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The Spatial-Temporal Model of COVID-19 Tests, Cases, and Deaths in the State of Nebraska

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Abstract

The goal of this project was to illustrate the spread of COVID-19 tests, cases, and deaths within the state of Nebraska and identify non-random clusters using a spatial-temporal model. This project is pertinent and innovative, as few spatial-temporal models in the United States revolving around COVID-19 offer information at the county, let alone, the state level. De-identified data was extracted from the State of Nebraska's Department of Health and Human Services COVID-19 dashboard, transformed and prepared for analysis using SAS coding language. Clusters were identified though SaTScan software using a space-time permutation model. The model identified 5 different clusters related to cases and deaths, as well as 3 clusters linked to tests. The majority of the identified clusters could be explained by outbreaks in Nebraska meat-packing communities or long-term care facilities. This project offers insight on how COVID-19 impacted Nebraska communities and explains how the pandemic evolved throughout 2020.

I. Project Description

Specific Aims

As of December 1st,2020, nearly 750,000 Nebraskans have been tested for COVID-19 infection. Of the individuals who received testing, just over 17% of them have received a positive test result. At that time, the state had faced just over 1,000 deaths associated with COVID-19 infection (1). While the number of tests, cases, and deaths have inevitably increased over time, little is known regarding whether these measures are random or clustered. This study allows us to better understand how measures related to COVID-19 infection may be dependent on the areas in which an individual lives, relative to the social determinants of health within that defined location. This information could be used to impact policy making, as well as the identification of gaps in resources, which could promote initiatives and funding within that area.

Aim 1: Use SaTScan space-time permutation model to determine if the number of COVID-19 tests, cases, and deaths in Nebraska can be defined by clusters.

Aim 2: Create a public-access dashboard using Tableau software to display trends and clusters related to COVID-19 tests, cases, and deaths.

SatScan software will be utilized to identify high and low clusters of Nebraska's COVID-19 tests, cases, and deaths spatially and over time. Identified clusters are further evaluated to assess whether they are driven by local policy change or events, such as mask mandates or stay-at-home requirements.

Tableau Public software will be utilized to display and animate the spread of tests cases and deaths across the state of Nebraska. This dashboard will be public access so

those who are interested can visualize the various trends and clusters identified through this project.

Significance/Background

We have been at war with COVID-19 over the past year. As a world, nation, and state, we have fought endlessly to conquer this pandemic. We have witnessed a lack of testing resources and access to healthcare, as well as numerous policy changes, and various attitudes toward COVID-19. While COVID-19 related measures, such as the number of tests, cases, and deaths appear to be random, the factors described above may have the potential to influence these measures. The goal of this project is to assess whether COVID-19 tests, cases, and deaths within the state of Nebraska can be defined by clustered spread using the SaTScan space-time permutation model. The identified clusters will be further evaluated to determine if they are linked to local events or policy changes, such as mask mandates.

Spatial-temporal models have become increasingly used within epidemiological studies as they are beneficial in predicting and defining disease outbreaks. These models are diversifiable and have been used to better understand cancer mortality in various areas as well as predict risk for being exposed to Zika virus (2,3). These models have been able to differentiate between random and non-random incidence of disease and further act on those that are non-random to produce better health outcomes. One study using a Bayesian spatial-temporal model was able to identify particulate matter concentrations across the United States. High concentrations of particulate matter had the greatest effects in locations where poverty was high. The study was able to define that the reduction in particulate matter pollution would lead to better health outcomes across the

entire country, but especially in areas where there are observable gaps in the social determinants of health (4). Spatial-temporal models have proven to be beneficial in predicting other epidemiological outbreaks, such as the Ebola virus epidemic of 2013. Researchers were able to identify that different Ebola virus genomes are associated with various levels of virulence, similar to the COVID-19 variants. If Ebola virus genomes are assessed immediately upon infection, public health officials may be better able to control transmission and prevent disease outbreaks (5).

COVID-19 may be the next hot topic when describing use of spatial-temporal models, as we aim to never go through another 2020. Around the same time the first COVID-19 case appeared in Nebraska, a study describing a spatial-temporal model aimed at controlling COVID-19 transmission was published out of Wuhan University in Wuhan, China. The study demonstrated that a country-wide quarantine mandate issued between January and March effectively controlled viral transmission across the country (6). A spatial-temporal analysis conducted on COVID-19 prevalence in the United States demonstrated that transmission was also dictated by areas where there were gaps in the social determinants of health. The prevalence of COVID-19 was greater in areas where obesity and smoking rates were high, in addition to areas where there is an increased concentration of minority groups. Counties that also had a high density of individuals aged 25-49 demonstrated an increased prevalence in COVID-19 (7).

