Factors affecting Cesarean Section Deliveries in Low Risk Pregnancies in North Carolina - BAS 220 - Spring 2016, Chris Mathews

# Overview

**OBJECTIVE:** This study was undertaken to determine individual and institutional level variables predictive of variations in nulliparous term singleton vertex cesarean delivery rates.

**STUDY DESIGN:** Retrospective cohort study of 33,004 nulliparous term singleton vertex births in North Carolina occurring in 2014.

**RESULTS:** The average nulliparous term singleton vertex cesarean delivery rate was 22.6%, the lowest hospital rate was 8.47%, high, 41.94%. The following individual level variables increased the nulliparous term singleton vertex cesarean delivery rate in a multivariable model: increased mother’s age, race, extremes of birthweight, labor induction, and the presence of medical conditions such as diabetes and hypertension. The delivery at a hospital with the lowest level of care or with gynecology residency was associated with an obstetrics and increased risk of cesarean delivery.

**CONCLUSION:** Substantial variations in nulliparous term singleton vertex cesarean delivery rates were seen in this analysis.

# Introduction

Studies of cesarean deliveries offer a rich picture of variations in cesarean delivery rates. These have examined overall cesarean delivery rates and primary cesarean delivery rates. These studies have shown variations by both clinical and nonclinical factors, including the presence or absence of conditions such as diabetes, preeclampsia, advanced maternal age, and various institutional factors.

These studies have limitations because, as evidenced in my earlier study, the overall cesarean delivery rate is heavily inﬂuenced by the vaginal birth after cesarean rate, and the primary cesarean delivery rate does not necessarily adjust for medical risk factors.

As a result, adjustments for risks through regression models or standardization must be established. However, there are no widely adopted quality measures, because of their complexity, the lack of agreement over which factors should be adjusted, and differing opinions of various risk factors when derived from different data. A common method, risk stratiﬁcation, attempts to create homogenous groups from which to make comparisons. Once such method compares cesarean rates among the “standardized nulliparous patient” was introduced in Great Britain.

This rate was broadened and adopted as the nulliparous, term, singleton, vertex (NTSV) cesarean delivery (CD) rate by the US Department of Health and Human Services in their Healthy People 2010 goals and the American College of Obstetrics and Gynecology (ACOG) as a possible quality measure. Despite its adoption, studies examining this measure have been limited.

In this study, I worked with the NTSV concept by studying variations among hospitals in the State of North Carolina, based on factors collected on birth certiﬁcates. I designed a retrospective cohort study to examine individual-level risk factors for variations in NTSV rates. Finally, these factors were combined in a multivariable model controlling for clinical and nonclinical risk factors, to study variations among hospitals and individuals.

# Variables of Indication

The initial dataset consisted of 123.940 birth certificates for the calendar year 2014. Individual birth events consisting of over 100 variables compose each individual birth record. Accounting for records with incomplete or missing data eliminates 6,404 records leaving us with 117,506 records. Further filtering records to first time pregnancy (nulliparous), gestation greater than 36 weeks (term), single child (singleton), and head facing down (vertex) records leaves us with a final dataset of 34,108 records.

Several variables are coded as bivariate in nature, either a Yes or No answer. These variables include cigarette use before and during pregnancy, existing and gestational diabetes and hypertension and conditions on the course of labor – prolonged labor and precipitous labor, whether labor was induced or augmented. Each variable is populated with at least 90% negative responses, a “No” condition. This will be used for the referent condition.

Turning to the categorical variables with more options the birth weight category of the baby. This should prove to be significant in the final analysis. The categories below 2000 grams are so sparsely populated they will be consolidated into a “2000 grams or less” group.

