The Effect of Barometric Pressure, Temperature, and Precipitation on Preterm Labor in Expecting Women in South Carolina

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Each year, approximately 9.9% of infants in the United States are born prematurely at less than 37 weeks of gestation with unidentified causes. From 2014 to 2016, the total preterm birth rate rose 3%, and late preterm birth rates rose almost 4%. One source of preterm labor that has been examined in recent years is its potential correlation with meteorological phenomena, including barometric pressure, temperature, and precipitation. In September of 2019, birth data recording 322 deliveries from two South Carolina hospitals was collected along with weather data on the given dates. The changes in temperature, barometric pressure, and precipitation for the day of each birth were calculated and paired with each individual. Simple linear regression analyses were used to determine the coefficient of correlation and statistical significance of individual factors. To examine the impact of multiple factors on preterm labor, multiple linear regression analyses were conducted. The individual simple regression tests revealed no statistically significant correlations between the number of weeks early that labor occurred and changes in pressure, temperature, or precipitation. One multiple regression test revealed a p-value of 0.064, indicating that the relationship between the number of weeks early and the combination of changes in pressure and precipitation was statistically significant at a 90% confidence level.

Introduction

Each year, approximately 3,855,500 infants are born in the United States. However, 9.9% of these children are born prematurely, at less than 37 weeks of gestation, with unidentified causes. In recent years, premature birth numbers have begun to rise. From 2014 to 2016, the United States preterm birth rate rose 3%, and late preterm birth rates, or the rate of births occurring between 34 and 37 weeks of gestation, rose almost 4%. Additionally, these early onsets of labor are beginning to occur even earlier in pregnancies, often transpiring at 34 or 35 weeks.[1] Preterm labor is medically recognized as an onset of labor and delivery before a pregnancy reaches 37 weeks gestation.[2] Premature births have been studied by hundreds of medical research organizations, and common responses of known causes include urinary tract infections, amniotic membrane infections, weakened cervixes, high blood pressure and other conditions.[3] However, one source of preterm labor that has been examined in recent years is the correlation between certain meteorological phenomena and the rupture of membranes, or the amniotic sac surrounding the baby. Though multiple studies have varying conclusions resulting in no correlation, there is detailed evidence that associations have been found between preterm labor and meteorological phenomena concerning changes in barometric pressure, changes in temperature, and onsets of precipitation.[4]

Some scientists are suggesting this link between climate and increased premature births because of the noticeable climb in global temperatures over the past 50 years. According to the National Oceanic and Atmospheric Administration (NOAA) 2018 Global Climate Summary, the combined land and ocean temperatures were increasing at a rate of 0.07 degrees Celsius per decade since 1880, but they found that the rate of temperature increase per decade since 1981 was 0.17 degrees Celsius; more than twice as great.[5] This global temperature rise has very large implications because it affects nearly every biological cycle and process occurring in Earth's atmosphere. Although research is still in the early stages, meteorologists and climate scientists like Kerry A. Emanuel (2013) have examined climate models that predict an increase in hurricane and tropical cyclone activity throughout the 21st century, and this predicted phenomenon could be rooted in the global temperature change.[6] Though not all researchers agree with Emanuel's conclusion, the majority agree on one idea concerning future tropical storms: their detrimental impacts will be greatly intensified. As explained by both the Center for Climate and Energy Solutions (2017) and the NOAA Geophysical Fluid Dynamics Laboratory (2019), the warmer sea surface temperatures could lead to a 2% to 11% increase in average maximum wind speeds, and rainfall rates are predicted to increase by about 20%.[7,8] Sea levels will rise anywhere from 1 to 4 feet in the next century, causing more destructive storm surges than before. Furthermore, the pressure in the atmosphere will fluctuate dramatically during storms. During a hurricane, the barometric pressure in the area encompassing the storm will drop to extremely low levels, which allows more air to be drawn in and builds the event.[9] Altogether, current research has made it clear that extreme changes are occuring in the global climate, whether it be due to anthropogenic actions or natural occurrences. It remains to be found whether or not these impactful weather conditions contribute to the growing number of spontaneous preterm labor admissions.

