having had a third-degree tear during delivery and the risk of SAPC. These again highlight the emphasis of early identification of pregnant women who are at risk of such tissue trauma to improve the perinatal pain management.

The strength of the study lies in the high response rate (>90%) of our study, which could be attributed to the generally young, highly educated (>80% with a university degree and above) patients recruited. It is likely that these mothers are tech-savvy and open to the use of mobile phone for various tasks including survey participation [35]. Given the fact that mothers are generally given 12–16 weeks of maternity leave in Singapore, administering the online survey at post-partum 6–10 weeks would allow them to have the flexibility to provide survey responses at any time while caring for their newborns at home [36]. To our knowledge, this is the first study that reports a positive association with SAPC during COVID-19 pandemic. The prospective study design in the primary study to collect longitudinal data contributes to the limited available evidence on the important factors that govern the development of SAPC. The recent research in chronic pain populations has shown that psychological, social, and clinical factors could all contribute to increased risk of pain and other adverse outcomes during COVID-19 pandemic, and our present findings again confirm these associations in the context of SAPC in post-partum women [37]. Nevertheless, interventions to target these factors to reduce incidence of SAPC may be challenging to be applied in the perinatal settings. For instance, greater central sensitization may be addressed via pharmacological treatment aiming at specific peripheral pain generators or neuromodulators (e.g., gabapentin, pregabalin, nortriptyline), but these drugs are generally not recommended in pregnant population due to the potential harm to the fetus [38]. Non-pharmacological treatments such as cognitive behavioral therapy (CBT), massage, acupuncture etc. may improve central sensitization and general health, but these methods often require significant time and commitment to learn or implement, which will be difficult for both the pregnant and post-partum women while simultaneously caring for their own health and fetus/infant. Nonetheless, positive advancements in telehealth CBT have emerged as alternative to provide real-time and interactive psychological interventions especially during COVID-19 pandemic [39], with future studies warranted to confirm its effectiveness, acceptance, and cost-effectiveness in improving central sensitization.

Notably, there are several limitations in this study. Firstly, the study population was recruited from a population mainly comprising individuals of Chinese ethnicity. As a result, more than 50% of the study cohort was Chinese. In addition, the pre-delivery surveys were administered in English language during the labor process, and hence it is likely that important data was missed from non-English speaking or elective cesarean participants. Secondly, the COVID-19 lockdown protocols implemented in Singapore had halted the patient recruitment on 7 Apr to Jun 1, 2020. Those who had given birth during the two-months lockdown may represent a population not adequately captured in our sample, yet this cohort may have the most prominent levels of pain and psychological vulnerabilities given the stressful situations. The multiple phases of reopening in Singapore with different restrictions and protocols might also impact an individual's ability to cope with their pain and psychological state, which consequently influence their pain perception. Additionally, the pre-existing dataset did not capture the COVID-19 infection status of the patients during COVID-19 pandemic. A previous study has shown that the neurotropism exhibited by the SARS-CoV2 virus could result in neuropathic pain or exacerbation of pre-existing neuropathic pain [40]. Without the data on the COVID-19 infection status, it is difficult to assess if COVID-19 infection would have an impact on the patients' pain status. Lastly, this study was a secondary analysis of a pre-existing dataset and therefore no sample size was calculated, nor powered a priori as post-hoc power calculation is usually discouraged [41,42]. On the contrary, it is essential to interpret the current findings in light of the confidence interval of the associated factors, recognizing them as the potential spectrum for the plausible true effect.

We understand that this pandemic was unsurprisingly heterogeneous with respect to approaches of different countries to controlling the impact of COVID-19. This would limit the generalizability of the study to other countries of different cultural/demographic backgrounds and therefore the subsequent difference in pain perception [43]. Nevertheless, the study has shed light that the COVID-19

pandemic may play a role in governing maternal health, and this may imply diverse ramifications across the framework concerning post-partum pain amid the pandemic. First, healthcare providers should be aware of the increased risk of post-partum pain during the pandemic and be prepared to offer additional support services including pain management and counseling, as well as telehealth services due to potential lockdowns and restrictions. Patient education should emphasize on pregnant individuals and new parents to navigate post-partum expectations, coping mechanisms, and available support services to better manage the post-partum pain and recovery. Potential long-term effects of heightened post-partum pain should also be explored in further research, especially the impact of social isolation, changes in healthcare access etc. that may impact maternal physical and mental health. Finally, policy recommendations should take into considerations the implications of post-partum pain during the pandemic to emphasize postpartum support in times of crises, such as increased funding, telehealth access, and flexible work arrangements for new parents.

5. Conclusions

In conclusion, this study examined the associated factors related to SAPC before and during COVID-19 pandemic. The generated multivariable association model would help healthcare professionals better understand the shift in pain and psychological aspects of women during COVID-19 pandemic, and identify those who are at higher risk of SAPC. Future studies could look into modifiable association factors that could improve SAPC, with personalized treatments and therapies to better address the pain and psychological health during post-partum care management.

Ethics declaration

This study was reviewed and approved by SingHealth Centralized Institutional Review Board, with the approval number: 2017/2090; and registered on Clinicaltrials.gov, with the registration number: NCT03167905. All patients provided informed consent to participate in the study.

Data availability

Data will be made available on request.

CRediT authorship contribution statement

Chin Wen Tan: Writing – original draft, Methodology, Funding acquisition, Data curation, Conceptualization. **Rehena Sultana:** Writing – review & editing, Visualization, Software, Formal analysis, Data curation. **Azriel Nicol Chang:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Hon Sen Tan:** Writing – review & editing, Methodology, Conceptualization. **Ban Leong Sng:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Chin Wen Tan is an associate editor of Heliyon, Women's Health section. All other authors declare no competing interests.

Acknowledgements

We would like to thank Miss Sili Tan (Clinical Research Coordinator) and Miss Agnes Teo (Senior Clinical Research Coordinator) for their administrative support in this work. Chin Wen Tan is supported by KKH Academic Medicine Research Start-Up Grant (ref no. KKH-AM/2022/01). and Azriel Nicol Chang and Ban Leong Sng are awarded the Academic Medicine – Enhancing Training, Healthcare, Outcomes and Standards (AM-ETHOS) Medical Student Research Fellowship Award by Singapore Duke-NUS in year 2023-24 (ref no. AM-ETHOS01/FY2023/18-A18). Ban Leong Sng is supported by Singapore National Medical Research Council (NMRC) Clinician Scientist award (ref no. CSAINV16may004).

Abbreviations

A-LPQ	Angle Labor Pain questionnaire
aOR	Adjusted odds ratio
ARM	Artificial rupture of membrane
ASA	American Society of Anesthesiologists
AUC	area under the curve
CBT	Cognitive behavioral therapy
CI	Confidence interval
CSI	Central Sensitization Inventory
EPDS	Edinburgh Postnatal Depression Scale

EQ-5D-3L EuroQol five-dimensional-three-level
FACS Fear-avoidance Components Scale
IQR interquartile range
LSCS Lower segment cesarean section
OA Occiput anterior
OP Occiput posterior
OR Odds ratio
PCS Pain Catastrophizing Scale
PROM Premature rupture of membrane
PSS Perceived Stress Scale
SAPC Sub-acute pain after childbirth
SD Standard deviation
STROBE Strengthening the Reporting of Observational studies in Epidemiology
VAS Visual analogue scale

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e27240.

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