Not All C-sections Are the Same: Investigating Emergency vs. Elective C-section deliveries as an Adverse Pregnancy Outcome*

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Electronic Health Records (EHR) contain detailed information about a patient's medical history and can be helpful in understanding clinical outcomes among populations generally underrepresented in research, including pregnant individuals. A cesarean delivery is a clinical outcome often considered in studies as an adverse pregnancy outcome, when in reality there are circumstances in which a cesarean delivery is considered the safest or best choice given the patient's medical history, situation, and comfort. Rather than consider all cesarean deliveries to be negative outcomes, it is important to examine other risk factors that may contribute to a cesarean delivery being an adverse event. Looking at emergency admissions can be a useful way to ascertain whether or not a cesarean delivery is part of an adverse event. This study utilizes EHR data from Penn Medicine to assess patient characteristics and pregnancy-related conditions as risk factors for an emergency admission at the time of delivery. After adjusting for pregnancy number and cesarean number for each patient, preterm birth increased risk of an emergency admission, and patients younger than 25, or identifying as Black/African American, Asian, or Other/Mixed, had an increased risk. Later pregnancies and repeat cesareans decreased the risk of an emergency delivery, and White, Hispanic, and Native Hawaiian/Pacific Islander patients were at decreased risk. The same risk factors and trends were found among cesarean deliveries, except that Asian patients did not have an increased risk, and Native Hawaiian/Pacific Islander patients did not have a reduced risk in this group.

Keywords: Electronic Health Records; pregnancy; cesarean section; C-section; emergency admission; population health.

1. Background and Significance

Electronic Health Records (EHR) contain rich information on patient medical history and treatment and can be used to study effects of prenatal exposures on delivery-related outcomes. These databases chronicle a patient's medical history, and therefore information at the pregnancy-level for each of a patient's pregnancies must be extracted from patient-specific medical information. This study utilizes an algorithm designed to extract delivery episode details from the EHR [1]. Our previously developed algorithm enables multiple deliveries to be extracted per patient from the EHR and does not limit the data to one pregnancy per patient, which is an improvement over other algorithms in the field. The purpose of this study is to assess the impact of pregnancy-specific maternal morbidity and patient-specific characteristics on experiencing an emergency admission at the time of delivery and its relationship to Cesarean section (C-section) deliveries.

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The United States has one of the highest rates of maternal mortality among developed nations at 24.7% [2,3] and high rates of C-section deliveries at 31.6%[4]. The World Health Organization found that a country-level C-section rate of greater than 10% was not associated with reductions in maternal and newborn mortality rates[5] and the American College of Obstetricians and Gynecologists expressed concern for the potential that C-sections were being overused after observing the rapid increase of C-sections between 1996 and 2011 without clear evidence of concomitant decreases in maternal morbidity or mortality rates [6,7]. Some suggest financial incentives [8–10] and the resource and scheduling convenience associated with C-section procedures [11–13] may play a role.

Primary C-sections, or individuals' first C-section, have been associated with some increased risk in morbidity, and subsequent or repeat C-sections in the future pose even greater risk[14]. There also exists consensus within the medical community that a C-section procedure is sometimes the best approach, as in placenta previa or uterine rupture [7]. Understanding that not every C-section can be considered an adverse pregnancy outcome, it is important to consider other factors that may be indicative of an adverse event. In this study, we examine emergency admissions as an adverse event among the general population as well as the population of patients with C-sections while considering a variety of patient- and pregnancy-specific characteristics as risk factors. We investigate preterm birth, multiple birth, and stillbirth diagnoses as risk factors along with patient-specific characteristics (at time of birth) including age, marital status, and race/ethnicity. The decision to investigate a patient's race or ethnicity as a risk factor has no biological basis but rather is grounded in an effort to explore how systemic racism[15,16] may be reflected in the health outcomes studied. Importantly, there are no race-based or ancestry-specific genetic factors that have been implicated in increasing the risk of C-section deliveries.

2. Methods

We identified pregnant patients who delivered via a C-section using structured EHR data that included a combination of inpatient and outpatient encounters within the health system. This data was coupled with information about type of admission to the clinic (i.e. elective or emergency), patient race/ethnicity, and patient age and marital status at the time of the encounter. We also determined if each pregnancy resulted in a multiple birth, preterm birth, or stillbirth using structured billing codes. We constructed a generalized logistic model to explore the relationship between these predictors and an emergency admission as a binary outcome variable.

All code for this analysis and data visualization was implemented in R[17] (version 4.0.2) using the tidyverse collection of packages[18], and EHR data was stored on a HIPAA secure server in a MySQL database. This study was approved by the Institutional Review Board of the University of Pennsylvania.