Though the results of previous studies may be conflicting in determining the cause of prematurity, the conclusions of those prior indicate that the impacts of climate change are widespread and affect a multitude of other natural processes. Likewise, the impacts of preterm birth can also be relatively widespread as this occurrence has an influence on affected families, hospitals, and medical personnel. According to Healthline, an online American health organization, premature infants are more likely to be born with life-threatening conditions, including brain or pulmonary hemorrhages, hypoglycemia, and anemia.[3] The risk of preterm infant death is high, and those who do survive may face developmental delay, cerebral palsy, and hearing or vision problems.[10] The idea that these negative outcomes could have been prevented often leads to lawsuits that can be costly to hospitals. Additionally, professional consultants like those at Thurswell Law (2018) affirm that a large number of parents that experience preterm birth complications raise questions about medical malpractice due to a lack of attention in the neonatal intensive care unit.[11] On the other hand, hospitals that have sudden influxes of unexpected births can suffer economically if they have to call in additional staff, pay the present staff overtime, or even transfer the baby to another unit due to a lack of trained personnel available.[12]

Hypothesis

The significant impact of premature births and the questions surrounding its potential cause begs the question: To what extent do changes in barometric pressure, temperature, and precipitation in South Carolina influence premature labor in expecting women? After examining the conclusions of previous studies, several hypotheses were made regarding this study. First, it was predicted that there would be a strong correlation between sudden changes in temperature and increases in premature labor. The second prediction was that there would be a slightly weaker but still significant correlation between atmospheric pressure changes and increases in premature labor. Finally, the third hypothesis was that precipitation would not play a statistically significant role in preterm labor.

Literature Review

In 2011, researchers Ochiai, Gonçalves, Ambrizzi, Florentino, Wei, Soares, Araujo & Gualda from the University of São Paulo in Brazil conducted a multivariate analysis to assess the extent of influence external factors had on childbirth. The neonatal data was gathered from the delivery unit of a university hospital in São Paulo between January 1, 2003, and December 31, 2007, and 17,417 consecutive labor admissions and births were recorded in this time. The meteorological factor measurements were collected from a data log by the Institute of Astronomy, Geophysics and Atmospheric Science, which was in close proximity to the chosen hospital. By correlational research methods of a multiple linear regression analysis, the research concluded that an increase of 3.2°C in outdoor temperatures increased labor probability by 74%, and a decrease of atmospheric pressure by 0.88 hectopascals (HPa) increased labor probability by 27%. The researchers also compared factors such as lunar phases and nearby tidal amplitudes, but they found no significant correlation. When discussing the practical implications of their findings, the authors suggested that it would be beneficial to provide 20% more multi-professional staff on weekday mornings and limit professional vacations in times of predicted childbirth peaks.[13]

Another study completed in 2016 by Cox et al., a group of professors and medical specialists from Belgium, London and Sweden, examined the impact that temperature changes had on the labors of expecting women in areas of temperate climate. The research was performed in Flanders, Belgium, where the Study Center for Perinatal Epidemiology (SPE) provided childbirth data and the Belgian Interregional Environment Agency provided half-hourly temperature measurements during the period from 1998 to 2011. The results indicated a trend among 807,825 singleton births that demonstrated an increased risk of preterm birth with same day delivery for sudden increases in temperature and increased risk of preterm birth with sudden drops in temperature 1-2 days before delivery. Altogether, the study suggests that pregnant women should be aware of the impacts of temperature on their labor process. A gap in their research was seen in the lack of data collected about the impact of severe weather events in differing intensities and frequencies.[4]

With an alternate conclusion, in 1999, Linda Owen of Grand Valley State University conducted her Masters Theses on this topic, specifically on the "Concurrence of Decreases in Barometric Pressure and Spontaneous Rupture of Membranes in Term Gravid Women." Owen gathered information from delivery logbooks and charts of women admitted to a specific hospital in the midwest from 1997 to 1998. After using a retrospective design to examine the relationships between hospital admission due to spontaneous rupture of membranes and barometric pressure decreases of at least 10 millibars, Owen concluded that the factors demonstrated no correlation. However, Owen's study faced limitations such as discrepancies in climate measurements. The researchers acknowledged that at the given time, there was no common consensus among meteorologists of what constituted a significant change in barometric pressure.[14]

This same conclusion of limited correlation was found in a study examining the influence of seasonality and weather changes on premature birth incidence. Directed by Romainian obstetrics and neonatal researchers Muresan, Staicu, Zaharie, Marginean & Rotar (2016), the aim was to analyze the influence of atmospheric conditions by studying 189 premature births with gestational ages between 24 and 37 weeks. After collecting weather data from the commercial weather site "Wunderground.com," a Pearson's product-moment correlation test was run to assess the relationships between the numerous factors. The results showed that while there were moderately positive correlations between temperature variations and preterm birth incidence, there were no significant statistical correlations between changes in atmospheric pressure, wind speed, or humidity.[15] Altogether, the results of this study dispute the predicted outcome of the current research project because of the lack of correlation with atmospheric pressure, which was hypothesized to be the most contributing factor.