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| ***Birth Weight Group*** | ***Final Birth Weight Group*** | ***Frequency*** | ***Percent*** |
| ***501 - 1000 grams*** | ***2000 grams and less*** | 183 | 0.54 |
| ***1001 - 1500 grams*** |  |  |  |
| ***1501 - 2000 grams*** |  |  |  |
| ***2001 - 2500 grams*** | ***2001 - 2500 grams*** | 1334 | 3.91 |
| ***2501 - 3000 grams*** | ***2501 - 3000 grams*** | 6534 | 19.16 |
| ***3001 - 3500 grams*** | ***3001 - 3500 grams*** | 14437 | 42.33 |
| ***3501 - 4000 grams*** | ***3501 - 4000 grams*** | 9171 | 26.89 |
| ***4001 - 4500 grams*** | ***4001 - 4500 grams*** | 2152 | 6.31 |
| ***4501 grams or more*** | ***4501 grams or more*** | 297 | 0.87 |
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Most of the demographic categories such as mother’s race and ethnic background have proven significant in other studies. The distribution indicates 64.40% of records are from white mothers, a good candidate for the referent condition. The mother’s ethnic origin is 88.74% negative 11.26% positive indicating Hispanic origin. The largest group will be taken as the referent category.

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| ***Mother's Race*** | ***Frequency*** | ***Percent*** |
| ***White*** | 21967 | 64.40 |
| ***Black or African American*** | 7336 | 21.51 |
| ***American Indian or Alaska Native*** | 445 | 1.30 |
| ***Other*** | 4360 | 12.78 |
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| ***Hispanic Origin*** | ***Frequency*** | ***Percent*** |
| ***No*** | 30268 | 88.74 |
| ***Yes*** | 3840 | 11.26 |
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Mother’s education will likely prove to be significant. The data are somewhat evenly distributed and progress from least educated to more highly educated. “Less than High School” will be the referent category. Mother’s marital status is evenly distributed between married and single.

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| ***Education of Mother*** | ***Frequency*** | ***Percent*** |
| ***Less than High School*** | 4285 | 12.56 |
| ***High School Graduate or GED*** | 7520 | 22.05 |
| ***Some College*** | 10865 | 31.85 |
| ***Bachelors Degree*** | 7364 | 21.59 |
| ***Masters or PhD*** | 4074 | 11.94 |
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Mother’s age is likely to be significant on C-section likelihood and is an ordered nominal variable. The mean and median values are nearly identical (mean = 25.22 and median = 25.00) indicating a nearly normal distribution. The skewedness of 0.46 indicates a left shifted distribution. Half the distribution exists between 11 years of age and 25 year. The kurtosis is -0.33 indicating a broadly distributed population with short tails. The extreme ages are not highly represented but still important.

Mothers weight as measured by the BMI categorical variable. This should prove to be somewhat significant as an indicator of general maternal health. The categories have a natural progression from least to greatest with underweight being a valid referent category.

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| ***Mother’s BMI*** | ***Frequency*** | ***Percent*** |
| ***Underweight (less than 18.5)*** | 1682 | 4.93 |
| ***Normal (18.5-24.9)*** | 17430 | 51.10 |
| ***Overweight (25.9-29.9)*** | 7875 | 23.09 |
| ***Obese (30.0+)*** | 7121 | 20.88 |
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Number of prenatal care visits is an ordinal indicator of prenatal health. The data are another normal distribution given the mean and median are nearly identical (mean = 12.08 and median = 12.00). The skewedness of 0.30 indicates left shifted distribution and the kurtosis 4.44 indicates a tightly packed distribution with long, thin tails. Visual inspection of the frequency distribution confirm the observations.

Looking at primary payer might lead to an indicator of hospital policy. Does private pay vs. government payer affect rate of C-sections. The variable is categorical split primarily between Medicaid at 39.6% and private insurance at 48.9% with self-pay and other accounting for the remaining 11.5%. Private Insurance with act as the referent category.

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| ***Primary Payment Method*** | ***Frequency*** | ***Percent*** |
| ***Medicaid*** | 13491 | 39.55 |
| ***Private Insurance*** | 16664 | 48.86 |
| ***Self-pay*** | 1616 | 4.74 |
| ***Other*** | 2337 | 6.85 |
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# Results

Overall, the model is significant. All global fit statistics are highly significant with regards to estimation of C-Section delivery. All tests are below 0.05 for all Alpha tests.