2.1. *Dataset characteristics*

We obtained EHR data for 1,060,100 female patients with visits to inpatient or outpatient clinics within the Penn Medicine system between 2010 and 2017. Previously, we developed and validated an algorithm to extract delivery episode information and delivery dates for each patient (accuracy of 98.6% and F-1 score of 92.1%) called MADDIE [1]. This algorithm identified 50,560 female patients with 63,334 distinct deliveries. The predominant race/ethnicity descriptions of the patients with deliveries were non-Hispanic Black or African American (47.3% of deliveries) and non-Hispanic White (33.9% of deliveries). We were able to identify pregnant patients who delivered by C-section and found that 35.52% (17,951 of 50,560) of patients delivered at least once via C-section and 32.99% (20,894 of 63,334) of all deliveries were via C-section (Table 1).

Table 1. Demographics of Patients with Deliveries at Penn Medicine

	All deliveries		C-section deliveries	
	Patients (%)	Deliveries (%)	Patients (%)	Deliveries (%)
Demographics	50560 (100)	63334 (100)	17951 (100)	20894 (100)
Patient race/ethnicity[a]				
Black/African American	23777 (47.0)	29965 (47.3)	8220 (45.8)	9502 (45.5)
White	17034 (33.7)	21443 (33.9)	6413 (35.7)	7626 (36.5)
Hispanic	4031 (8.0)	4985 (7.9)	1403 (7.8)	1611 (7.7)
Asian	3305 (6.5)	4073 (6.4)	1110 (6.2)	1269 (6.1)
Other or Mixed	2426 (4.8)	2883 (4.6)	569 (3.2)	638 (3.1)
Native Hawaiian/Pacific Islander	75 (0.15)	94 (0.15)	36 (0.2)	39 (0.2)
American Indian/Alaskan Native	61 (0.12)	81 (0.13)	19 (0.1)	28 (0.1)
Unknown	865 (1.71)	971 (1.53)	270 (1.5)	291 (1.4)
Patient age	29.5 ± 6.1	N/A	30.6 ± 6.1	N/A

[a]Race/ethnicity descriptions are 'non-Hispanic' unless otherwise indicated

2.2. *Identification of delivery outcomes*

Each delivery episode comprised a window of time containing an inferred delivery date. This delivery episode window consists of a start and end date corresponding to the start and end dates of when delivery codes were assigned. We needed to use an episode window because the visit to the hospital related to a delivery often can cross over multiple days and, in some cases, can last for several days. This is especially true for preterm deliveries where an attempt is made to delay the delivery, but is often unsuccessful. We use several outcomes (defined in subsections below) in this study. To link a patient delivery to a specific outcome, we required that the outcome diagnostic code be assigned within the delivery episode window for a particular delivery. We conducted our study at the pregnancy-level rather than the patient-level. However, later analysis looks at the effects of a prior C-section or a prior-pregnancy on subsequent pregnancy outcomes (thereby incorporating patient-level information).

2.2.1. *Cesarean section deliveries*

We used the U.S.-modified *International Classification of Diseases* version 9 (ICD-9) and version 10 (ICD-10) codes to identify all records that were assigned a C-section diagnosis or procedure code, and that had a C-section code assigned within the delivery episode window or time frame. In

the event that a C-section code was assigned on more than one date within a delivery episode, the date closest to the patient delivery date was selected as the C-section date.

2.2.2. *Preterm birth, stillbirth, and multiple birth deliveries*

In the absence of gestational weeks in the structured data, we used ICD-9 and ICD-10 codes to identify records that were assigned a preterm birth diagnosis code within the delivery episode, and created a binary variable accordingly. The same process was used to identify a stillbirth or multiple birth within the delivery episode. These three variables were included as predictors in the regression models.

2.3. *Integration of data from encounter records*

All delivery records were matched with admission type details in the encounter data to determine if patients had "emergency" or "elective" admissions to the hospital. Delivery admissions of type "emergency" were categorized as **emergency** deliveries while those recorded as "elective", "routine/elective", or "routine/elective admission" were categorized as **elective** deliveries. Categorization as an emergency admission was modeled as a binary response variable in the logistic regression models.

Each encounter date was mapping to the day of the week information (i.e. Monday, Thursday, Saturday, etc.) using R. Additional details within the encounter records were used to extract the patient's race/ethnicity as well as their age and marital status at the time of the delivery encounter. Patient age was included in the regression model as a categorical predictor variable with categories "<25 years", "25-34 years", and ">35 years", with "25-34 years" serving as the reference variable. This age breakdown was chosen to assess whether patients younger or older than the majority of pregnant patients in our cohort[1] were at a different risk of emergency admission. Marital status was considered only so far as whether the patient was 'Single' at the time of the encounter, and included in the model as a binary predictor variable.

