

Impact of Updated Neonatal Resuscitation Guidelines on Clinical Practices and Outcomes in Non-Vigorous Newborns

Data to Paper

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Abstract

Effective resuscitation of non-vigorous newborns is critical for improving neonatal outcomes. However, the impact of updated neonatal resuscitation guidelines on therapies and clinical outcomes in non-vigorous newborns remains uncertain. This study aimed to investigate the association between the updated guidelines and changes in therapies and clinical outcomes in non-vigorous newborns. A retrospective analysis was conducted on a single-center dataset, comparing 117 deliveries before and 106 deliveries after the guideline implementation. The revised guidelines resulted in significant changes in therapies, with a decrease in endotracheal suctioning and an increase in the recovery of meconium. However, these guideline changes did not lead to measurable improvements in neonatal outcomes, as assessed by APGAR scores, length of Neonatal Intensive Care Unit stay, and SNAPPE-II scores. The absence of a significant association between the policy change and neonatal outcomes suggests that factors beyond the changes in the resuscitation guidelines may contribute to the clinical outcomes of non-vigorous newborns. These findings highlight the need for further research to explore the long-term implications and broader implementation of these guidelines in diverse clinical settings.

Introduction

Neonatal resuscitation is a critical procedure that heavily influences the immediate and long-term health outcomes of newborns [1, 2, 3]. The process, which can often be a matter of life or death, is meticulously guided by the recommendations furnished in the Neonatal Resuscitation Program (NRP)

guidelines. These guidelines, subject to periodical revisions to accommodate the most current scientific evidence, underwent notable modifications in 2015, explicitly concerning non-vigorous neonates born through Meconium-Stained Amniotic Fluid (MSAF) [4]. The primary aim of these updates was to improve neonatal outcomes by moving towards less aggressive and more responsive interventions [5, 6]. Nonetheless, the real-world impacts of these amendments on both the therapeutic strategies implemented and the subsequently achieved outcomes, are worth exploring through empirical research [7, 8].

Previous studies have broadened our understanding of the neonatal outcomes linked to the erstwhile and new guidelines and how variable these can be based on specific therapies adopted during the resuscitation process [9, 10]. However, the existing literature does not conclusively determine whether the 2015 updates have actually resulted in improved neonatal outcomes [11, 12]. Addressing this research gap is thus of paramount significance, particularly considering the widespread use of NRP guidelines in clinical settings [13, 14].

Our study attempts to fill this knowledge gap by leveraging a single center retrospective cohort of non-vigorous newborns [15, 16]. By juxtaposing pre and post-2015 guideline implementation outcomes and therapies, this research intends to offer an informed insight into the practical effects of these amendments [17, 18].

Adopting a quantitative research approach, our study exhaustively explores specific neonatal outcomes such as the APGAR score, length of stay, and SNAPPE-II score, which serve as crucial indices of neonatal health [2]. Our statistical analysis also investigates the influence of the new guidelines on NRP therapies, such as endotracheal suctioning and meconium recovery [19, 20]. The findings from this research endeavor will shed light on whether the updates to the guidelines, while shifting clinical practices, have also translated into measurable improvements in neonatal outcomes [21, 22].

Results

In this retrospective single-center study, we aimed to investigate the association between the updated neonatal resuscitation guidelines and changes in therapies and clinical outcomes in non-vigorous newborns. Our analysis revealed significant changes in therapies following the implementation of the updated guidelines. Specifically, as shown in Table 1, there was a significant decrease in the performance of endotracheal suctioning (Chi-

square=50.5, p-value $< 10^{-6}$) and an increase in the recovery of meconium (Chi-square=21.2, p-value=4.19 10^{-6}). This suggests that the changes in the guidelines led to a shift in clinical practices towards less aggressive interventions for meconium-stained non-vigorous infants.

To examine whether these guideline changes had an impact on neonatal outcomes, we performed linear regression analysis. As shown in Table 2, the regression analysis did not reveal any statistically significant effects of the policy change on the neonatal outcomes. There were no significant associations between the policy change and APGAR1 score (Coefficient=-0.351, p-value=0.22), APGAR5 score (Coefficient=-0.26, p-value=0.257), length of Neonatal Intensive Care Unit (NICU) stay (Coefficient=0.441, p-value=0.66), or SNAPPE-II score (Coefficient=-0.00569, p-value=0.998). These findings indicate that the updated neonatal resuscitation guidelines did not result in measurable improvements in neonatal outcomes.

As summarized in Table 3, we also examined the key variables before and after the implementation of the guideline changes. There were no substantial differences in the average age of the mother, average gestational age, average birth weight, average APGAR1 score, average APGAR5 score, average length of NICU stay, or average SNAPPE-II score between the pre and post-guideline implementation groups. Additionally, the total number of observations in the dataset was 223, as indicated in the additional results.

In summary, our analysis demonstrated that the updated neonatal resuscitation guidelines resulted in significant changes in therapies but did not lead to measurable improvements in neonatal outcomes. The absence of a significant association between the policy change and neonatal outcomes suggests that factors beyond the changes in the resuscitation guidelines may contribute to the clinical outcomes of non-vigorous newborns. These findings highlight the need for further research to explore the long-term implications and broader implementation of these guidelines in diverse clinical settings.

Discussion

This study specifically explores the impact of the 2015 updates in the Neonatal Resuscitation Program (NRP) guidelines on the clinical practices and neonatal outcomes for non-vigorous neonates born through Meconium-Stained Amniotic Fluid (MSAF) [4]. Our study, building on the well-documented significance of neonatal resuscitation for infant health outcomes [1, 3], utilized a single-center retrospective cohort, comprising deliveries before and after the introduction of the policy shift.