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| ***Test*** | ***Chi-Square*** | ***DF*** | ***Pr >  ChiSq*** |
| ***Likelihood Ratio*** | 3522.7489 | 120 | <.0001 |
| ***Score*** | 3471.9501 | 120 | <.0001 |
| ***Wald*** | 2974.3926 | 120 | <.0001 |
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C-sections accounted for 7,579 of 34,108 records or 22.22% of records. Several of the tested variables were shown to be insignificant. The indicator for Hispanic ethnicity (P=0.4146), cigarette use before (P=0.0576) and during (P=0.0517) pregnancy and prenatal hypertension (P=0.0556) all were individual maternal characteristics without influence on the model. Neither prolonged labor (P=0.0781) nor premature rupture of the amniotic sac (P=0.6994) had a significant influence on the model. Surprisingly, the method of payment (P=0.1530) had no influence on the model.

Review of the odds estimates for the remaining variables paints a clearer pictures of the likely factors affecting C-section births. Choosing low birth weights as a reference, all other levels have a reduction effect on the likelihood of C-sections. Only extremely large infants (4500 grams or larger) have the likelihood of C-sections rising at almost twice or 199% increase. This likely to the stress on labor involved with large fetal size.

All races have a heightened likelihood C-Section over Whites. Blacks are highest at 154%, American Indians at 126% and other races at 120%. The mother’s level education has an effect to decreasing the likelihood C-sections. With less than a high school education as the reference, a mother with a high school diploma is 95% likely to have a C-section, some college 93%, a bachelor’s degree 84.4% and mothers with an advanced degree is 79.5%. Married women are 90.2% as likely have a C-section. All of these factors seem to allude to the effect of education of the possible complications affecting a woman choice of having a C-section.

A mother’s weight has an increased effect on C-section likelihood. Normal BMI range is 150% likely as underweight. Increased weight continues to increase the chance of C-sections. Overweight mothers are 214% and obese mothers are 317% more likely to have C-sections than underweight mothers.

The nominal variables all have an increasing likelihood on C-sections. A one year increase in age increases likelihood by 7%, each additional week of pregnancy increases C-section rate by 2% and each additional prenatal care visit increase likelihood by 2%. These are all expected behaviors.

As for the relevant factors involved with the labor itself that had significance. Inducement of labor increased the likelihood of labor to 114% while augmented labor decreased it to 68.5%. Prenatal diabetes induced the likelihood of C-sections to 247% while both gestational diabetes and hypertension increased the chances to 130% and 152%.

As expected, the hospital/facility where the birth event takes place significantly effects the likelihood of C-sections. We see swings of probability in the range of 40-50% to highs over 175% all the way to 225% more likely.

