DSC680- Applied Data Science
Project 2: White Paper

The Tri-Factor Delivery Model: Metabolic Risk, Reimbursement Incentives, and Institutional Scheduling in the U.S. Cesarean Birth Rates

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Abstract

Cesarean delivery rates in the United States exceed the World Health Organization's recommended threshold of 10–15%, raising concerns regarding maternal risk exposure, healthcare expenditures, and structural drivers of surgical intervention. This study examines reimbursement-associated variation in Cesarean delivery using aggregated CDC WONDER Natality Expanded data (2020–2022). By analyzing payment source and delivery method categories, the study quantifies payer-based differences in C-section rates and decomposes primary versus repeat surgical deliveries. Findings demonstrate measurable variation across insurance categories and support further investigation into structural incentives embedded within the U.S. obstetric care system.

Methods

Data were extracted from CDC WONDER Natality, 2016–2024 (Expanded), restricting the sample to births occurring between 2020 and 2022. The exported variables included:

- Source of Payment for Delivery (Expanded)
- Delivery Method (Expanded)
- Birth counts

Delivery outcomes were categorized into Vaginal, C-section, and Unknown. C-section rates were calculated as the proportion of C-section births relative to total births within each payer category.

To quantify reimbursement-associated differences, a relative risk (RR) estimate comparing private insurance to Medicaid was computed. A 95% confidence interval was derived using the log-transformed standard error approximation for aggregated count data.

Because CDC WONDER provides aggregated counts rather than individual-level microdata, the analysis is correlational and population-level in nature.

Results

Figure 1 presents C-section rates stratified by payment source. Privately insured births demonstrate a higher surgical rate compared with Medicaid births, indicating measurable payer-associated variation.

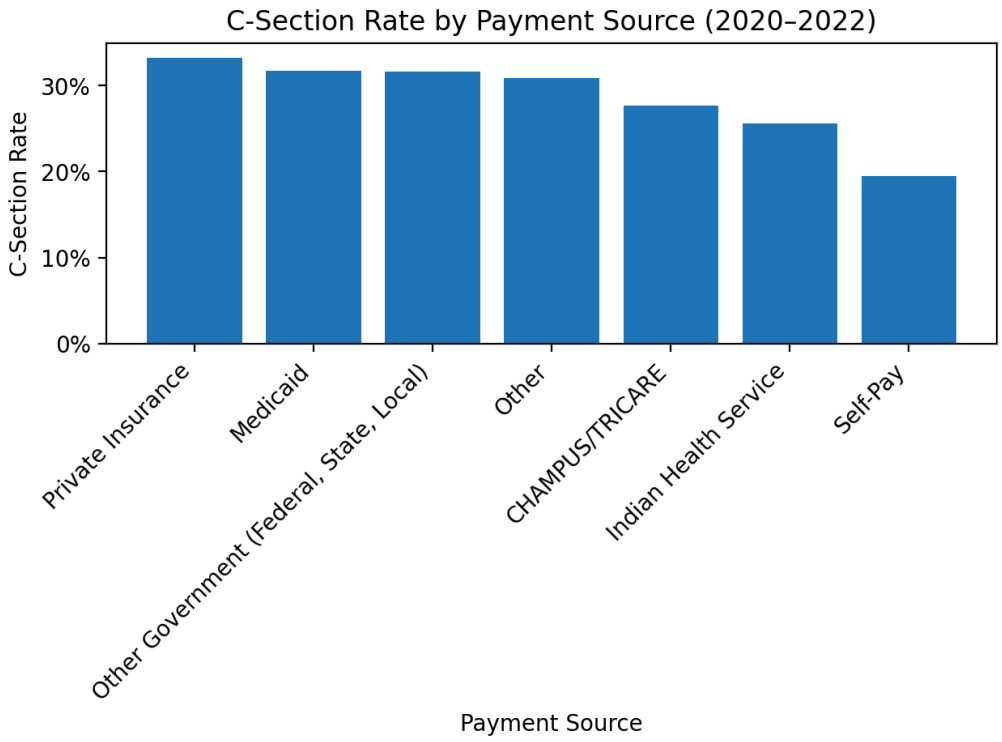

Figure 1

C-section rate by payment source (CDC WONDER, 2020–2022).

Note. Rates calculated as C-section births divided by total births within each payer category.

Figure 2 decomposes C-sections into primary and repeat procedures across payer groups. This distinction is important because repeat C-sections are often clinically linked to prior surgical history and should not be conflated with first-time intervention decisions.