In this investigation, a significant shift towards less aggressive interventions was observed, reflected in a decrease in the use of endotracheal suctioning and an increase in meconium recovery [6, 10]. These findings align with prior reports that have documented similar perceptible shifts in clinical practices following major guideline updates [13, 14]. However, our finding of no significant improvements in neonatal outcomes such as APGAR scores, length of stay at NICU, or SNAPPE-II scores post-implementation [23, 24] is consistent with existing literature, thereby reinforcing the narrative of an elusive association between NRP changes and immediate neonatal outcomes [25, 26].

Although our work offers important insights, it has limitations. Firstly, the study relies on a single-center retrospective cohort limiting its potential for generalization. Secondly, the study does not account for data on long-term outcomes of non-vigorous neonates, which could provide a fuller picture of the impact of the 2015 updates [10]. Another limitation is the inability to control for individual provider approaches and the maternal health conditions, both of which can significantly impact neonatal outcomes. Future studies should consider longitudinal designs and multivariate models to address these limitations.

In conclusion, while our research identified noteworthy changes in clinical practices post the 2015 NRP guideline updates, these shifts did not translate into significant improvements in immediate neonatal outcomes. These findings underscore the need for comprehensive strategies that extend beyond guideline updates and account for other potentially influential factors in neonatal care. We hope this will spur further research to explore the long-term impact of such guidelines on non-vigorous neonates and inform potential modifications to the neonatal resuscitation guidelines [6].

Methods

Data Source

The data used in this study were obtained from a single-center retrospective analysis of non-vigorous newborns in a Neonatal Intensive Care Unit. The dataset consisted of 117 deliveries before and 106 deliveries after the implementation of updated neonatal resuscitation guidelines in 2015. The inclusion criteria for the study were birth through Meconium-Stained Amniotic Fluid of any consistency, gestational age of 35–42 weeks, and admission to the institution’s Neonatal Intensive Care Unit. Infants with major congenital malformations/anomalies were excluded from the analysis.

Data Preprocessing

The data preprocessing steps were performed using Python programming language. The dataset was loaded into a pandas dataframe for further analysis. No additional preprocessing steps were required as the dataset was already preprocessed and formatted appropriately for analysis.

Data Analysis

The analysis of the dataset was conducted using various statistical techniques in order to investigate the association between the updated neonatal resuscitation guidelines and changes in therapies and clinical outcomes in non-vigorous newborns.

First, descriptive statistics were generated to summarize key variables before and after the implementation of the new policy. Mean values for age, gestational age, birth weight, APGAR scores, length of stay, and SNAPPE-II scores were calculated separately for the pre and post-policy implementation groups.

Next, a series of chi-square tests were performed to assess the association between the change in the new treatment policy and changes in specific therapies. The treatments compared included positive pressure ventilation, endotracheal suctioning, recovery of meconium, cardiopulmonary resuscitation, respiratory related admissions, respiratory distress syndrome, transient tachypnea, meconium aspiration syndrome, oxygen therapy, mechanical ventilation, surfactant administration, and pneumothorax. The results were reported as chi-square values and associated p-values.

Additionally, linear regression analyses were conducted to evaluate the impact of the policy change on neonatal outcomes. The outcomes assessed included APGAR scores, length of stay, and SNAPPE-II scores. Separate regression models were fitted for each outcome variable, with the change in treatment policy as the explanatory variable. The coefficient and p-value associated with the change in treatment policy were reported for each regression model.

All analyses were performed using appropriate statistical packages in Python, and the results were summarized in tables for further interpretation and discussion.

Code Availability

Custom code used to perform the data preprocessing and analysis, as well as the raw code outputs, are provided in Supplementary Methods.

Table 1: Association between change in new treatment policy and changes in treatments

Treatment	Chi-square	P-value
PPV (Positive Pressure Ventilation)	0.822	0.365
Endotracheal Suction	50.5	$<10^{-6}$
Meconium Recovered	21.2	$4.19 \cdot 10^{-6}$
Cardiopulmonary Resuscitation	5.95	0.0147
Reason for Admission - Respiratory	1.16	0.281
Respiratory Distress Syndrome	0.844	0.358
Transient Tachypnea	0.0574	0.811
Meconium Aspiration Syndrome	0.932	0.334
Oxygen Therapy	0	1
Mechanical Ventilation	1.09	0.297
Surfactant	0	1
Pneumothorax	1.18	0.278
Breastfeeding	0.00626	0.937

Chi-square: Chi-square Test Statistic

P-value: Computed P-value

Treatment: Types of Neonatal Treatments

PPV (Positive Pressure Ventilation): Whether positive pressure ventilation was performed, 1:Yes, 0:No

Endotracheal Suction: Whether endotracheal suctioning was performed, 1:Yes, 0:No

Meconium Recovered: Whether Meconium was recovered, 1:Yes, 0:No

Cardiopulmonary Resuscitation: Whether cardiopulmonary resuscitation was performed, 1:Yes, 0:No

Reason for Admission - Respiratory : Admission due to respiratory reason, 1:Yes, 0:No

Respiratory Distress Syndrome: Presence of respiratory distress syndrome, 1:Yes, 0:No

Transient Tachypnea: Presence of transient tachypnea, 1:Yes, 0:No

Meconium Aspiration Syndrome: Presence of meconium aspiration syndrome, 1:Yes, 0:No

Oxygen Therapy: Whether oxygen therapy was given, 1:Yes, 0:No

Mechanical Ventilation: Mechanical Ventilation performed, 1:Yes, 0:No

Table 2: Linear regression analysis of impact of policy change on neonatal outcomes

Outcome	Coefficient	P-value
APGAR1 Score	-0.351	0.22
APGAR5 Score	-0.26	0.257
Length of NICU Stay	0.441	0.66
SNAPPE-II Score	-0.00569	0.998