2.4. *Generalized regression models*

We constructed a binomial multivariate logistic regression model to explore the relationship between a variety of predictor variables and emergency admission as the binary **response**, within the delivery population. *Age*, *race/ethnicity*, marital status *single*, *preterm birth*, *multiple birth*, and *stillbirth* diagnoses were all modeled as **predictors** of an emergency admission.

A similar model was constructed to explore the risk of an emergency admission specifically among patients with C-sections. *Age*, *race/ethnicity*, marital status *single*, *preterm birth*, *multiple birth*, and *stillbirth* diagnoses were all modeled as predictors of an emergency admission. To account for any prior deliveries and/or C-sections, we also created adjusted models that included the *delivery number* and *C-section number* as **predictors**. All predictors were binary with the exception of *age* which was categorical, and *delivery number* (ranging from 0-7 deliveries) and *C-section number* (ranging from 0-5 C-sections) which were both continuous.

Patients' first deliveries were also modeled as a separate group to consider the possibility that a patient's first experience giving birth could relate differently to the risk of an emergency admission.

The odds ratio for each predictor in all models was estimated by exponentiating the coefficients produced by the regression models.

3. Results

3.1. *Utilization of cesarean section codes*

We found that 10 unique ICD-9 codes and 6 unique ICD-10 codes were utilized to record a C-section diagnosis or procedure within the EHR. Among ICD-9 codes, the most common diagnosis code was 649.81 "Spontaneous labor with planned C-section-delivered", and the most common procedure code was 74.1 "Low cervical C-section" (Figure 1A). Among ICD-10 C-section codes, which were utilized starting in 2015, the most common diagnosis code was O82 "Encounter for Cesarean delivery without indication," and the most common procedure code was 10D00Z1 "Extraction of products of conception, low, open approach" (Figure 1B). Overall, the most common codes were procedure codes ICD-9 74.1 and ICD-10 10D00Z1 (Figure 1C).

