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

Silvia P. Canelón, PhD[1] and Mary Regina Boland, MA, MPhil, PhD, FAMIA[1-3]

[1]Department of Biostatistics, Epidemiology, and Informatics, University of Pennsylvania, Philadelphia, PA
[2]Institute for Biomedical Informatics, University of Pennsylvania, Philadelphia, PA
[3]Department of Biomedical and Health Informatics, Children's Hospital of Philadelphia

Perelman School of Medicine University of Pennsylvania

Department of Biostatistics Epidemiology & Informatics

MOTIVATION

- The United States has **one of the highest rates of maternal mortality** among developed nations at 24.7%[1,2] and **high rates of Cesarean (C-section) deliveries** at 31.6%.[3]
- Primary C-sections have been associated with **increased risk in morbidity**, and repeat C-sections in the future pose greater risk.[4]
- A C-section procedure is **sometimes the best approach**, as in placenta previa or uterine rupture,[5] so **not every C-section can be considered an adverse pregnancy outcome**
- This study examines **emergency admissions as an adverse event** among the general population of patients vs. those with C-sections.[6]

STUDY APPROACH

- **Electronic health records (EHR)** contain rich information on a patient's medical history that can be used to study delivery-related outcomes
- This study utilizes the **MADDIE algorithm designed to extract delivery episode details from the EHR**.[7] This algorithm enables multiple deliveries to be extracted per patient from the EHR.
- These delivery episode details were leveraged to **map identified C-sections to specific pregnancies**.
- This study assesses the **impact of pregnancy-specific maternal morbidity and patient-specific characteristics on having an emergency admission** at the time of delivery, as related to C-sections.

SUMMARY

- We identified 50,560 patients with 63,334 deliveries at Penn Medicine 2010-2017, where **17,951 patients had 20,894 C-section deliveries**.
- An **increased risk of an emergency admission** was associated with: preterm birth, patients younger than 25, patients identifying as Black/African American, Asian, or Other/Mixed.
- A **decreased risk of an emergency admisison** was associated with: later pregnancies, repeat C-sections, and patients identifying as White, Hispanic, or Native Hawaiian/Pacific Islander.
- **Specific to C-sections**: Same trends except Asian patients did not have an increased risk, and Native Hawaiian/Pacific Islander patients did not have a reduced risk in this group.

C-SECTION IDENTIFICATION

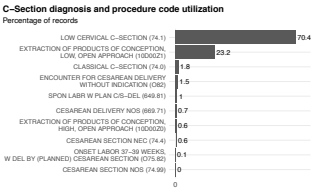
STEP 1. The MADDIE algorithm was used to identify 50,560 patients with 63,334 deliveries at Penn Medicine 2010-2017.

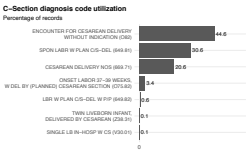
STEP 2. ICD version 9 (ICD-9) and version 10 (ICD-10) codes were used to identify 17,951 patients with C-section delivery diagnoses or procedures during any inpatient or outpatient clinic visit to Penn Medicine 2010-2017.

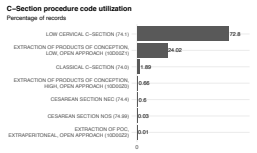
Penn Medicine Patient Population	All Deliveries		C-Section Deliveries	
Demographics	**Patients (%)**	**Deliveries (%)**	**Patients (%)**	**Deliveries (%)**
	50560 (100)	63334 (100	17951 (100)	20894 (100)
Age (years), average:	29.5 ± 6.1		30.6 ± 6.1	
Race/Ethnicity[a]				
Black or African American	23777 (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 or other Pacific Islander	75 (0.15)	94 (0.15)	36 (0.2)	39 (0.2)
American Indian or 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)

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

Most common ICD code. The ICD code most utilized to code for a C-section was ICD-9 procedure code 74.1 "Low cervical C-section"







TYPE OF ADMISSION

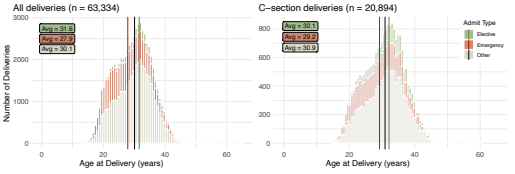
STEP 3. All EHR encounter records were mined to reveal 62 distinct admission types. All admission types that were not explicitly emergency and not explicitly elective were categorized as "Other."

10 most common admission types

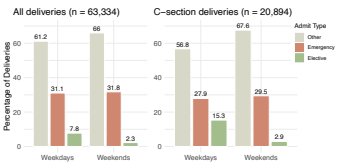
Of particular interest:
- Emergency
- Elective
- Routine elective admission

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%)

Patient age distribution by admit type



Number of deliveries by weekday and admit type



The decrease in elective admissions between weekdays and the weekend was 2.25x greater among C-section deliveries

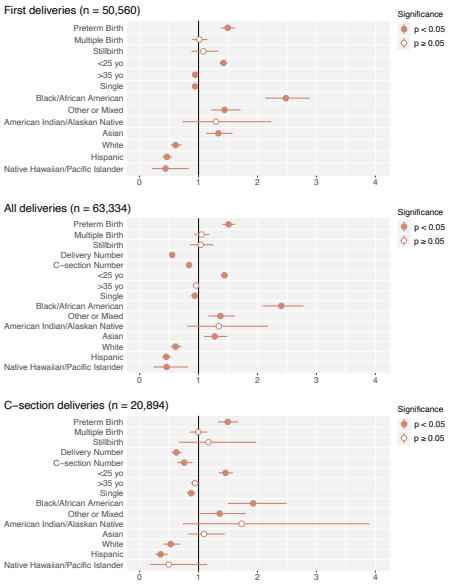
Surgical Incision Type for C-section by admit type

The type of surgical C-section incision (e.g. low vs. classical) did not vary much by admission 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%)

ALL DELIVERIES VS. C-SECTIONS: RISK OF AN EMERGENCY ADMISSION

Odds Ratio & 95% Confidence Interval



STEP 4. Binomial multivariate logistic regression model created with emergency admission as the binary **response** with both patient-specific and pregnancy-related conditions as **predictors**.

Adjusted models accounted for any prior deliveries and/or C-sections, by including *delivery number* and *C-section number* as **predictors**.

Patients' **first deliveries** also modeled to consider if a first experience giving birth could relate differently to the risk of an emergency.

Risk factors
- Preterm birth
- Delivery number
- C-section number
- Single marital status
- Age
- Black/African American
- Other
- Mixed
- White
- Hispanic

Predictor	Original Model		Adjusted Model	
	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 (0.53–0.56)	<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 (0.86–1.94)	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

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.

CONCLUSIONS

Our methodological approach enabled the findings presented in this study that support the importance of:
- **Examining emergency vs. elective C-sections**
- **Assessing pregnancy C-sections as an adverse outcome rather than assuming that all C-sections are adverse events**

REFERENCES

1. Kassebaum, NJ et al. Lancet. 2016; 388:1775–1812.
2. NPR, ProPublica. The Last Person You'd Expect to Die in Childbirth 2017.
3. Hehir, NP et al. Am J Obstet Gynecol. 2018; 219:105.e1-105.e11.
4. Silver, RM et al. Obstet Gynecol. 2006; 107:1226–1232
5. ACOG. Safe Prevention of the Primary Cesarean Delivery, 2014
6. **Canelón, SP and Boland, MR. Biocomputing 2021. 2020; 67-78**
7. **Canelón, SP et al. Int J Med Inform. 2020; j.ijmedinf.2020.104339**

Penn University of Pennsylvania