While COVID-19 spatial-temporal analyses are increasing as the pandemic persists, the proposed study offers novelty. Few spatial-temporal models revolving around COVID-19 offer information at the county, let alone, the state level. This study aims to identify clusters that are linked to the spread of the number of tests, cases, and deaths at the

county-level in addition to identifying potential influencers of the non-random spread. It is evident that the spread of the virus varied immensely between urban and rural areas within the state of Nebraska. Observationally, Nebraska appears to be one of the few states where policy making, such as mask mandates and directives, occurred more often at the local versus the state level. This project offers a sense of transparency regarding COVID-19 data within our state, which is crucial in defining how COVID-19 has impacted Nebraska, uniquely, at the state and county levels.

II. Methodology

The general methodology for conducting spatial-temporal analysis is surrounded within 6 steps: data collection and preparation, mapping and examining, pre-process, define and model spatial structure, evaluate model, and utilize results (8). The number of COVID-19 tests, cases, and deaths were acquired through Nebraska's Department of Health and Human Services (DHHS) COVID-19 Dashboard via web scraping technique using R coding language. As data is processed and expressed on the Nebraska DHHS Dashboard, it can take some time for the tests, cases, and deaths to be assigned to their respective county. The data was collected through January 17th, 2021 and the final two weeks were truncated to only show data through January 2nd, 2021, to ensure the data had been assigned a county. This was also the last epidemiological week of 2020. The original data represents cumulative tests, cases, and deaths by county within the state of Nebraska. SAS coding language was used to prepare the data to represent the new tests, cases, and deaths by epidemiological week and county. Test data for the state began on February 14th, 2020, which is represented as epidemiological week 7. Case and death data began on March 6th, 2020, which is represented as

epidemiological week 10. Tests, cases, and deaths were all age-adjusted using the percent of the county that is aged 65 or older by week using Poisson log-linked regression analysis. Predicted values were then multiplied by 2019 U.S. Census (9) predictions for each county to return the age-adjusted counts. Both age-adjusted and raw counts for tests, cases, and deaths were transformed into rates per 10,000 people to protect the privacy of individuals who live in counties with small population density. Arthur, Banner, Blaine, Deuel, Harlan, Hayes, Keya Paha, Logan, Loup, Sioux, Thomas, and Wheeler counties reported no deaths during the time study, so all rates were described as 0 for both raw and age-adjusted counts. Geographical data from 2019 U.S. Census (9)was merged into the dataset to provide latitude and longitude values for each of the counties. The SaTScan (10) space-time permutation model was then used to assess for high or low case clusters for each week, in each county, relative to the rest of the state. The space-time permutation model was the model chosen because it treats all space and time locations as if they are independent of one another and compares it to the expected outcome. This model functions by identifying 93 different centroids for the 93 different counties within the state of Nebraska. Clusters will be identified by running a window over the centroid (county) of interest to assess for that week in time to assess for higher levels of incidence in tests, cases, and deaths than what the expected rates are. Monte Carlo simulations will be utilized to assess for the presence of clusters within a certain centroid for a designated week in time. When a cluster is identified, it suggests that a specific location at a specific time period has a higher or lower case count than expected compared to other space-time locations. These clusters are then explored at a deeper level by looking through news and media outlets that may be able

to best describe the reasoning behind a cluster. The raw and age-adjusted rates of COVID-19 tests, cases, and deaths as well as identified clusters over time are further illustrated using Tableau Public (11) software. The dashboard depicts both the actual and age adjusted trends in COVID-19 tests, cases, and deaths. These map trends were formed by using the original data that had been prepared to express non-cumulative, weekly totals. Latitude and longitude were added to the rows and columns section which prompts the software to produce a map. The number of actual or age adjusted tests, cases, and deaths were then placed in the marks card to display the values in each of the counties. Epidemiological week was place in the page section which further animates the maps, showing how the number of COVID-19 tests, cases, and deaths fluctuated across the study period. Cluster maps were produced using exported shape files from SaTScan. Latitude and longitude were again placed in the columns and rows section. The clusters IDs were placed in the marks card along with the observed and expected values to be displaced on the map. The radius of the clusters was expressed using a geometrical variable associated with the shape file. The cluster maps were then animated by using the start and end epidemiological weeks in the page card. The dashboard can be viewed by clicking HERE.

III. Results

The original data represented the number of cumulative tests, cases, and deaths per county, which was prepared to represent the new numbers of tests, cases, and deaths for each epidemiologic week (Table 1). After all data sets were age-adjusted and transformed into rates per 10,000 people, the actual and the age-adjusted rates were compared (Figure 1). The age-adjusted rates appear to be consistent with the actual

rates for the entire dataset. However, when the data was filtered by each county, smaller counties appeared to have expected rates that varied moderately from the actual rates. This is likely due to the smaller sample size of those counties. Because of this phenomenon, the spread of tests, cases, and deaths across the state as well as identified clusters are depicted using the actual rates.