A study conducted to address the gap of precipitation and storms on preterm birth was completed in 2016 to examine 2004 Hurricane Charley's impact on childbirth rates in Florida. Overall, they found that pregnant women who were exposed to the extreme weather conditions experienced increased risk of extremely preterm delivery of 32 to 34 weeks. However, the risk decreased once the women reached about 37 weeks, leading to the suggestion that the sudden change in weather would affect the women greatly at that moment, but for those who do not deliver prematurely after exposure, the effects would fade and delivery could proceed as planned. Additionally, the researchers established the importance of these extremely preterm births, explaining that there is a high risk of fetal death at these earlier weeks of gestation and that the infants could experience negative consequences like "respiratory and cognitive impairment." The study states that further research in this area is needed because "associations between hurricane exposure and preterm delivery need to be better understood as coastal populations and hurricane severity increase(s) in the United States." Furthermore, the researchers believe that the results should potentially be made known to public health leaders to aid in creating recommendations for prenatal care during storm seasons.[16]

Gap

Notably, in a large majority of the previously mentioned studies, there is either a clear lack of concrete weather data, or there is a correlation examination conducted with a minimal number of factors. To resolve this gap, in this study, all weather data was collected from a credible commercial weather site, and was cross-checked for accuracy with several other sources. Additionally, multiple weather factors were examined at the aim of determining which conditions are the most influential on preterm births, meaning that a minimal number of factors was not an issue. Both individual and multivariate correlation tests were performed to determine whether an impact resulted from a single variable or a combination of factors

Methods

In order to test the hypothesis, a correlational research method was employed to report the levels of association between the occurrence of premature births and weather conditions. A correlational method was selected because of the lack of public access and legal ability to gather individual birth data and the specialized expertise held by professional weather stations on meteorological data collection, both of which discouraged an experimental method. Furthermore, the incorporation of this method allows for the analysis of several specific points of information individually. The next method of correlational analysis would be conducted through a multiple linear regression analysis that would examine the potential impact of the exposure to several explanatory variables at once on the response variable. The identified explanatory, or X, variables were magnitudes of change in barometric pressure, temperature, and precipitation in the hours leading up to the onset of labor. The response, or Y, variable represented the level of prematurity or weeks of gestation of the mother at the time of delivery. Additionally, the design of this study was observational, meaning that no outside treatments were imposed, and that only natural, already occurring events would be recorded.

Birth Data Collection

The first step of data collection was to select hospitals in the state of South Carolina that would be willing to provide birth charts from September 1, 2019 to September 30, 2019. The length of this time period was chosen due to the difficulty in accessing more than one month's worth of birth data. After contacting several neonatal departments by phone and email, a hospital in the midlands and a hospital near the coast, referred to as Hospital 1 and Hospital 2, respectively, agreed to supply data for this time period. These hospitals were chosen due to their differences in location, and therefore climate, within the state of South Carolina, and for their willingness to provide the requested information in a timely fashion. As suggested in 2018 by a similar study conducted in Puerto Rico by Yu, Feric, Cordero, Meeker and Alshawabkeh concerning the influence of temperature and precipitation on preterm labor, information about the mother's weeks of gestation, time and date of labor admission, delivery method, known maternal risk factors, and any other useful record denoting the mother's labor process were collected from these hospitals. The additional labor information allowed for the researchers to disregard any deliveries resulting from an induction of labor, as these occurrences were not natural or spontaneous. The method incorporated by the similar study of excluding births of twins, triplets, or any other multiple offspring birth data from the study was also replicated.[17] These data points were eliminated due to the potential presence of a confounding variable if they were included, as the majority of studies previously conducted on the topic found correlations between multiple offspring pregnancies and preterm births.

Weather Data Collection

The next step of data collection was gathering the records of weather trends and behavior for the area surrounding each specific hospital from September 1, 2019 to September 30, 2019. The data points were collected from a credible commercial weather service called Weather Underground that records the detailed meteorological condition reports from specific time intervals in areas worldwide and is open to the public. It reliably provides daily measurements including temperature, wind speed, barometric pressure, humidity, and more.[18] The temperature measurements were collected in degrees Fahrenheit, barometric pressure measurements were collected in inches of mercury (Hg), and precipitation measurements were collected in inches of precipitation per day.