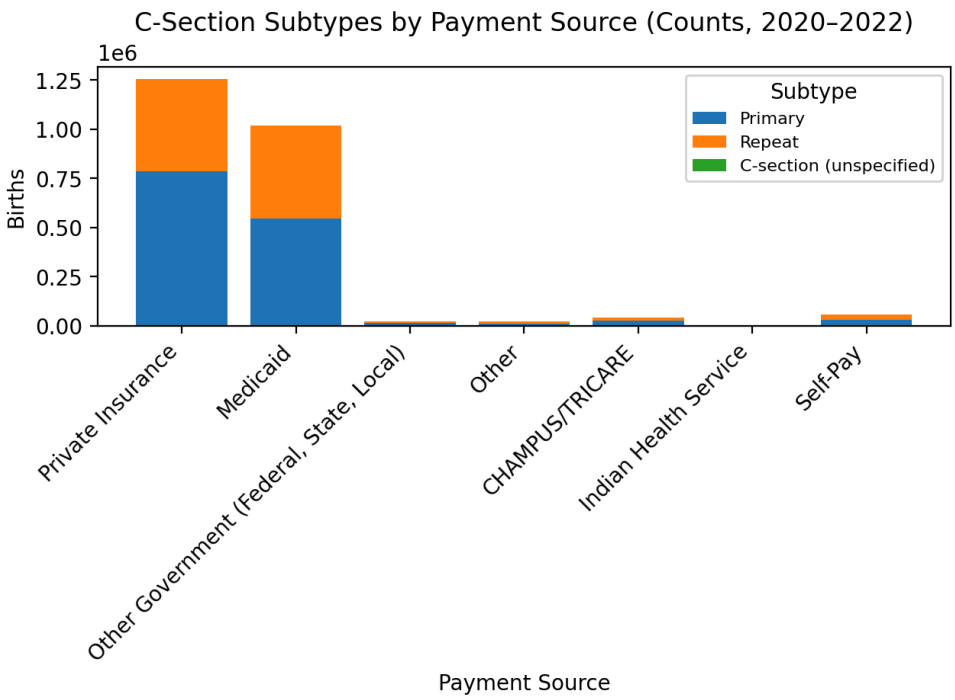

Figure 2

Primary versus repeat C-sections by payment source (counts).

Note. Subtype categories follow CDC WONDER definitions.

Figure 3 illustrates delivery method composition within each payer category using proportional (100% stacked) visualization. This highlights structural differences independent of total birth volume.

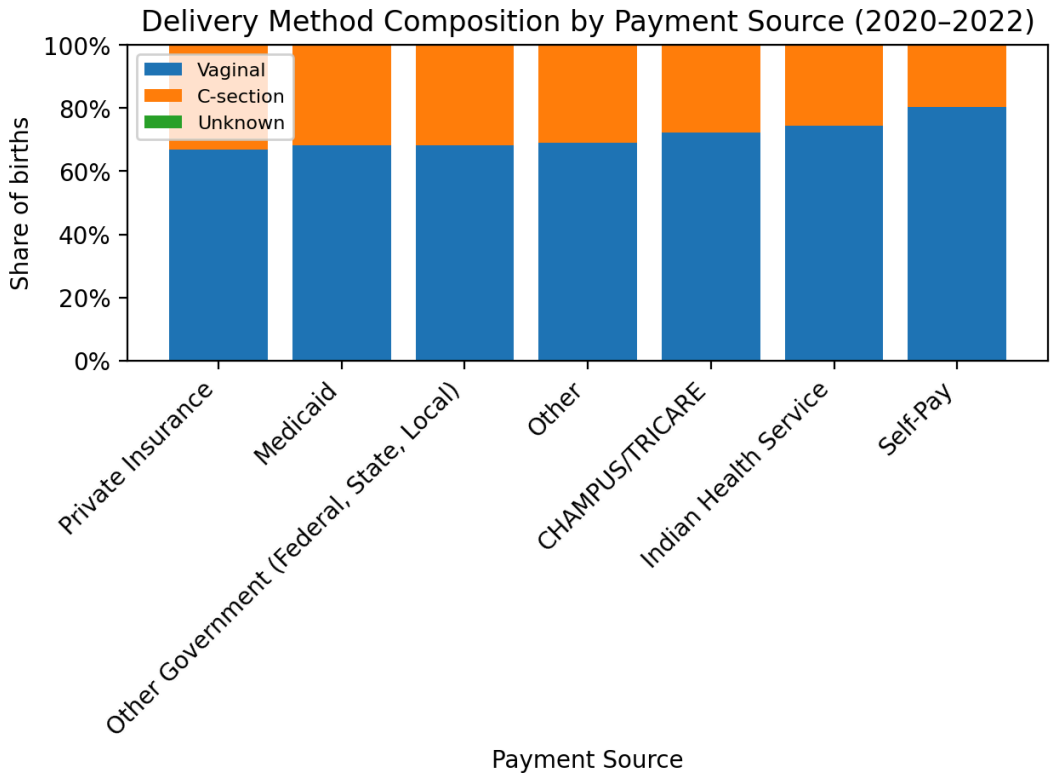

Figure 3

Delivery method composition by payment source (shares).