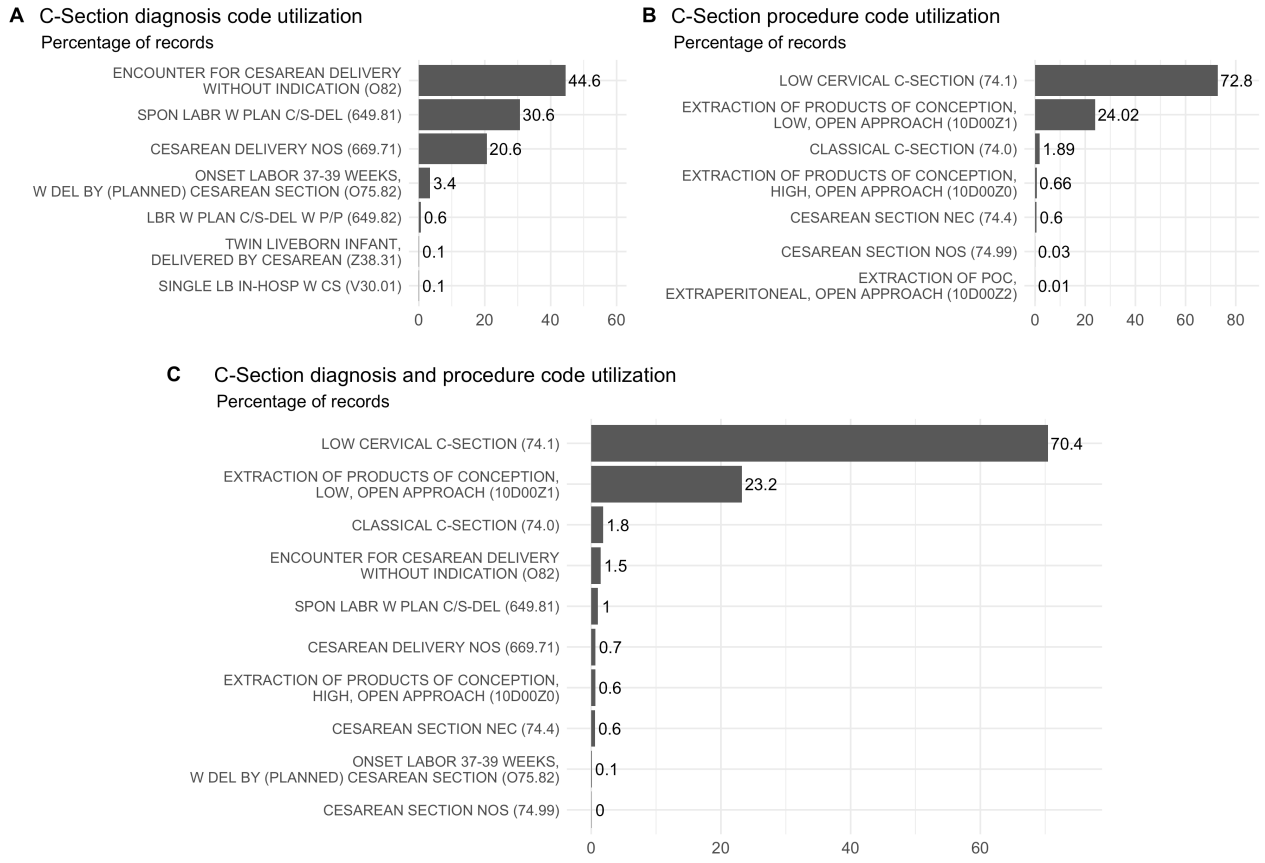

Fig 1. Distribution of ICD-9/10 codes most commonly utilized to code for a C-section delivery.

3.2. *Admission types recorded in encounter records*

The encounter records revealed 62 distinct admission types (excluding the empty field) among all delivery records and 47 among C-sections. The most common admission types recorded in the EHR at the time of the encounter for both groups included "emergency", "elective", and "routine elective

admission". Among all deliveries, "emergency" made up 25.3% of records, "elective" made up 4.8%, and "routine elective admission" made up 0.9%. The most common admission types and a similar pattern were seen among C-section deliveries, with "emergency" making up 22.1%, "elective" making up more encounters compared to all deliveries at 10.1%, and "routine elective admission" making up 1.3% of records (Table 2). We grouped all admission types that were not explicitly emergency and not explicitly elective into an 'Other' admission type for the purposes of our study.

Table 2. Ten Most Common Admission Types Recorded in the Encounter Records

Admission type	Encounters	Patients	Deliveries
All deliveries	N = 78505	N = 50560	N = 63334
PREGNANCY	37699 (48%)	30688 (60.7%)	35856 (56.6%)
EMERGENCY	19873 (25.3%)	17250 (34.1%)	19766 (31.2%)
(empty field)	6930 (8.8%)	6477 (12.8%)	6645 (10.5%)
OTHER	3912 (5%)	3879 (7.7%)	3894 (6.1%)
ELECTIVE	3806 (4.8%)	3541 (7%)	3614 (5.7%)
RETURN OB	2295 (2.9%)	2237 (4.4%)	2269 (3.6%)
NON STRESS TEST	1610 (2.1%)	1594 (3.2%)	1606 (2.5%)
ROUTINE ELECTIVE ADMISSION	688 (0.9%)	655 (1.3%)	657 (1%)
INDUCTION	436 (0.6%)	430 (0.9%)	430 (0.7%)
US LIMITED	295 (0.4%)	292 (0.6%)	293 (0.5%)
C-section deliveries	N = 27034	N = 17951	N = 20895
PREGNANCY	11905 (44%)	10213 (56.9%)	11216 (53.7%)
EMERGENCY	5971 (22.1%)	5447 (30.3%)	5883 (28.2%)
(empty field)	2960 (10.9%)	2760 (15.4%)	2798 (13.4%)
ELECTIVE	2717 (10.1%)	2461 (13.7%)	2526 (12.1%)
OTHER	1137 (4.2%)	1126 (6.3%)	1128 (5.4%)
NON STRESS TEST	700 (2.6%)	692 (3.9%)	696 (3.3%)
RETURN OB	670 (2.5%)	639 (3.6%)	644 (3.1%)
ROUTINE ELECTIVE ADMISSION	364 (1.3%)	334 (1.9%)	335 (1.6%)
US LIMITED	131 (0.5%)	129 (0.7%)	129 (0.6%)
INDUCTION	113 (0.4%)	107 (0.6%)	107 (0.5%)

3.3. *Age distribution by delivery admit type*

Among all deliveries, the average age at the time of delivery was 27.9 ± 6.3 years for emergency deliveries, 31.6 ± 5.9 years for elective deliveries, and 30.1 ± 5.8 years for "Other" admission types. Within C-sections, the average age was higher for all admission categories with an average age of 29.2 ± 6.5 years for emergency deliveries, 32.1 ± 5.5 years for elective deliveries, and 30.9 ± 5.9 years for other admissions (Figure 2).