Figure 1 (see Appendix A) is an example of a broad view of weather data from the weather collection area in the midlands of South Carolina for Hospital 1. *Figure 2* (see Appendix A) is an example of a broad view of weather data from the collection area near the coast of South Carolina for Hospital 2. Though Weather Underground only provided visual monthly representations for temperature and precipitation, all three measurements (pressure, temperature, and precipitation) were recorded in charts. After gathering all these points of data, enough evidence had been collected to perform correlation tests and come to a conclusion regarding the impact of weather conditions on prematurity.

Data Analysis and Results

To measure the correlation between preterm labor and the weather conditions, the preterm labor time and determined dates would be examined, and then barometric pressure, temperature, and precipitation data points from the hours before labor admission for each delivery would be properly denoted for each individual. Correlation tests through ordered pair matches would be used to graph a line of regression to determine the coefficient of correlation and its possible statistical significance. To examine the impact of multiple factors on preterm labor, a multiple linear regression analysis would be conducted. The Minitab 19 program was used to analyze the information and run statistical tests on the data.[19]

When the data was collected, 166 total labor admissions were recorded from Hospital 1, 32 of which were preterm, and 156 total labor admissions were recorded from Hospital 2, 28 of which were preterm, for September of 2019. For each delivery, the weeks of gestation were converted into numerical values with decimals reporting the total time of fetal development at the occurrence of labor admission, which will be remaining confidential in *Figure 3* found in Appendix A. Both hospitals requested for the majority of the birth data to remain private, therefore the full data spreadsheets included in this study will not release any "Weeks Early" or "Time" data points. For data analyses, the "Weeks Early" values, calculated by subtracting the total weeks of gestation from the accepted 40 week full term status, were used in place of the actual total weeks values to emphasize the distinction between full term and early births. In total, 8 tests were completed to determine any correlation between the factors, collecting information about p-values, R-squared values, and fitted models. The p-values collected will interpret the probability that a linear relationship between the variables is present, given the data provided. The R-squared values record the percentage of variation in the data that can be accounted for by the provided fitted model. This means that a low R-squared value would indicate that the equation used to create the model is only able to account for a low amount of variation, and this suggests that the model may not be well-suited for explaining data trends, possibly because no trends are actually present.

Hospital 1 Data Analysis and Results

For Hospital 1, three simple linear regression tests and one multiple linear regression test were conducted. Because of the large sample size ($n = 166$), normality is likely not a limitation, and the sample is large enough to obtain a precise estimate of the strength of the relationship.

The simple linear regression for "Weeks Early" and "Precipitation" at Hospital 1 yielded a p-value of 0.150 ($p > 0.05$), which exceeded the significance level of 0.05, meaning that there was not a statistically significant relationship between the factors. The suggested linear model, seen in *Figure 3* (see Appendix B), yielded a R-squared value of 1.26%, indicating that only 1.26% of the variation in results could be explained using the regression model.

When examining the relationship between "Weeks Early" and "Temperature Change" for Hospital 1, the association was also found to be statistically insignificant. The p value of 0.895 ($p > 0.05$) largely oversteps the 95% confidence interval. The fitted model for this set of variables is shown in *Figure 4* (see Appendix B). The R-squared value was 0.01%, indicating that an extremely small percent of variation of results would be explained by the proposed linear regression.

A simple linear regression test for "Weeks Early" and "Pressure Change" yielded yet another statistically insignificant p-value of 0.394 ($p > 0.05$). The fitted model is shown in *Figure 5* (see Appendix B). The R-squared value was 0.46%, meaning that only this percentage of variation in the results would be explained by the equation.

Next, the multiple linear regression with "Weeks Early" as the Y, or response, variable and "Precipitation" and "Pressure change" as the X, or explanatory, variables did reveal a statistically significant relationship when using a 90% confidence level. Initially, "Temperature Change" was also loaded into the Minitab program as a part of the regression, but this factor was determined to not be a statistically significant variable and was excluded from the calculation of the p-value and R-squared value. The p-value was 0.064 ($0.05 < p < 0.10$), suggesting that there is a relationship present between the "Weeks Early" and "Precipitation" and "Pressure Change." On the other hand, the R-squared value was 2.11%, meaning that the provided regression can explain 2.11% of variation in the results. The final model equation is shown in *Figure 6* (see Appendix B), with X2 representing "Pressure Change" and X3 representing "Precipitation."