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| ***Effect*** | ***Point Estimate*** | ***95% Wald Confidence Limits*** | |
| ***BWGRP\_NEW - 2001 - 2500 grams vs 2000 grams or less*** | 0.436 | 0.309 | 0.616 |
| ***BWGRP\_NEW - 2501 - 3000 grams vs 2000 grams or less*** | 0.327 | 0.237 | 0.453 |
| ***BWGRP\_NEW - 3001 - 3500 grams vs 2000 grams or less*** | 0.340 | 0.247 | 0.469 |
| ***BWGRP\_NEW - 3501 - 4000 grams vs 2000 grams or less*** | 0.468 | 0.339 | 0.647 |
| ***BWGRP\_NEW - 4001 - 4500 grams vs 2000 grams or less*** | 0.773 | 0.553 | 1.079 |
| ***BWGRP\_NEW - 4501 grams or more vs 2000 grams or less*** | 1.999 | 1.333 | 2.997 |
| ***MRACE - American Indian or Alaska Native vs White*** | 1.255 | 0.968 | 1.628 |
| ***MRACE - Black or African American vs White*** | 1.541 | 1.424 | 1.667 |
| ***MRACE - Other vs White*** | 1.199 | 1.074 | 1.339 |
| ***MEDUC - High School Graduate or GED vs Less than High School*** | 0.952 | 0.856 | 1.057 |
| ***MEDUC - Some College vs Less than High School*** | 0.927 | 0.833 | 1.032 |
| ***MEDUC – Bachelor’s Degree vs Less than High School*** | 0.844 | 0.742 | 0.959 |
| ***MEDUC - Masters or PhD vs Less than High School*** | 0.795 | 0.688 | 0.917 |
| ***MARITAL - Married vs Not Married*** | 0.902 | 0.835 | 0.974 |
| ***BMIG - Normal (18.5-24.9) vs Underweight (less than 18.5)*** | 1.499 | 1.272 | 1.766 |
| ***BMIG - Overweight (25.9-29.9) vs Underweight (less than 18.5)*** | 2.137 | 1.806 | 2.528 |
| ***BMIG - Obese (30.0+) vs Underweight (less than 18.5)*** | 3.165 | 2.674 | 3.745 |
| ***PDIAB - Yes vs No*** | 2.465 | 1.790 | 3.393 |
| ***GDIAB - Yes vs No*** | 1.304 | 1.151 | 1.478 |
| ***GHYPE - Yes vs No*** | 1.515 | 1.365 | 1.682 |
| ***PRIC - Yes vs No*** | 0.202 | 0.140 | 0.290 |
| ***PROL - Yes vs No*** | 1.154 | 0.984 | 1.354 |
| ***INDL - Yes vs No*** | 1.138 | 1.069 | 1.212 |
| ***AUGL - Yes vs No*** | 0.685 | 0.641 | 0.731 |
| ***WKSGEST*** | 1.029 | 1.012 | 1.047 |
| ***MAGE*** | 1.076 | 1.069 | 1.083 |
| ***VISITS*** | 1.022 | 1.014 | 1.030 |

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| --- | --- | --- | --- | --- |
| ***Top 10 Hospitals Most Likely For C-Sections*** | |  | ***Top 10 Hospitals Least Likely For C-Sections*** | |
| ***High Point Regional Hospital*** | 161.20% |  | ***Women's Hospital of Greensboro*** | 27.10% |
| ***Wayne Memorial Hospital*** | 163.00% |  | ***Womack Army Medical Center*** | 40.20% |
| ***Vidant Chowan Hospital*** | 166.70% |  | ***Ashe Memorial Hospital*** | 42.50% |
| ***Thomasville Medical Center*** | 177.20% |  | ***Angel Medical Center*** | 49.00% |
| ***Charles A Gannon Memorial Hospital*** | 181.00% |  | ***Nash General Hospital*** | 49.70% |
| ***Scotland Memorial Hospital*** | 185.00% |  | ***Wakemed (Main)*** | 52.30% |
| ***Vidant Duplin Hospital*** | 191.20% |  | ***Maria Parham Hospital Medical Center*** | 59.40% |
| ***Bladen County Hospital*** | 193.30% |  | ***University of North Carolina Hospital*** | 63.30% |
| ***Rutherford Hospital*** | 206.10% |  | ***Harris Regional Hospital*** | 65.20% |
| ***Firth Health Richmond Memorial Hospital*** | 225.20% |  | ***Vidant Roanoke-Chowan Hospital*** | 65.30% |

# Conclusion

Using the 2014 data from North Carolina, it was found that variations across hospitals in the likelihood of cesarean delivery of lower risk women could not be fully explained by differences in patient population with regard to mothers’ demographics, socioeconomic, pregnancy-related factors or preexisting medical conditions.

Association of a woman’s likelihood of cesarean delivery and her socio-economic were somewhat consistent with other studies. Older ages, non-White women, infants at the extremes of birth weight, induced labor, and pre-existing medical conditions were all associated with an increased risk. One of the main outcomes North Carolina hopes to affect in the near term is reduction in racial disparity in medical care. Evidence here would indicate there is still work to done to achieve that goal.

Other studies have noted that more educated women were at a higher risk while the risks in North Carolina appear to be well published and available for research as evidenced by reduced likelihood of cesarean delivery by those populations with more education.

Explanation of the variance could not be fully explained with supporting data to determine if insurance related factors, presence and type of training program (teaching hospital), individual physicians approach to delivery were present at the hospital level.