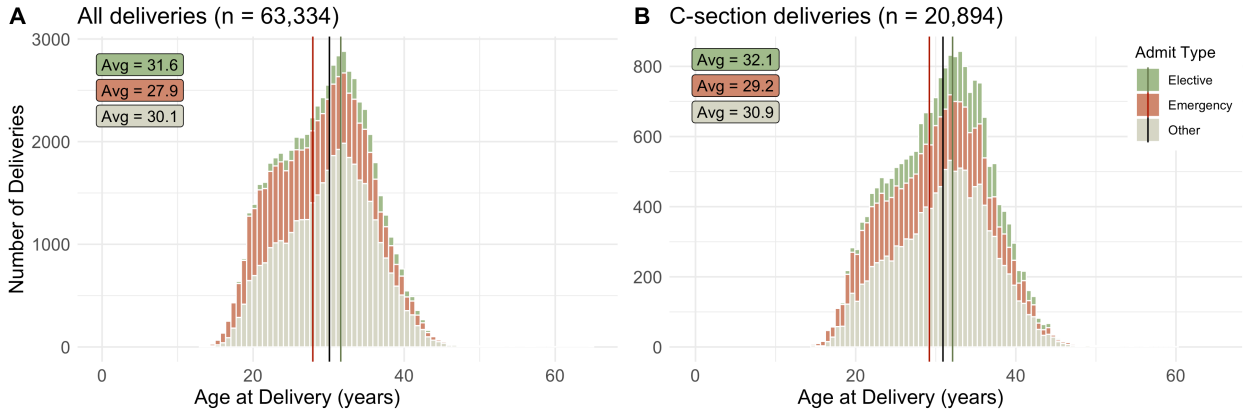

Fig 2. Distribution of patient age at time of delivery by admit type for (A) all deliveries and (B) C-sections.

3.4. *Number of deliveries by weekday and admit type*

Overall, most deliveries occurred during the work week from Monday to Friday with a noticeable decline on Saturday and Sunday, a trend further emphasized within C-sections (Figure 3). The decrease in elective admissions between weekdays and the weekend was 2.25x greater among C-section deliveries (12.4% vs. 5.5% for all deliveries). This difference between C-section deliveries and all deliveries was similar for the modest increase in emergency admissions on the weekend (1.6% vs. 0.7% for all deliveries). This transition between weekday and weekend with regards to emergency vs. elective C-section deliveries was expected given that C-sections are not scheduled for the weekend except in the case of an emergency. Most deliveries were associated neither with an elective nor an emergency admission but one of the "Other" admission types (Table 3).

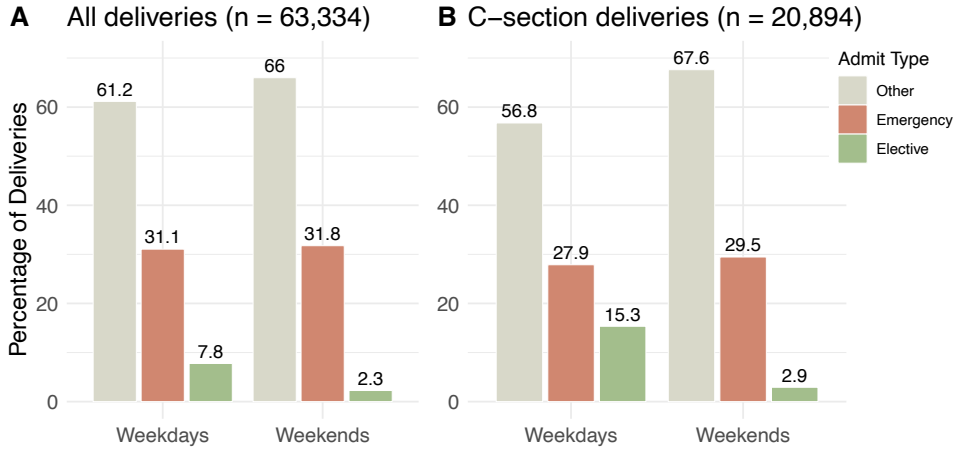

Fig 3. Deliveries on weekdays compared to weekends by admit type for (A) all deliveries and (B) C-sections.

Table 3. Proportion of Deliveries by Weekday and Admit Type

Weekday	Elective	Emergency	Other
All deliveries			
Avg. Weekday	777 (7.8%)	3107.2 (31.1%)	6118.4 (61.2%)
Avg. Weekend	150.5 (2.3%)	2115 (31.8%)	4395 (66.0%)
C-section deliveries			
Avg. Weekday	544.8 (15.4%)	993.6 (27.9%)	2020.6 (56.8%)
Avg. Weekend	45.5 (2.9%)	457.5 (29.5%)	1047.5 (67.6%)

4. Generalized regression model

Figure 4 presents odds ratio estimates for risk of an emergency delivery from the logistic regression models constructed for three groups of deliveries: first deliveries, all deliveries, and C-section deliveries. Among first deliveries for all patients, preterm birth and age <25 years increased the risk, and patients Black/African American, Other or Mixed, or Asian were at increased risk. Patients >35 years of age, single, White, Hispanic, or Native Hawaiian/Pacific Islander were at a decreased risk.