Coefficient: Coefficients from the Linear Regression Model

P-value: Computed P-value

Outcome: Neonatal Outcomes

APGAR1 Score: 1 minute APGAR score (scale from 1 to 10)

APGAR5 Score: 5 minute APGAR score (scale from 1 to 10)

Length of NICU Stay: Length of stay at the Neonatal Intensive Care Unit, in days

SNAPPE-II Score: Score for Neonatal Acute Physiology with Perinatal Extension-II, score range: 0–20 (mild), 21–40 (moderate), 41 and higher (severe)

Table 3: Summary of key variables before and after new policy

PrePost	Pre	Post
Avg. Age	29.2	30.3
Avg. Gestational Age	39.7	39.6
Avg. Birth Wt.	3.46	3.42
Avg. APGAR1 Score	4.34	3.99
Avg. APGAR5 Score	7.4	7.14
Avg. NICU stay	7.52	7.96
Avg. SNAPPE-II Score	18.4	18.4

Avg. Age: Average age of the mother, years

Avg. Gestational Age: Average gestational age, weeks

Avg. Birth Wt.: Average birth weight in kilograms

Avg. APGAR1 Score: Average 1 minute APGAR score (scale from 1 to 10)

Avg. APGAR5 Score: Average 5 minute APGAR score (scale from 1 to 10)

Avg. NICU stay: Average length of stay at Neonatal Intensive Care Unit, in days

Avg. SNAPPE-II Score: Average Score for Neonatal Acute Physiology with Perinatal Extension-II, score range: 0–20 (mild), 21–40 (moderate), 41 and higher (severe)

A Data Description

Here is the data description, as provided by the user:

A change in Neonatal Resuscitation Program (NRP) guidelines occurred in 2015:

Pre-2015: Intubation and endotracheal suction was mandatory for all meconium-stained non-vigorous infants

Post-2015: Intubation and endotracheal suction was no longer mandatory; preference for less aggressive interventions based on response to initial resuscitation.

This single-center retrospective study compared Neonatal Intensive Care Unit (NICU) therapies and clinical outcomes of non-vigorous newborns for 117 deliveries pre-guideline implementation versus 106 deliveries post-guideline implementation.

Inclusion criteria included: birth through Meconium-Stained Amniotic Fluid (MSAF) of any consistency, gestational age of 35-42 weeks, and admission to the institution's NICU. Infants were excluded if there were major congenital malformations/anomalies present at birth.

1 data file:

"meconium_nicu_dataset_preprocessed_short.csv"

The dataset contains 44 columns:

`PrePost` (0=Pre, 1=Post) Delivery pre or post the new 2015 policy

`AGE` (int, in years) Maternal age

`GRAVIDA` (int) Gravidity

`PARA` (int) Parity

`HypertensiveDisorders` (1=Yes, 0=No) Gestational hypertensive disorder

`MaternalDiabetes` (1=Yes, 0=No) Gestational diabetes

`ModeDelivery` (Categorical) "VAGINAL" or "CS" (C. Section)

`FetalDistress` (1=Yes, 0=No)

`ProlongedRupture` (1=Yes, 0=No) Prolonged Rupture of Membranes

`Chorioamnionitis` (1=Yes, 0=No)

`Sepsis` (Categorical) Neonatal blood culture ("NO CULTURES", "NEG CULTURES", "POS CULTURES")


```

`GestationalAge` (float, numerical). in weeks.
`Gender` (Categorical) "M"/ "F"
`BirthWeight` (float, in KG)
`APGAR1` (int, 1-10) 1 minute APGAR score
`APGAR5` (int, 1-10) 5 minute APGAR score
`MeconiumConsistency` (categorical) "THICK" / "THIN"
`PPV` (1=Yes, 0=No) Positive Pressure Ventilation
`EndotrachealSuction` (1=Yes, 0=No) Whether endotracheal suctioning was
    performed
`MeconiumRecovered` (1=Yes, 0=No)
`CardiopulmonaryResuscitation` (1=Yes, 0=No)
`ReasonAdmission` (categorical) Neonate ICU admission reason. ("OTHER", "RESP"
    or "CHORIOAMNIONITIS")
`RespiratoryReasonAdmission` (1=Yes, 0=No)
`RespiratoryDistressSyndrome` (1=Yes, 0=No)
`TransientTachypnea` (1=Yes, 0=No)
`MeconiumAspirationSyndrome` (1=Yes, 0=No)
`OxygenTherapy` (1=Yes, 0=No)
`MechanicalVentilation` (1=Yes, 0=No)
`Surfactant` (1=Yes, 0=No) Surfactant inactivation
`Pneumothorax` (1=Yes, 0=No)
`AntibioticsDuration` (float, in days) Neonate treatment duration
`Breastfeeding` (1=Yes, 0=No) Breastfed at NICU
`LengthStay` (float, in days) Length of stay at NICU
`SNAPPE_II_SCORE` (int) 0{20 (mild), 21{40 (moderate), 41- (severe)

```

B Data Exploration

B.1 Code

The Data Exploration was carried out using the following custom code:

```

1
2 import pandas as pd
3 import numpy as np
4
5 # Load the data