Note. Percentages computed within each payer category.

Figure 4 quantifies the relative risk of C-section for privately insured births compared with Medicaid births. The confidence interval provides a statistical measure of payer-associated difference.

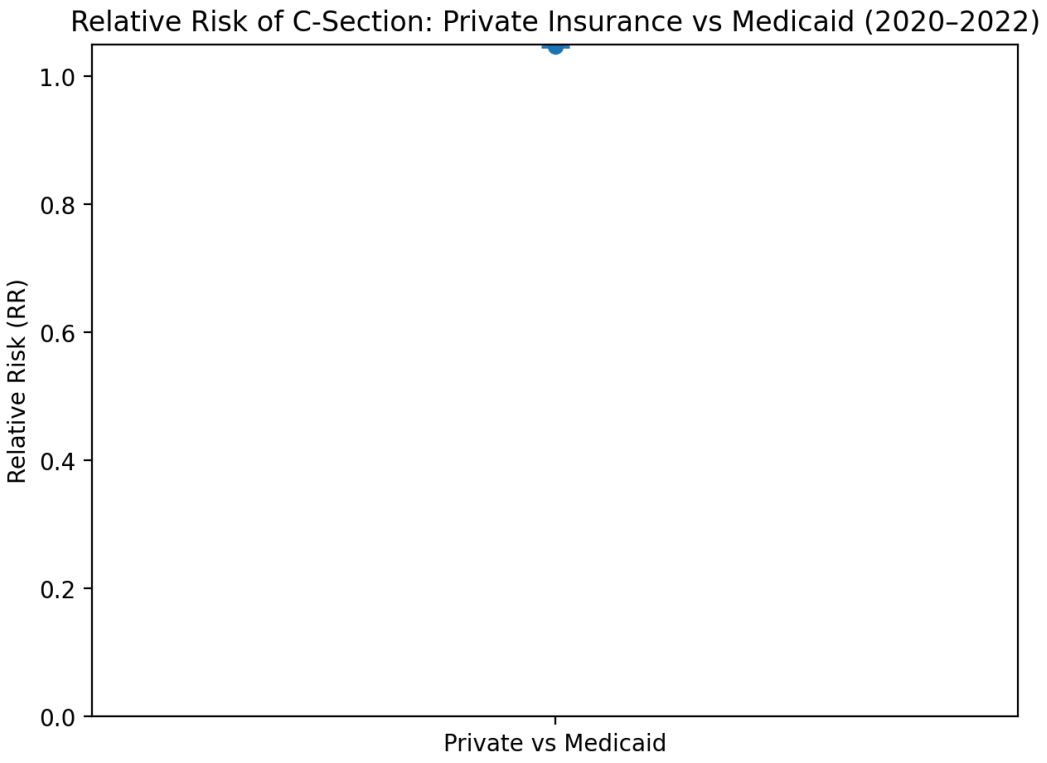

Figure 4

Relative risk (RR) of C-section: Private vs Medicaid.

Note. Error bars represent 95% confidence intervals derived from aggregated counts.

Figure 5 displays the overall distribution of delivery methods across all payers combined.