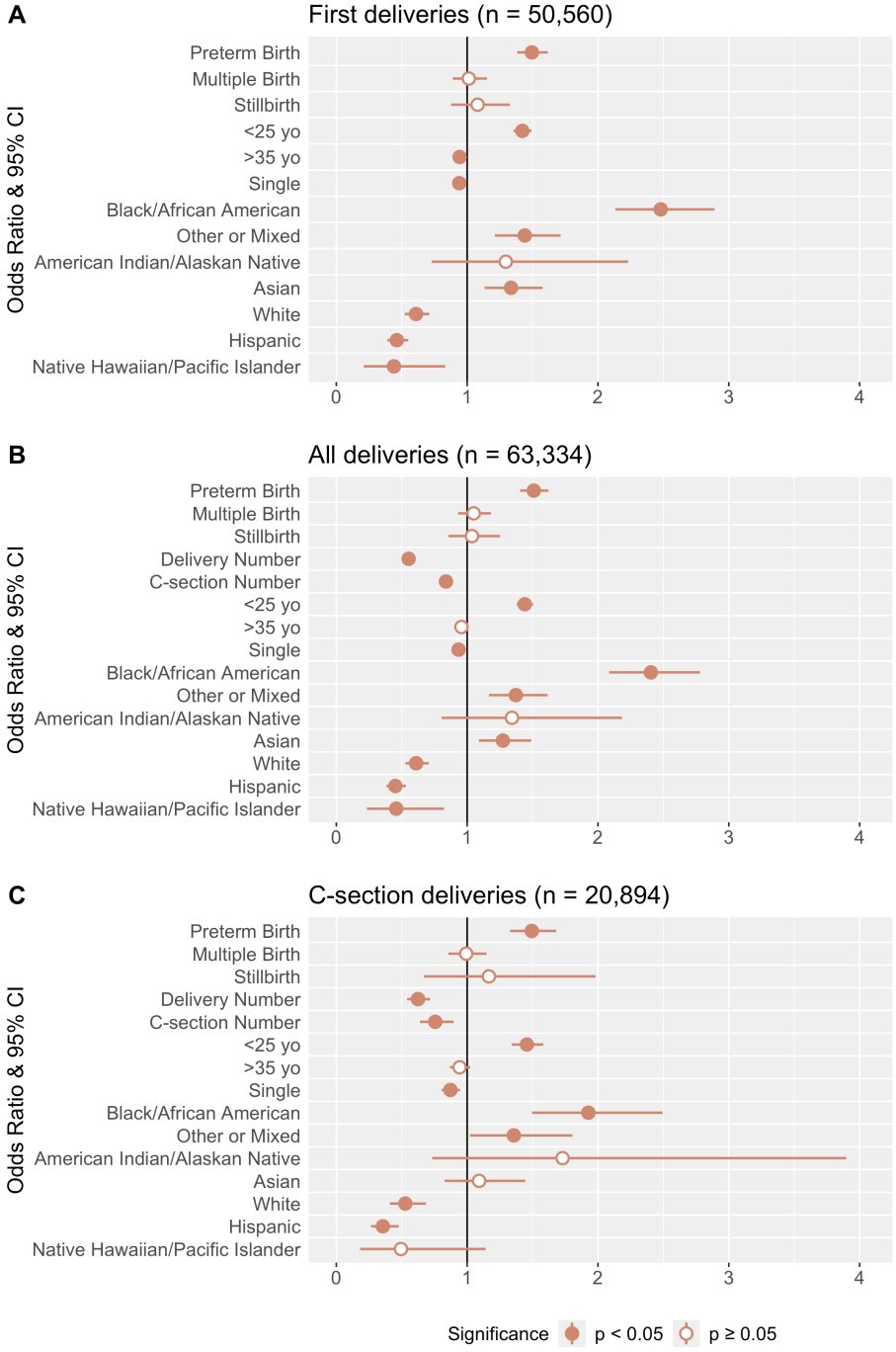

Fig 4. Odds ratio estimates showing risk of an emergency delivery for first deliveries (A), all deliveries (B), and C-section deliveries (C).

These trends persisted when considering all deliveries together and also after adjusting for the delivery number and C-section number, the only difference being that patients >35 years were no longer at decreased risk of an emergency admission.

In the C-section subgroup, all the same significant risk factors were identified, with the exceptions that Asian patients were no longer at increased risk and Native Hawaiian/Pacific Islander patients were no longer found to be at decreased risk of an emergency admission (Table 4).

Across all three groups, preterm birth, age, and single marital status were found to be significant risk factors for an emergency admission, as well as identifying as Black/African American, Other, or Mixed, White, or Hispanic. All deliveries and the C-section subgroup also shared in common the number of delivery and number of C-section as significant risk factors. Notably, each model reflects that Black/African American patients were at a higher risk of having an emergency delivery than any other racial/ethnic group. Hispanic patients were the least likely to experience an emergency delivery, followed closely by White patients.