Hospital 2 Data Analysis and Results

The same series of simple linear and multiple linear regression tests were once again performed for Hospital 2 ($n = 156$). In the simple linear regression for "Weeks Early" and "Precipitation," the p-value was 0.185 ($p > 0.05$) which is not statistically significant in the given 95% confidence interval. The fitted equation for the linear model describing this relationship is shown in *Figure 7* (see Appendix C). The R-squared value was

1.14%, meaning that the model only explains 1.14% of variation in the results.

Another simple linear regression test was performed between "Weeks Early" and "Temperature Change," and it yielded a statistically insignificant p-value of 0.240 ($p > 0.05$). The R-squared value was 0.90%, meaning that 0.90% of variation in results was explained by the fitted linear model shown in *Figure 8* (see Appendix C).

The last simple linear regression test was for "Weeks Early" and "Pressure change," and it produced a statistically insignificant p-value of 0.904 ($p > 0.05$). The fitted equation for the model is above (see Appendix C, *Figure 9*), but the R-squared value reflects that this model would only explain 0.01% of variation in the "Weeks Early" results.

Finally, for Hospital 2, a multiple linear regression test concluded that there was no relationship between any of the X and Y variables, meaning that a p-value could not be computed. There was not enough evidence of correlation to develop a plausible model to reflect the data, therefore all three X factors, "Precipitation," "Pressure Change," and "Temperature Change," were excluded from the Minitab measurements and no numerical results could be acquired.

Discussion

The original hypotheses made in this study were for the most part not supported by the results of the data analyses. While the prediction that precipitation would not be a statistically significant factor was supported in the simple linear regression tests for both hospitals, precipitation was one of the variables that exhibited statistical significance after the multiple linear regression for Hospital 1. Additionally, it was hypothesized that both temperature changes and barometric pressure changes would have strong correlations with the number of weeks early, but aside from the pressure change showing statistical significance during the multiple linear regression for Hospital 1, no other regression tests revealed significant or strong correlations between the explanatory and response variables.

New Understanding

While these results do not carry much statistically significant weight overall, they may bring some new understanding to the selected field by suggesting that there is a weak relationship between preterm labor, precipitation, and pressure change, and this is a conclusion that has not been reached in previous studies of similar topics. A possible explanation for this conclusion may result from the fact that precipitation and pressure changes frequently occur as a result of one another during storms while temperature has a less direct short-term relationship with these factors. Because low pressure causes air to converge and creates condensation and precipitation, these pressure and precipitation data points could have been more likely to arise in the same time periods.[20] Additionally, the results significantly suggest that there are no individual relationships between any of the examined weather conditions and preterm labor in South Carolina. While this conclusion has been reached by previous researchers, this was likely the first study conducted in this region analyzing these specific factors, which could contribute to a new field of information considering that many states have distinctively different climates. Overall, this new understanding gained may encourage researchers to either conduct further studies for validity or to conclude that many of the chosen weather factors are insignificant and begin examining other possible sources of preterm birth.

Implications

The greatest implication stemming from the results of this study is that research concerning sources of preterm labor may begin to retreat from weather as a primary cause. Because the majority of statistical tests revealed no correlation, and the only significant test was at a 90% confidence level, it may be concluded that if weather was a factor in preterm labor, it would not be contributing greatly. This conclusion could lead to researchers branching out to continue researching the root of the problem presenting by increasing cases of preterm labor.

The outcome of this study could additionally have implications concerning the medical field and the education of expecting women. By considering the idea that a combination of precipitation and pressure change can increase preterm labor in South Carolina, local hospitals could make adjustments to the amount of medical personnel available on days with the significant factors forecasted in order to better predict and address problems arising from spontaneous preterm labor. The medical personnel could be more prepared to attend to the sudden influxes of preterm labor admissions and could feel more security in having a general estimate of the level of responsibility that they will have on a given day. However, greater research over a longer period of time would be advised before hospitals make any major financial decisions based on these results. Another implication on the South Carolina community that could be brought into effect more easily is to encourage expecting women to be made aware of the risks associated with preterm labor and its tentative connection with precipitation and pressure change. A possible positive impact of making this knowledge widespread would be a decreased number of lawsuits due to incidents during preterm labor. Additionally, if it is known that combinations of precipitation and pressure change can influence preterm labor, then there may be a chance of similar weather conditions having an impact on patients facing other medical diagnoses. The conclusion reached in this study could serve as a foundation for greater research into weather changes' impacts on patients with chronic conditions like joint pain and migraines.[21]