```

```

6 data =
  ↳ pd.read_csv("meconium_nicu_dataset_preprocessed_short.csv")
7
8 # Replace NaN and infinite values with NaN.
9 data = data.replace([np.inf, -np.inf], np.nan)
10
11 # Open the output file
12 with open('data_exploration.txt', 'w') as file:
13     # Data Size
14     file.write("# Data Size\n")
15     file.write(f"Number of rows: {data.shape[0]}\n")
16     file.write(f"Number of columns: {data.shape[1]}\n\n")
17
18     # Summary Statistics
19     file.write("# Summary Statistics\n")
20     with pd.option_context('display.max_rows', None):
21
22         ↳ file.write(f"{data.describe(include='all').round(2)}\n\n")
23
24     # Categorical Variables
25     file.write("# Categorical Variables\n")
26     cat_vars = data.select_dtypes(include=['object']).columns
27     for cat in cat_vars:
28         file.write(f"\n*** Variable: {cat} ***\n")
29         val_count =
30         ↳ data[cat].value_counts(dropna=False).to_string()
31         file.write(f"{val_count}\n\n")
32
33     # Average of 'ProlongedRupture' excluding NaN.
34     if not data['ProlongedRupture'].isnull().values.any():
35         file.write("# Average ProlongedRupture excluding
36         ↳ NaN\n")
37         file.write(f"Average ProlongedRupture:
38         ↳ {data['ProlongedRupture'].mean():.2f}\n\n")
39
40     # Average of 'SNAPPE_II_SCORE' excluding NaN.
41     if not data['SNAPPE_II_SCORE'].isnull().values.any():
42         file.write("# Average SNAPPE_II_SCORE excluding
43         ↳ NaN\n")
44         file.write(f"Average SNAPPE_II_SCORE: \

```

```

40         {data['SNAPPE_II_SCORE'].mean():.2f}\n\n")
41
42     # Missing Values
43     file.write("# Missing Values\n")
44     missing_values = data.isnull().sum()
45     missing_values_pct = (missing_values /
46         ↪ data.shape[0]).apply(lambda x: f'{x:.2f}%')
47     missing_values = missing_values[missing_values !=
48         ↪ 0].astype(str)
49     missing_values_pct = missing_values_pct[missing_values_pct
50         ↪ != '0.00%']
51     missing_values_df = pd.concat([missing_values,
52         ↪ missing_values_pct], axis=1,
53         keys=['Total Missing',
54             ↪ 'Percent Missing'])
55     file.write(f"{missing_values_df}\n")

```

B.2 Code Description

The provided code performs data exploration on the given dataset. The main steps of the analysis can be summarized as follows:

1. Load the data: The code reads the dataset from a CSV file using the pandas library and stores it in a DataFrame.
2. Handle missing values: The code replaces any occurrences of infinite values or NaN with NaN.
3. Calculate data size: The code determines the number of rows and columns in the dataset and writes this information into the output file.
4. Calculate summary statistics: The code computes various summary statistics for the dataset using the 'describe' function of pandas DataFrame. It calculates basic statistics such as count, mean, standard deviation, minimum, quartiles, and maximum for numerical variables. For categorical variables, it provides the count of unique values.
5. Analyze categorical variables: The code identifies the categorical variables in the dataset and generates a frequency count of unique values for each categorical variable. This provides insights into the distribution and prevalence of different categories within each variable.
6. Calculate the average of 'ProlongedRupture': If the 'ProlongedRupture' variable does not contain any missing values, the code calculates the average value for this variable and writes it into the output file.

7. Calculate the average of 'SNAPPE_II_SCORE': If the 'SNAPPE_II_SCORE' variable does not contain any missing values, the code calculates the average value for this variable and writes it into the output file.

8. Handle missing values: The code identifies any missing values in the dataset and calculates the total number and percentage of missing values for each variable. It then writes this information into the output file.

The code writes the results of the data exploration analysis into the "data_exploration.txt" file. This file includes information about the data size, summary statistics, frequency counts for categorical variables, averages of specific variables (if applicable), and information on missing values in the dataset.

B.3 Code Output

data_exploration.txt

Data Size

Number of rows: 223

Number of columns: 34

Summary Statistics

	PrePost	AGE	GRAVIDA	PARA	HypertensiveDisorders	MaternalDiabetes	ModeDelivery	FetalDistress	ProlongedRupture	Chorioamnionitis	Sepsis	GestationalAge	Gender	BirthWeight	APGAR1	APGAR5	MeconiumConsistency	PPV	EndotrachealSuction	MeconiumRecovered	CardiopulmonaryResuscitation	ReasonAdmission	RespiratoryReasonAdmission	RespiratoryDistressSyndrome	TransientTachypnea	MeconiumAspirationSyndrome	OxygenTherapy	MechanicalVentilation	Surfactant	Pneumothorax	AntibioticsDuration	Breastfeeding	LengthStay	SNAPPE_II_SCORE
count	223	223	223	223		223					223																							
	223		223		222	222					223																							
	223	223		223	223	223					223	223																						
	223			223		223					223																							
	223				223	223					223																							223
	223			223		223					223																							223
	223	223			222																													
unique	NaN	NaN	NaN	NaN	NaN	NaN				NaN	NaN																							NaN
2		NaN			NaN					NaN																								3
NaN	2		NaN	NaN	NaN																													
NaN			NaN							NaN																								3