Table 4. Logistic Regression Model Results

	Original Model		Adjusted Model	
Predictor	OR (95% CI)	P-value	OR (95% CI)	P-value
All deliveries				
Preterm Birth	1.52 (1.42-1.64)	<0.001	1.51 (1.41-1.62)	<0.001
Multiple Birth	0.98 (0.87-1.10)	0.709	1.05 (0.93-1.18)	0.437
Stillbirth	1.08 (0.90-1.30)	0.409	1.04 (0.86-1.25)	0.716
Age <25 years	1.52 (1.45-1.58)	<0.001	1.44 (1.38-1.51)	<0.001
Age >35 years	0.93 (0.88-0.97)	0.003	0.96 (0.91-1.01)	0.091
Marital Status Single	0.94 (0.90-0.98)	0.009	0.93 (0.89-0.98)	<0.01
Black/African American	2.16 (1.88-2.50)	<0.001	2.40 (2.08-2.78)	<0.001
Other or Mixed	1.30 (1.11-1.53)	0.001	1.37 (1.17-1.61)	<0.001
American Indian/Alaskan Native	1.19 (0.72-1.92)	0.491	1.34 (0.80-2.18)	0.245
Asian	1.21 (1.04-1.42)	0.015	1.27 (1.09-1.49)	0.002
White	0.58 (0.50-0.67)	<0.001	0.61 (0.53-0.58)	<0.001
Hispanic	0.42 (0.36-0.50)	<0.001	0.45 (0.38-0.53)	<0.001
Native Hawaiian/Pacific Islander	0.43 (0.22-0.77)	0.008	0.46 (0.23-0.82)	0.014
Delivery Episode	N/A	N/A	0.55 (0.53-0.58)	<0.001
C-section Episode	N/A	N/A	0.84 (0.81-0.87)	<0.001
C-section deliveries				
Preterm Birth	1.55 (1.38-1.74)	<0.001	1.49 (1.33-1.68)	<0.001
Multiple Birth	0.99 (0.86-1.15)	0.935	0.99 (0.86-1.15)	0.922
Stillbirth	1.15 (0.66-1.94)	0.690	1.17 (0.67-1.98)	0.577
Age <25 years	1.50 (1.38-1.62)	<0.001	1.46 (1.34-1.58)	<0.001
Age >35 years	0.94 (0.86-1.02)	0.128	0.94 (0.87-1.02)	0.156
Marital Status Single	0.89 (0.82-0.96)	0.004	0.87 (0.80-0.95)	<0.001
Black/African American	1.77 (1.38-2.29)	<0.001	1.93 (1.50-2.49)	<0.001
Other or Mixed	1.33 (1.00-1.76)	0.050	1.36 (1.02-1.80)	0.035
American Indian/Alaskan Native	1.35 (0.58-2.99)	0.467	1.73 (0.73-3.90)	0.194
Asian	1.06 (0.80-1.40)	0.690	1.09 (0.83-1.44)	0.538
White	0.50 (0.39-0.65)	<0.001	0.53 (0.41-0.68)	<0.001
Hispanic	0.34 (0.25-0.46)	<0.001	0.36 (0.27-0.48)	<0.001
Native Hawaiian/Pacific Islander	0.49 (0.18-1.12)	0.117	0.49 (0.18-1.14)	0.127
Delivery Episode	N/A	N/A	0.62 (0.54-0.72)	<0.001
C-section Episode	N/A	N/A	0.76 (0.64-0.90)	<0.001

4.1. *Surgical Incision Type for C-section and Effect on Emergency Admission*

Not all C-section procedures are the same with regards to the surgical incisions, so we explored whether the type of C-section incision was indicative of an elective vs. emergency delivery. Low C-section procedures have become the default procedure compared to the classical/high approach[19]. Figure 1B showed the two most common categories of C-section procedures corresponded to low C-section procedures and classical/high C-section procedures which were much less common. Including both ICD-9 and ICD-10 codes, low C-section procedures made up nearly 97% of all C-section records. In contrast, classical/high C-section procedures only made up roughly 2.5% of records. After categorizing these two types of procedures by admission type, we did not find that surgical incision type varied much by admission type (elective vs. emergency delivery): 10.7% vs. 13.6% of classical vs. low C-sections were elective deliveries and 28.4% vs. 28.0% of classical vs. low C-sections were emergency deliveries (Table 5). From this, we conclude that the emergency vs. elective admission type confers different information then surgical incision type.