Limitations

One limitation of the study was the inability to use more specific information concerning the change that occurred in weather. Previous studies, including Mathew et al. (2017), compared the impact of increases and decreases in temperature, and Akutagawa, Nishi, & Isaka (2006) compared the impact of increases and decreases in barometric pressure.[22,23] Due to time limitations and the difficulty of determining the exact increase or decrease in selected variables for all 322 collected data points, the daily range of temperature, daily range of barometric pressure, and total daily temperature was gathered for each date, resulting in soley positive quantities. If the weather data had been measured with consideration to increases and decreases for each value, the conclusion reached may have been more specific or could have shown different measures of statistical significance. Time limitations also caused this study to only examine short-term effects of weather conditions on preterm labor, and the data was only gathered over the span of one month, which could have affected the accuracy of the results or the implications of the results to a larger scale.

Another factor that may have impacted the results of this study was the presence of Hurricane Dorian at the time the data was collected. Hurricane Dorian made landfall in Elbow Cay, Bahamas on September 1, 2019 as a Category 5 hurricane, and it was the first major hurricane of the 2019 Atlantic hurricane season. South Carolina was affected by the storm as a Category 4 hurricane on September 4, 5 and 6.[24] The coastal data collection illustrated that a fair amount of precipitation data was collected during this time period, however, because of mandatory evacuations and rough conditions, there must be a recognized margin of error to the gathered measurements. Even with equipment fine tuned to record these weather phenomenons, every sudden change in temperature, precipitation, and pressure may not have been noted by the chosen weather source, Weather Underground.

Future Work

Future work will focus on the application of the chosen methodology with an increased number of variables. Greater research should be conducted concerning the lunar cycle and the relation of this process to preterm labor due to the large number of medical personnel testimonies claiming that certain moon phases result in elevated numbers of deliveries.[25] Research could also be conducted with variables like humidity, wind speed, dew point, and visibility. Another step that could be taken to improve the accuracy of results would be to replicate the study in a wider range of climates. Though a climate variation was attempted in this study by focusing on both coastal and midlands areas of South Carolina, doing so on a larger scale could yield different results. On a nationwide scale, future work could involve examining any differences in results based on a location's longitude, latitude, and proximity to certain water sources. Additional information about the change in average yearly measures of temperature, barometric pressure, and precipitation, the change in average yearly numbers of premature births, and the change in harmful emissions or air pollution levels in the selected areas over the past several decades could also be collected from state records to determine if any long-term patterns exist, expanding the body of knowledge about this subject.

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Appendix A: Graphical Example of Weather Data

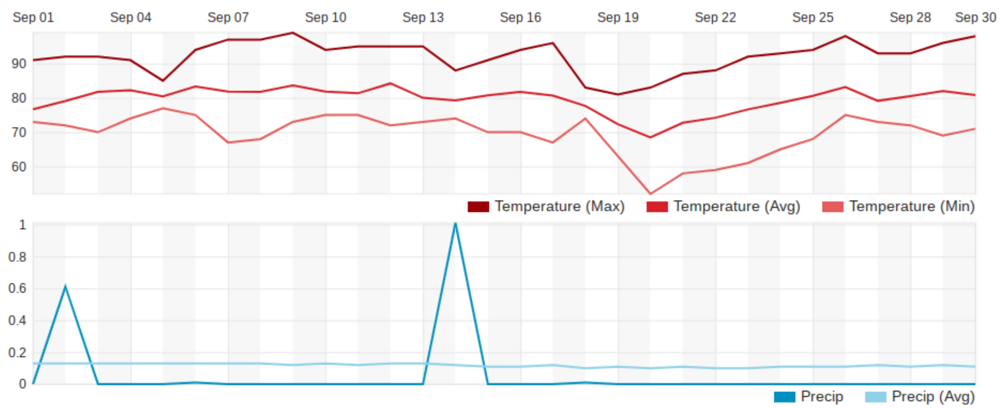

Figure 1. Example of weather data collection for Hospital 1 (Weather Underground, 2019)