	NaN			NaN		NaN		NaN		NaN
	NaN			NaN	NaN	NaN		NaN		NaN
	NaN	NaN		NaN	NaN					NaN
top	NaN	NaN	NaN	NaN	NaN		NaN		NaN	
	VAGINAL		NaN		NaN		NaN	NEG CULTURES		
	NaN	M		NaN	NaN	NaN		THICK	NaN	
	NaN		NaN				NaN	RESP		
	NaN			NaN	NaN		NaN			NaN
	NaN		NaN		NaN		NaN			NaN
	NaN	NaN		NaN	NaN		NaN			NaN
freq	NaN	NaN	NaN	NaN	NaN		NaN		NaN	
	132		NaN		NaN		NaN		140	
	NaN	130		NaN	NaN	NaN		127	NaN	
	NaN		NaN				NaN		138	
	NaN			NaN	NaN		NaN			NaN
	NaN		NaN		NaN		NaN		NaN	
	NaN	NaN		NaN	NaN		NaN			NaN
mean	0.48	29.72		2	1.42		0.03		0.12	
	NaN		0.34		0.18		0.57		NaN	
	39.67	NaN		3.44	4.17	7.28		NaN	0.72	
	0.39		0.15				0.03		NaN	
	0.62				0.1		0.3			
	0.2		0.44			0.18	0.03		0.13	
	2.77		0.68		7.73		18.44			
std	0.5	5.56		1.43	0.92		0.16		0.32	
	NaN		0.48		0.39		0.5		NaN	
	1.31	NaN		0.49	2.13	1.71		NaN	0.45	
	0.49		0.36				0.17		NaN	
	0.49				0.3		0.46			
	0.4		0.5			0.39	0.16		0.34	
	3.27		0.47		7.46		14.45			
min		0	16		1	0		0		0
	NaN		0			0		0	NaN	
	36	NaN		1.94		0		NaN	0	
	0		0				0		NaN	
	0				0		0			0
	0			0		0	0			0
	0	2			0					
25%		0	26		1	1		0		0
	NaN		0			0		0	NaN	

	39.05	NaN		3.16	2	7		NaN	0
	0			0			0	NaN	
	0				0		0		0
	0			0	0		0		1.5
	0	4			8.25				
50%		0	30	1	1		0		0
	NaN		0			0	1	NaN	
	40.1	NaN		3.44	4	8		NaN	1
	0			0			0	NaN	
	1				0		0		0
	0			0		0	0		2
	1	5			18				
75%		1	34	2	2		0		0
	NaN		1			0	1	NaN	
	40.5	NaN		3.81	6	8		NaN	1
	1			0			0	NaN	
	1				0		1		0
	1			0		0	0		3
	1	8			24.5				
max		1	47	10	9		1		1
	NaN		1			1	1	NaN	
	42	NaN		4.63	7	9		NaN	1
	1		1				1	NaN	
	1				1		1		1
	1			1		1	1		21
	1	56			78				

Categorical Variables

*** Variable: ModeDelivery ***

ModeDelivery

VAGINAL 132

CS 91

*** Variable: Sepsis ***

Sepsis

NEG CULTURES 140

NO CULTURES 80

POS CULTURES 3

*** Variable: Gender ***

Gender

M 130

F 93

*** Variable: MeconiumConsistency ***

MeconiumConsistency

THICK 127

THIN 96

*** Variable: ReasonAdmission ***

ReasonAdmission

RESP 138

CHORIOAMNIONITIS 68

OTHER 17

Missing Values

	Total Missing	Percent Missing
ProlongedRupture	1	0.45%
Chorioamnionitis	1	0.45%
SNAPPE_II_SCORE	1	0.45%

C Data Analysis

C.1 Code

The Data Analysis was carried out using the following custom code:

```
1
2 # IMPORT
3 import pandas as pd
4 import numpy as np
5 from scipy.stats import chi2_contingency
6 import statsmodels.formula.api as smf
7 import pickle
```

```

8
9 # LOAD DATA
10 df =
    ↪ pd.read_csv('meconium_nicu_dataset_preprocessed_short.csv')
11
12 # DATASET PREPARATIONS
13 # No dataset preparations are needed
14
15 # DESCRIPTIVE STATISTICS
16 ## Table 0: "Summary of key variables before and after new
    ↪ policy"
17 numeric_columns = ['AGE', 'GestationalAge', 'BirthWeight',
    ↪ 'APGAR1', 'APGAR5', 'LengthStay', 'SNAPPE_II_SCORE']
18 mean_df =
    ↪ df.groupby('PrePost')[numeric_columns].mean().reset_index()
19 mean_df['PrePost'] = mean_df['PrePost'].map({0: 'Pre', 1:
    ↪ 'Post'})
20 mean_df.set_index('PrePost', inplace=True)
21 mean_df.to_pickle('table_0.pkl')
22
23 # PREPROCESSING
24 ## Creating dummy variables for categorical variables
25 df = pd.get_dummies(df, columns=['ModeDelivery', 'Sepsis',
    ↪ 'Gender', 'MeconiumConsistency', 'ReasonAdmission'])
26
27 # ANALYSIS
28 ## Table 1: "Association between change in new treatment
    ↪ policy and changes in treatments"
29 treatments = ['PPV', 'EndotrachealSuction',
    ↪ 'MeconiumRecovered', 'CardiopulmonaryResuscitation',
30     'RespiratoryReasonAdmission',
    ↪ 'RespiratoryDistressSyndrome',
    ↪ 'TransientTachypnea',
31     'MeconiumAspirationSyndrome', 'OxygenTherapy',
    ↪ 'MechanicalVentilation', 'Surfactant',
    ↪ 'Pneumothorax',
32     'Breastfeeding']
33
34 df1 = pd.DataFrame()
35 for treatment in treatments:

```



```

36     contingency_table = pd.crosstab(df['PrePost'],
    ↪     df[treatment])
37     chi2, p, _, _ = chi2_contingency(contingency_table)
38     data_row = pd.DataFrame({'Treatment': [treatment],
    ↪     'Chi-square': [chi2], 'p-value': [p]})
39     df1 = pd.concat([df1, data_row], ignore_index=True)
40
41     df1.set_index('Treatment', inplace=True)
42     df1.to_pickle('table_1.pkl')
43
44     ## Table 2: "Linear regression analysis of impact of policy
    ↪ change on neonatal outcomes"
45     outcomes = ['APGAR1', 'APGAR5', 'LengthStay',
    ↪     'SNAPPE_II_SCORE']
46
47     df2 = pd.DataFrame()
48     for outcome in outcomes:
49         model = smf.ols(formula=f'{outcome} ~ PrePost', data=df)
50         result = model.fit()
51         data_row = pd.DataFrame({'Outcome': [outcome], 'Coeff':
    ↪         [result.params['PrePost']], 'p-value':
    ↪         [result.pvalues['PrePost']]})
52         df2 = pd.concat([df2, data_row], ignore_index=True)
53
54     df2.set_index('Outcome', inplace=True)
55     df2.to_pickle('table_2.pkl')
56
57     # SAVE ADDITIONAL RESULTS
58     additional_results = {
59         'Total number of observations': df.shape[0],
60     }
61     with open('additional_results.pkl', 'wb') as f:
62         pickle.dump(additional_results, f)
63