Further study expanding the study and focusing on variations within a specific hospital or hospital group to identify the specific modifiable characteristics would be the next appropriate step. Identifying major factors of cesarean delivery between institutions with the ultimate goal of reducing the influence of non-clinical factors on cesarean delivery risks is still the goal.

# Appendix – SAS Code

1. LIBNAME FINAL 'C:\Users\cmathews\Dropbox\Public\Final Project\SAS';
3. OPTIONS FMTSEARCH=(FINAL);
5. OPTIONS NOFMTERR;
6. proc print data=FINAL.births2014(obs=20);
7. run;
9. proc catalog c = final.formats;
10. contents stat;
11. run;
13. proc format
14. library = final.formats fmtlib;
15. select COOCCA;
16. run;
18. proc contents data=FINAL.Births2014NTSV;
19. run;
21. data FINAL.Births2014NTSV;
22. set FINAL.births2014Filtered;
24. format bwgrp\_new BWGRPA.;
26. **if** bwgrp in (1, 2, 3) then bwgrp\_new = 3; **else** bwgrp\_new = bwgrp;
28. where (TOTPREG EQ 1)
29. and (WKSGEST GE 36)
30. and (PLUR=1)
31. and (PRES=1)
32. and (PAY NE 9)
33. AND (BIRTHLOCAT NE '1-183') AND (BIRTHLOCAT NE '1-97') AND (BIRTHLOCAT NE 'I-135');
35. run;
37. proc print data=FINAL.births2014NTSV(obs=20);
38. run;
40. proc freq data=FINAL.births2014NTSV;
41. tables bwgrp bwgrp\_new /plots=freqplot;
42. run;
44. proc freq data=FINAL.births2014NTSV;
45. tables birthlocat\*COOCC /plots=all;
46. run;
48. /\* Create a new FB summary and report workbook for this snapshot
49. of Facebook data                                             \*/
50. filename fbout "c:\temp\Report\_&SYSDATE..xlsx";
52. /\* A little ODS style trick to make headings in my sheet \*/
53. ods escapechar='~';
54. %let bold\_style=~S={font\_size=12pt font\_weight=bold}~;
56. /\* CREATES a new XLSX file \*/
57. ods excel (id=fb) file=fbout
58. /\* choose a style you like \*/
59. style=journal\_borders;
60. /\* SHEET\_INTERVAL of NONE means that each PROC won't generate a
61. new sheet automatically                                     \*/
63. proc freq data=FINAL.births2014NTSV;
64. tables BWGRP MRACE METHNIC
65. MEDUC MARITAL MAGE
66. BMIG VISITS WIC PAY CIGBEF
67. CIGDUR PDIAB GDIAB PHYPE GHYPE
68. PROM PRIC PROL INDL AUGL
69. VISITS WKSGEST ROUT /plots=freqplot;
70. run;
72. PROC UNIVARIATE data=final.Births2014NTSV;
73. var VISITS WKSGEST MAGE;
74. run;
76. proc logistic data=FINAL.births2014NTSV
77. plots(only)=(effect oddsratio (type=horizontalstat)) DESCENDING;
78. **class** BWGRP\_NEW (ref='1501 - 2000 grams') MRACE (ref='White')
79. METHNIC (ref='No') MEDUC (ref='Less than High School') MARITAL
80. BMIG (ref='Underweight (less than 18.5)') CIGBEF CIGDUR PDIAB (ref="No")  PHYPE (ref="No")
81. PAY GDIAB (ref="No") GHYPE (ref="No")  PROM (ref="No") PRIC (ref="No") PROL (ref="No") INDL (ref="No") AUGL (ref="No") BIRTHLOCAT;
82. model ISCSECT = BWGRP\_NEW MRACE METHNIC MEDUC MARITAL
83. MAGE BMIG VISITS CIGBEF CIGDUR PDIAB PHYPE
84. GDIAB GHYPE PROM PRIC PROL INDL
85. PAY AUGL BIRTHLOCAT VISITS WKSGEST;
86. run;
88. ods excel (id=fb) close;