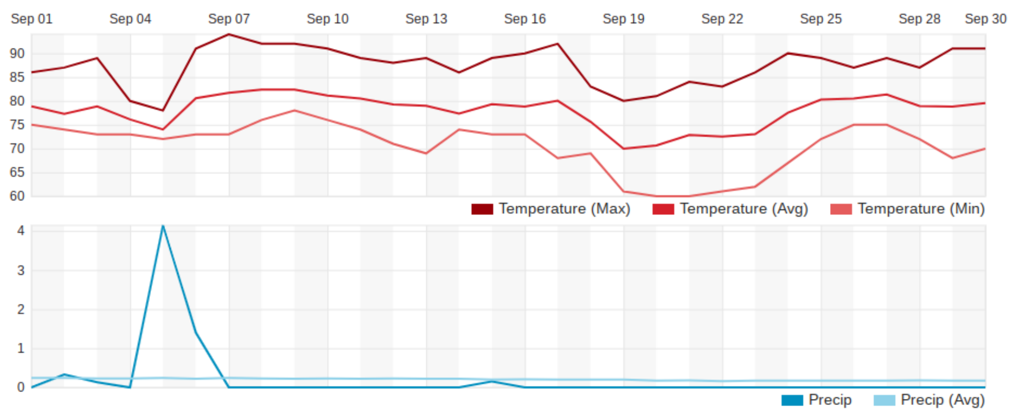

Figure 2. Example of weather data collection for Hospital 2 (Weather Underground, 2019)