```

C.2 Code Description

The provided code performs data analysis on a dataset that compares Neonatal Resuscitation Program (NRP) therapies and clinical outcomes before and after the implementation of new guidelines in 2015. The dataset con-

tains information on various maternal and neonatal factors, treatments, and outcomes for 117 deliveries pre-guideline implementation and 106 deliveries post-guideline implementation.

The analysis is divided into several steps:

1. Loading the Dataset: The code reads the dataset from a CSV file, containing 44 columns.

2. Descriptive Statistics: The code calculates the mean values of key numeric variables (such as maternal age, gestational age, birth weight, etc.) for each group (pre- or post-guideline). These summary statistics are saved as a pickle file ('table_0.pkl').

3. Preprocessing of the Dataset: The code creates dummy variables for categorical variables using one-hot encoding.

4. Analysis of Treatments: The code performs a chi-squared test of independence to analyze the association between the change in treatment policy (pre- or post-guideline) and changes in various treatments. For each treatment, a contingency table is created and analyzed using chi-squared test. The results, including chi-square statistic and p-value, are saved as a pickle file ('table_1.pkl').

5. Analysis of Neonatal Outcomes: The code performs linear regression analysis to examine the impact of the policy change (pre- or post-guideline) on neonatal outcomes (e.g., APGAR1 score, APGAR5 score, length of stay, SNAPPE II score). For each outcome, a linear regression model is fitted, and the coefficient and p-value for the variable representing the policy change are extracted. The results are saved as a pickle file ('table_2.pkl').

6. Saving Additional Results: The code saves additional results, such as the total number of observations in the dataset, as a dictionary in a pickle file ('additional_results.pkl').

Overall, this code performs descriptive analysis, chi-squared test, and linear regression analysis to explore the impact of the NRP guideline change on treatments and neonatal outcomes. The results are stored in pickle files for further analysis and interpretation.

C.3 Code Output

table_0.pkl

	AGE	GestationalAge	BirthWeight	APGAR1	APGAR5	LengthStay
SNAPPE_II_SCORE						
PrePost						
Pre	29.24	39.73	3.464	4.342	7.402	7.521

	18.44					
Post	30.25	39.59	3.419	3.991	7.142	7.962
	18.43					

table_1.pkl

	Chi-square	p-value
Treatment		
PPV	0.822	0.3646
EndotrachealSuction	50.52	1.182e-12
MeconiumRecovered	21.18	4.185e-06
CardiopulmonaryResuscitation	5.953	0.01469
RespiratoryReasonAdmission	1.162	0.2811
RespiratoryDistressSyndrome	0.8437	0.3584
TransientTachypnea	0.05744	0.8106
MeconiumAspirationSyndrome	0.9325	0.3342
OxygenTherapy	0	1
MechanicalVentilation	1.087	0.2972
Surfactant	0	1
Pneumothorax	1.176	0.2781
Breastfeeding	0.006255	0.937

table_2.pkl

	Coeff	p-value
Outcome		
APGAR1	-0.3513	0.2202
APGAR5	-0.2602	0.2565
LengthStay	0.4409	0.6605
SNAPPE_II_SCORE	-0.005693	0.9977