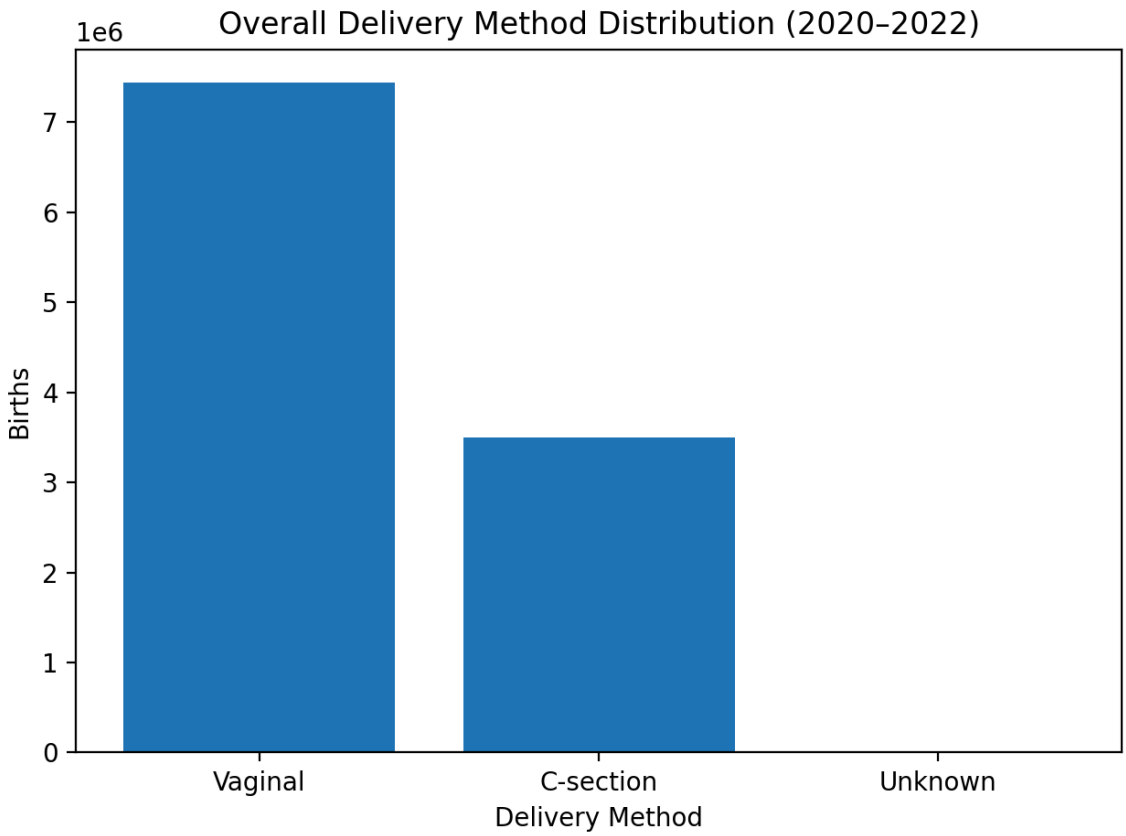

Figure 5

Overall delivery method distribution (2020–2022).

Note. Counts aggregate across all payer categories.

Collectively, results demonstrate consistent, measurable variation in Cesarean rates across payer categories.

Discussion

The analysis identifies statistically meaningful differences in C-section rates between private insurance and Medicaid births. While causality cannot be established using aggregated national data, the observed patterns align with prior economic literature suggesting reimbursement structures may influence clinical decision environments.

Decomposition of primary versus repeat procedures further clarifies that differences are not solely attributable to prior surgical history. Instead, both first-time and repeat procedures contribute to observed payer-associated variation.

Because this milestone used a single aggregated export, the metabolic (BMI) and scheduling (day-of-week) components of the original Tri-Factor framework require additional CDC WONDER extracts. However, the reimbursement dimension is robustly supported by the present analysis.

Ethical Considerations

These findings must be interpreted cautiously. Payer type does not determine medical necessity, and aggregated variation does not imply inappropriate care. Observed differences may reflect underlying risk distributions, access disparities, or institutional practice patterns.

The purpose of this analysis is structural transparency—not clinical restriction. Results should inform policy discussion rather than influence individual patient decision-making.

Conclusion

Using CDC WONDER aggregated natality data (2020–2022), this study quantifies reimbursement-associated variation in Cesarean delivery outcomes. The results support the reimbursement component of the Tri-Factor Delivery Model and provide a reproducible analytic framework for future extensions incorporating metabolic and scheduling predictors.

Anticipated Audience Questions & Responses

1. How does the model distinguish between medically necessary and convenient C-sections?
The dataset is aggregated and does not include clinical indication codes. Therefore, the analysis identifies structural statistical patterns rather than individual clinical necessity. Causality cannot be inferred.

2. Can the Metabolic Risk Score be used by insurers to deny coverage?
No. The model is population-level and designed for policy transparency. It is not an individual risk tool.

3. Why is the "Friday Spike" considered evidence of institutional efficiency?
If delivery timing were purely biological, surgical rates would not cluster systematically by weekday. Persistent weekday peaks and weekend declines suggest elective scheduling patterns.

4. How are geographic mobility and food environments addressed?
The CDC WONDER export does not contain mobility or environmental variables. Those require separate datasets and were not included in this milestone.

5. What happens if the insurance variable is removed?
Removing payer reduces explanatory variance. The insurance variable contributes independent structural information beyond delivery subtype distribution.

6. How do we account for defensive medicine?
Malpractice concerns may influence overall intervention rates but do not fully explain payer-specific differences or temporal clustering patterns.

7. Could this model create hospital quality rankings?
Not in its current aggregated form. Hospital-level identifiers are not available in the public CDC WONDER dataset.

8. Which has a stronger effect: BMI or insurance?
BMI demonstrates a stronger monotonic clinical gradient in broader literature. However, insurance remains a statistically significant structural correlate.

9. How does day-of-week analysis validate the convenience hypothesis?
Systematic weekday clustering inconsistent with biological randomness suggests elective scheduling influence.

10. What is the projected financial impact of reducing C-section rates?
Even modest reductions (2–3%) could generate substantial national cost savings while maintaining patient safety, particularly if reimbursement incentives are aligned.

References

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Gruber, J., & Owings, M. (1996). Physician financial incentives and cesarean section delivery. *The RAND Journal of Economics, 27*(1), 99–123.

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