Appendix B: Hospital 1 Graphical Results

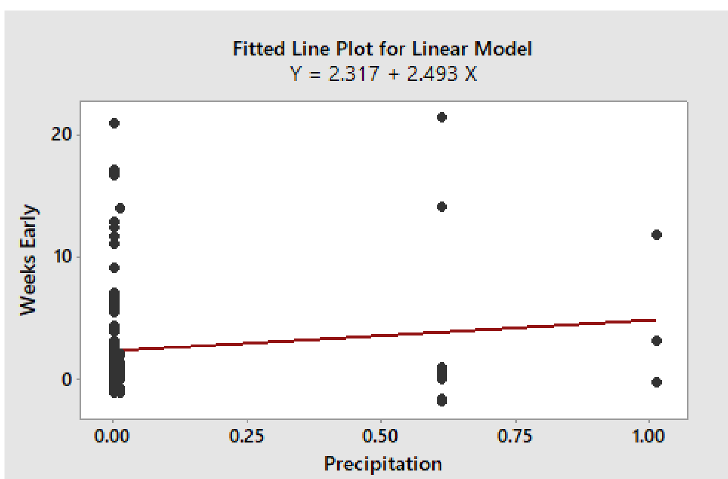

Figure 3. Fitted line plot for Weeks Early vs. Precipitation at Hospital 1

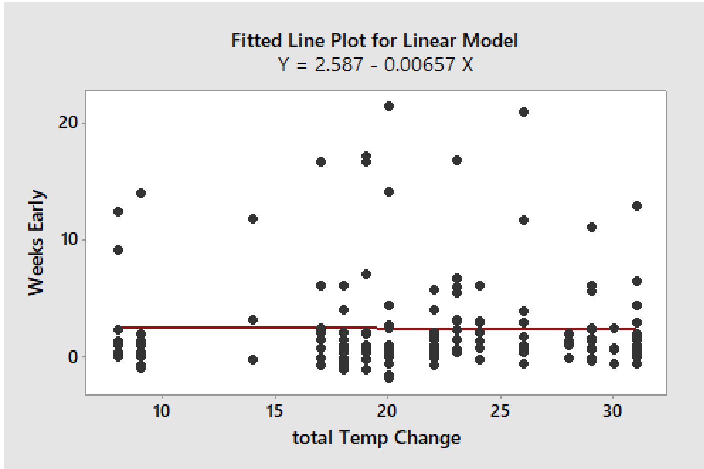

Figure 4. Fitted line plot for Weeks Early vs. Temperature Change for Hospital 1

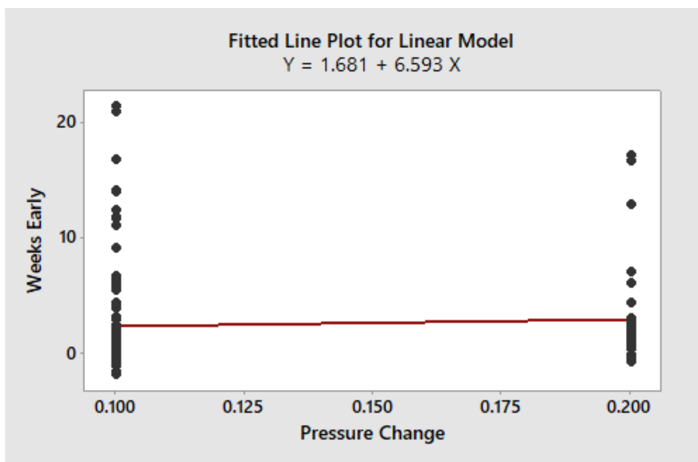

Figure 5. Fitted line plot for Weeks Early vs. Pressure Change for Hospital 1

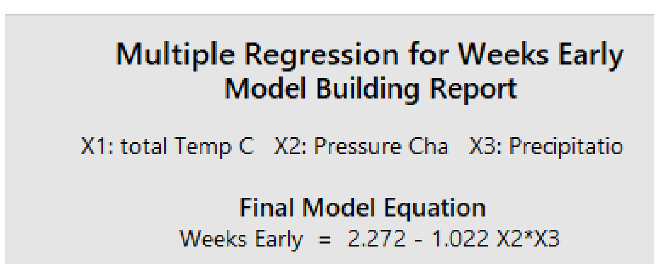

Figure 6. Final model equation for Weeks Early vs. Precipitation & Pressure Change for Hospital 1

Appendix C: Hospital 2 Graphical Results

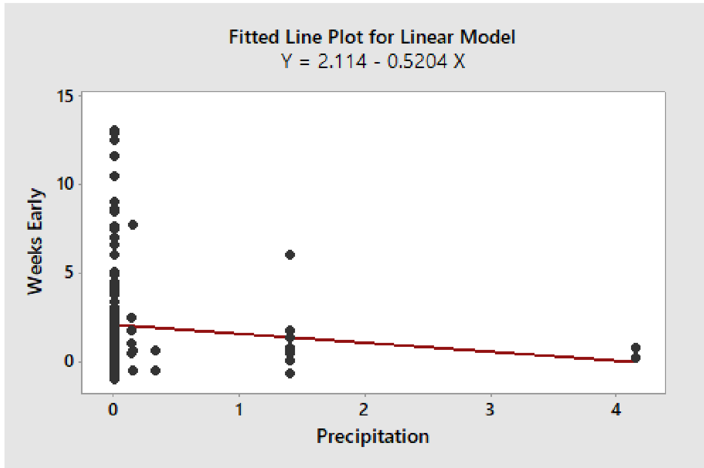

Figure 7. Fitted line plot for Weeks Early vs. Precipitation for Hospital 2

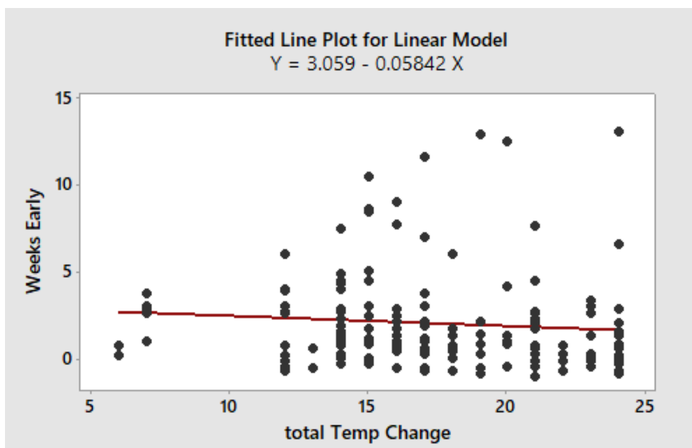

Figure 8. Fitted line plot for Weeks Early vs. Temperature Change at Hospital 2

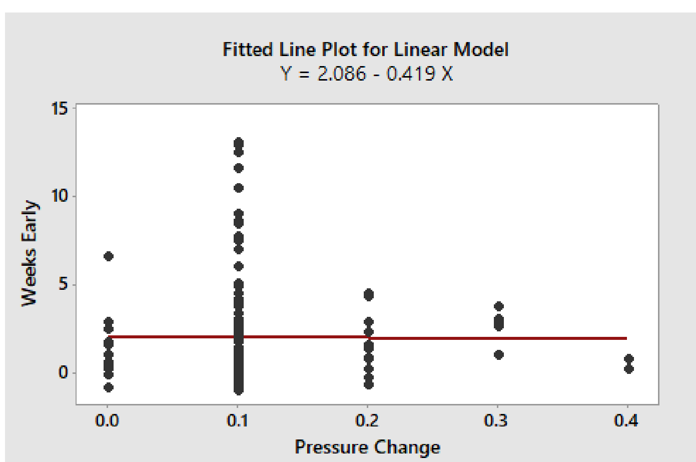

Figure 9. Fitted line plot for Weeks Early vs. Pressure Change at Hospital 2