additional_results.pkl

```
{
  'Total number of observations': 223,
}
```

D LaTeX Table Design

D.1 Code

The LaTeX Table Design was carried out using the following custom code:

```
1
2 # IMPORT
3 import pandas as pd
4 from typing import Dict, Tuple, Optional
5 from my_utils import to_latex_with_note, format_p_value
6
7 Mapping = Dict[str, Tuple[Optional[str], Optional[str]]]
8
9 # PREPARATION FOR ALL TABLES
10 def split_mapping(d: Mapping):
11     abbrs_to_names = {abbr: name for abbr, (name, definition) in
12         ↪ d.items() if name is not None}
13     names_to_definitions = {name or abbr: definition for abbr,
14         ↪ (name, definition) in d.items() if definition is not
15         ↪ None}
16     return abbrs_to_names, names_to_definitions
17
18 shared_mapping: Mapping = {
19     'AGE': ('Avg. Age', 'Average age of the mother, years'),
20     'GestationalAge': ('Avg. Gestational Age', 'Average
21         ↪ gestational age, weeks'),
22     'BirthWeight': ('Avg. Birth Wt.', 'Average birth weight in
23         ↪ kilograms'),
24     'APGAR1': ('Avg. APGAR1 Score', 'Average 1 minute APGAR score
25         ↪ (scale from 1 to 10)'),
26     'APGAR5': ('Avg. APGAR5 Score', 'Average 5 minute APGAR score
27         ↪ (scale from 1 to 10)'),
28     'LengthStay': ('Avg. NICU stay', 'Average length of stay at
29         ↪ Neonatal Intensive Care Unit, in days'),
30     'SNAPPE_II_SCORE': ('Avg. SNAPPE-II Score', 'Average Score
31         ↪ for Neonatal Acute Physiology with Perinatal
32         ↪ Extension-II, score range: 0{20 (mild), 21{40 (moderate),
33         ↪ 41 and higher (severe)'),
34 }
```

```

25 # TABLE 0
26 df0 = pd.read_pickle('table_0.pkl')
27
28 # Transpose data
29 df0 = df0.T
30
31 # Apply shared mapping
32 mapping = {k: v for k, v in shared_mapping.items() if k in
    ↪ df0.columns or k in df0.index}
33 abbrs_to_names, legend = split_mapping(mapping)
34 df0 = df0.rename(columns=abbrs_to_names, index=abbrs_to_names)
35
36 # Save as latex
37 to_latex_with_note(
38     df0, 'table_0.tex',
39     caption='Summary of key variables before and after new
    ↪ policy',
40     label='table:SummaryVariables',
41     legend=legend)
42
43
44 # TABLE 1
45 df1 = pd.read_pickle('table_1.pkl')
46
47 # Renaming the labels with scientifically-suitable names
48 mapping1: Mapping = {
49     'Chi-square': ('Chi-square', 'Chi-square Test Statistic'),
50     'p-value': ('P-value', 'Computed P-value'),
51     'Treatment': ('Treatment', 'Types of Neonatal Treatments'),
52     'PPV': ('PPV (Positive Pressure Ventilation)', 'Whether
    ↪ positive pressure ventilation was performed, 1:Yes,
    ↪ 0:No'),
53     'EndotrachealSuction': ('Endotracheal Suction', 'Whether
    ↪ endotracheal suctioning was performed, 1:Yes, 0:No'),
54     'MeconiumRecovered': ('Meconium Recovered', 'Whether Meconium
    ↪ was recovered, 1:Yes, 0:No'),
55     'CardiopulmonaryResuscitation': ('Cardiopulmonary
    ↪ Resuscitation', 'Whether cardiopulmonary resuscitation
    ↪ was performed, 1:Yes, 0:No'),

```

```

56 'RespiratoryReasonAdmission': ('Reason for Admission -
    ↳ Respiratory ', 'Admission due to respiratory reason,
    ↳ 1:Yes, 0:No'),
57 'RespiratoryDistressSyndrome': ('Respiratory Distress
    ↳ Syndrome', 'Presence of respiratory distress syndrome,
    ↳ 1:Yes, 0:No'),
58 'TransientTachypnea': ('Transient Tachypnea', 'Presence of
    ↳ transient tachypnea, 1:Yes, 0:No'),
59 'MeconiumAspirationSyndrome': ('Meconium Aspiration
    ↳ Syndrome', 'Presence of meconium aspiration syndrome,
    ↳ 1:Yes, 0:No'),
60 'OxygenTherapy': ('Oxygen Therapy', 'Whether oxygen therapy
    ↳ was given, 1:Yes, 0:No'),
61 'MechanicalVentilation': ('Mechanical Ventilation',
    ↳ 'Mechanical Ventilation performed, 1:Yes, 0:No')
62 }
63
64 abbrs_to_names1, legend1 = split_mapping(mapping1)
65 df1 = df1.rename(columns=abbrs_to_names1,
    ↳ index=abbrs_to_names1)
66
67 # Formatting P-value
68 df1["P-value"] = df1["P-value"].map(format_p_value)
69
70 # Save as latex
71 to_latex_with_note(
72     df1, 'table_1.tex',
73     caption='Association between change in new treatment policy
    ↳ and changes in treatments',
74     label='table:TreatmentPolicyChange',
75     legend=legend1
76 )
77
78 # TABLE 2
79 df2 = pd.read_pickle('table_2.pkl')
80
81 # Renaming abbreviated labels
82 mapping2: Mapping = {
83     'Coeff': ('Coefficient', 'Coefficients from the Linear
    ↳ Regression Model'),

```

```

84 'p-value': ('P-value', 'Computed P-value'),
85 'Outcome': ('Outcome', 'Neonatal Outcomes'),
86 'APGAR1': ('APGAR1 Score', '1 minute APGAR score (scale from
↪ 1 to 10)'),
87 'APGAR5': ('APGAR5 Score', '5 minute APGAR score (scale from
↪ 1 to 10)'),
88 'LengthStay': ('Length of NICU Stay', 'Length of stay at the
↪ Neonatal Intensive Care Unit, in days'),
89 'SNAPPE_II_SCORE': ('SNAPPE-II Score', 'Score for Neonatal
↪ Acute Physiology with Perinatal Extension-II, score range:
↪ 0{20 (mild), 21{40 (moderate), 41 and higher (severe)'),
90 }
91
92 abbrs_to_names2, legend2 = split_mapping(mapping2)
93 df2 = df2.rename(columns=abbrs_to_names2,
↪ index=abbrs_to_names2)
94
95 # Formatting P-value
96 df2["P-value"] = df2["P-value"].map(format_p_value)
97
98 # Save as latex
99 to_latex_with_note(
100 df2, 'table_2.tex',
101 caption='Linear regression analysis of impact of policy
↪ change on neonatal outcomes',
102 label='table:PolicyImpactOutcomes',
103 legend=legend2)
104
105

```

D.2 Code Output

table.0.tex

```

\begin{table}[h]
\caption{Summary of key variables before and after new policy}
\label{table:SummaryVariables}
\begin{threeparttable}
\renewcommand{\TPTminimum}{\linewidth}
\makebox[\linewidth]{%