Table 5. Proportion of C-section Patients and Deliveries by Procedure Type and Admit Type

Procedure type	Elective	Emergency	Other
Patients			
Low C-section	2669 (15.3%)	5261 (30.2%)	10668 (61.1%)
Classical (high) C-section	54 (11.0%)	142 (28.8%)	301 (61.1%)
Other C-section	192 (24.4%)	143 (18.2%)	457 (58.0%)
Deliveries			
Low C-section	2745 (13.6%)	5665 (28.0%)	11810 (58.4%)
Classical (high) C-section	54 (10.7%)	143 (28.4%)	307 (60.9%)
Other C-section	192 (24.2%)	143 (18.0%)	458 (57.8%)

5. Discussion

The extraction of diagnosis and procedure records, encounter records, and delivery date information from the EHR facilitates the study of adverse pregnancy-related outcomes with patient-specific as well as pregnancy-specific information. This information serves to provide rich context for patient's healthcare experience and makes it possible to investigate outcomes with a broader perspective. A C-section procedure as the mode of delivery is an example of a health outcome that requires richer context. There may be multiple reasons for a patient and their healthcare provider to consider a C-section delivery over a vaginal delivery, which may include a medical indication or patient preference. Therefore, automatically categorizing all C-sections, as adverse pregnancy outcomes would not be appropriate because not all C-sections are the same. It is important when studying pregnancy-related outcomes to explore additional factors that may contribute to an adverse experience. The approach taken by this study considers **emergency** deliveries to be the adverse event rather than C-sections more generally speaking, and evaluates a number of patient-specific and pregnancy-specific details as risk factors for an emergency admission at the time of delivery.

In addition to investigating C-sections as a subset of all deliveries, we also studied a subset containing only the first delivery from each patient in the dataset. Because our dataset includes EHR data for patients at Penn Medicine, the first delivery of each patient in our cohort is the first delivery that Penn Medicine has on record for that patient. This is a limitation because it means our dataset

does not include deliveries that may have occurred prior to that first record or outside of Penn Medicine. The first deliveries subset provides a baseline perspective and accounts for the possibility that a patient's first delivery experience at Penn Medicine may itself relate to an emergency delivery. A limitation to note here is potential selection bias with our cohort if patients had an extremely negative delivery experience at Penn Medicine and chose not to return for future pregnancy care.

Our logistic regression models found that patients with a *preterm birth* diagnosis, younger than *25 years,* and identifying as *Black/African American or Other/Mixed,* were at an increased risk of an emergency delivery among first deliveries, all deliveries, and C-section deliveries. A greater risk among patients with a preterm birth diagnosis is expected, as public health efforts to prevent preterm birth have suggested as an intervention the elimination of early elective deliveries [20]. For related reasons, multiple birth and stillbirth diagnoses were also included in the analysis though neither were found to increase risk of emergency C-sections. A greater risk at a younger age may be due in part to a lack of familiarity with the birth process and anxiety in anticipation of birth [21]. This may cause them to choose to be admitted through the emergency department when entering labor and have an elective delivery (C-section or otherwise) that is ultimately captured as an emergency admission. This theory is supported by the decreased risk for patients with more deliveries or repeat C-sections among all deliveries and C-sections. This was unexpected as repeat C-sections have been associated with other adverse outcomes[14], suggesting other risk factors are more strongly correlated with emergency deliveries. The health disparities evident in the results of this study align with patterns identified in pregnancy care[22] and more broadly throughout healthcare[16,23].

Patients who have experienced more births (multiparous) may have a lower risk of an emergency delivery because they are more informed about what to expect and perhaps more confident in advocating for themselves and/or finding support in their delivery experience. Patients with more births may also have had prior positive experiences at Penn Medicine and/or suffer less disease overall and be able to sustain more pregnancies as a result. Relative to all deliveries combined, patients with C-sections were on average older regardless of admission type, and there was a clearer distinction between elective and emergency deliveries. When considering deliveries throughout the week, we confirmed that most deliveries occurred on weekdays (Monday–Friday), including C-sections. For both groups, the proportion of elective deliveries dropped substantially from weekdays to the weekend. Among C-sections the drop was more pronounced showing it is less likely for a patient to have an elective C-section scheduled on the weekend, but instead during the conventional work week. These last findings support the hypothesis that resource and scheduling conveniences of C-section procedures contribute to overall C-section rates[11–13].

This study elucidated the importance of considering a variety of risk factors contributing to a patient's adverse experience during delivery, and the benefit of considering admission type as a way to distinguish between elective and emergency C-sections. It also generated opportunities to further explore, including: the decreased risk of an emergency delivery with later pregnancies and C-sections, further understanding of "other" admission types (i.e., not emergency or elective), and the relationship between repeat C-sections and emergency deliveries. We believe leveraging pregnancy-specific details extracted from the EHR is critical in understanding pregnancy-related outcomes at the patient level, and a useful approach to exploring deliveries with a greater level of granularity. In conclusion, our methodological approach enabled the findings presented in this study that support

the importance of examining emergency vs. elective C-sections and assessing emergency C-sections as an adverse outcome rather than assuming that all C-sections are adverse events.

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