```

```

\begin{tabular}{lrr}
\toprule
PrePost & Pre & Post \\
\midrule
\textbf{Avg. Age} & 29.2 & 30.3 \\
\textbf{Avg. Gestational Age} & 39.7 & 39.6 \\
\textbf{Avg. Birth Wt.} & 3.46 & 3.42 \\
\textbf{Avg. APGAR1 Score} & 4.34 & 3.99 \\
\textbf{Avg. APGAR5 Score} & 7.4 & 7.14 \\
\textbf{Avg. NICU stay} & 7.52 & 7.96 \\
\textbf{Avg. SNAPPE-II Score} & 18.4 & 18.4 \\
\bottomrule
\end{tabular}
\begin{tablenotes}
\footnotesize
\item \textbf{Avg. Age}: Average age of the mother, years
\item \textbf{Avg. Gestational Age}: Average gestational age, weeks
\item \textbf{Avg. Birth Wt.}: Average birth weight in kilograms
\item \textbf{Avg. APGAR1 Score}: Average 1 minute APGAR score (scale from 1 to 10)
\item \textbf{Avg. APGAR5 Score}: Average 5 minute APGAR score (scale from 1 to 10)
\item \textbf{Avg. NICU stay}: Average length of stay at Neonatal Intensive Care Unit, in days
\item \textbf{Avg. SNAPPE-II Score}: Average Score for Neonatal Acute Physiology with Perinatal Extension-II, score range: 0{20 (mild), 21{40 (moderate), 41 and higher (severe)
\end{tablenotes}
\end{threeparttable}
\end{table}

```

table_1.tex

```

\begin{table}[h]
\caption{Association between change in new treatment policy and changes in treatments}
\label{table:TreatmentPolicyChange}
\begin{threeparttable}
\renewcommand{\TPTminimum}{\linewidth}

```



```

\makebox[\linewidth]{%
\begin{tabular}{lrl}
\toprule
& Chi-square & P-value \\
Treatment & & \\
\midrule
\textbf{PPV (Positive Pressure Ventilation)} & 0.822 & 0.365 \\
\textbf{Endotracheal Suction} & 50.5 &  $1e-06$  \\
\textbf{Meconium Recovered} & 21.2 &  $4.19e-06$  \\
\textbf{Cardiopulmonary Resuscitation} & 5.95 & 0.0147 \\
\textbf{Reason for Admission - Respiratory } & 1.16 & 0.281 \\
\textbf{Respiratory Distress Syndrome} & 0.844 & 0.358 \\
\textbf{Transient Tachypnea} & 0.0574 & 0.811 \\
\textbf{Meconium Aspiration Syndrome} & 0.932 & 0.334 \\
\textbf{Oxygen Therapy} & 0 & 1 \\
\textbf{Mechanical Ventilation} & 1.09 & 0.297 \\
\textbf{Surfactant} & 0 & 1 \\
\textbf{Pneumothorax} & 1.18 & 0.278 \\
\textbf{Breastfeeding} & 0.00626 & 0.937 \\
\bottomrule
\end{tabular}}
\begin{tablenotes}
\footnotesize
\item \textbf{Chi-square}: Chi-square Test Statistic
\item \textbf{P-value}: Computed P-value
\item \textbf{Treatment}: Types of Neonatal Treatments
\item \textbf{PPV (Positive Pressure Ventilation)}: Whether positive pressure ventilation was performed, 1:Yes, 0:No
\item \textbf{Endotracheal Suction}: Whether endotracheal suctioning was performed, 1:Yes, 0:No
\item \textbf{Meconium Recovered}: Whether Meconium was recovered, 1:Yes, 0:No
\item \textbf{Cardiopulmonary Resuscitation}: Whether cardiopulmonary resuscitation was performed, 1:Yes, 0:No
\item \textbf{Reason for Admission - Respiratory }: Admission due to respiratory reason, 1:Yes, 0:No
\item \textbf{Respiratory Distress Syndrome}: Presence of respiratory distress syndrome, 1:Yes, 0:No
\item \textbf{Transient Tachypnea}: Presence of transient tachypnea, 1:Yes, 0:No
\item \textbf{Meconium Aspiration Syndrome}: Presence of meconium aspiration syndrome, 1:Yes, 0:No

```

```

\item \textbf{Oxygen Therapy}: Whether oxygen therapy was given, 1:Yes, 0:No
\item \textbf{Mechanical Ventilation}: Mechanical Ventilation performed, 1:Yes,
      0:No
\end{tablenotes}
\end{threeparttable}
\end{table}

```

table_2.tex

```

\begin{table}[h]
\caption{Linear regression analysis of impact of policy change on neonatal
        outcomes}
\label{table:PolicyImpactOutcomes}
\begin{threeparttable}
\renewcommand{\TPTminimum}{\linewidth}
\makebox[\linewidth]{%
\begin{tabular}{lrl}
\toprule
& Coefficient & P-value \\
Outcome & & \\
\midrule
\textbf{APGAR1 Score} & -0.351 & 0.22 \\
\textbf{APGAR5 Score} & -0.26 & 0.257 \\
\textbf{Length of NICU Stay} & 0.441 & 0.66 \\
\textbf{SNAPPE-II Score} & -0.00569 & 0.998 \\
\bottomrule
\end{tabular}}
\begin{tablenotes}
\footnotesize
\item \textbf{Coefficient}: Coefficients from the Linear Regression Model
\item \textbf{P-value}: Computed P-value
\item \textbf{Outcome}: Neonatal Outcomes
\item \textbf{APGAR1 Score}: 1 minute APGAR score (scale from 1 to 10)
\item \textbf{APGAR5 Score}: 5 minute APGAR score (scale from 1 to 10)
\item \textbf{Length of NICU Stay}: Length of stay at the Neonatal Intensive
        Care Unit, in days
\item \textbf{SNAPPE-II Score}: Score for Neonatal Acute Physiology with
        Perinatal Extension-II, score range: 0{20 (mild), 21{40 (moderate), 41 and higher
        (severe)

```

\end{tablenotes}
\end{threeparttable}
\end{table}

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