The spread of tests across the state is represented by Figure 2. Panel A demonstrates the number of tests per 10,000 people conducted at the beginning of the study period (Week 7, February 14th, 2020) where there was little to no testing happening across the state. Panel B illustrates the testing rate at epidemiological week 19. Dakota, Dawson, Colfax, and Saline counties all demonstrate increased testing at this time period. The entire state averaged nearly 53 tests per week per 10,000 people. Dakota, Dawson, Colfax, and Saline had 652, 260, 367, 300 tests per 10,000 people, respectively, that week. Panel C represents the testing rates for the state at epidemiological week 47. This panel shows how the testing rates are similar and have increased across the entire state. Nebraska's average testing rate was approximately 203 tests per 10,000 people at week 47. Panel D expresses the testing rates at the end of the study period, week 53. Test rates are similar across the state and have decreased. The average testing rate for the state was 75 tests per 10,000 people at the end of the study period.

The number of cases per 10,000 people is represented by Figure 3. Case rate are represented at epidemiological weeks 10, 19, 47, and 53. Week 10 (Panel A) expresses the case rate per 10,000 people at the beginning of the study period, where there were very few cases present across the state. Similarly, to testing rates at this time period, week 19 (Panel B) demonstrates outbreaks in Dakota, Dawson, Colfax, and

Saline counties. The average case rate for the entire state at week 19 was 11 cases per 10,000 people. Dakota, Dawson, Colfax, and Saline counties reported having 223, 82, 244, and 106 cases per 10,000 people respectively. Week 47 (Panel C) illustrates the case rate per 10,000 people during Nebraska's surge period, where the whole state is experiencing an increase in the number of cases with an average case rate of 79 cases per 10,000 people. The final map (Panel D) demonstrates the case rates across Nebraska at epidemiological week 53, which is the end of the study period. At this time, the case rate is similar across the entire state and the number of cases has decreased to 27 cases per 10,000, on average.

The number of deaths per 10,000 people is represented by Figure 4. In order to compare with test rate and case rate, epidemiological weeks 10, 19, 47, and 53 were chosen to depict this measure. Week 10 (Panel A) is representative of the beginning of the study period where there were very little deaths rates reported. Despite having an increased rate of testing and case rates at week 19 in Dakota, Dawson, Colfax, and Saline counties, there were still very few deaths that were reported at the chosen time periods. Nebraska began seeing an increased number of deaths when the state entered surge mode and tests and cases increased across the entire state. At week 47, Nebraska averaged 1.6 deaths per 10,000 people across the entire state. At this time, Garfield, Grant, and Hooker counties appeared to have increased death rates at 15, 16, and 29 deaths per 10,000 people. The measure fell again at the end of the study period (Week 53) to 0.5 deaths per 10,000 people for the entire state.

After learning more observationally from the data, SaTScan was used to test for various clusters for each of the three datasets. The program was set up to look for clusters of

higher or lower values than expected. When analyzing the test data, 3 clusters were detected. During epidemiological weeks 15-19, Sarpy, Cass, Otoe, Saunders, Douglas, and Washington counties had lower testing rates than expected when being compared to other geographical areas. These counties expected to see just over 17,000 tests administered during this time period, however, only 9,732 tests were dispensed. A very large cluster was identified between weeks 15-20. Higher testing occurred than expected in this time period (9,402 vs. 18,518) in the following counties: Holt, Boyd, Rock, Wheeler, Garfield, Antelope, Knox, Loup, Keya Paha, Brown, Pierce, Valley, Greeley, Boone, Madison, Blaine, Cedar, Nance, Sherman, Wayne, Howard, Custer, Platte, Stanton, Merrick, Thomas, Dixon, Logan, Colfax, Polk, Cuming, Hall, Buffalo, Dakota, Hamilton, Cherry, Thurston, Butler, and Dawson. The final cluster occurred in Saline county during weeks 18 and 19. Again, higher than expected testing occurred at this time. The single county administered 824 tests between those two weeks but were only expecting to give 162 tests.

In respect to case counts, SaTScan identified 5 clusters throughout the study period. The initial cluster detected lower case counts than expected between epidemiological weeks 11 and 23 in the following counties: Richardson, Pawnee, Gage, Jefferson, Nemaha, Otoe, Lancaster, Cass, and Sarpy counties. The expected value derived from SaTScan was 4,232 cases within that time period, whereas only 2,236 cases were identified in all 9 counties. The next cluster was detected between weeks 14 and 18 and centered around Buffalo county. This cluster also included Sherman, Howard, Dawson, Buffalo, Hall, Gosper, Phelps, Kearney, and Adams counties. Higher case counts occurred at this time period than expected when compared to the rest of the

geographical centroids. The expected number of cases detected was only 532, while just over 2,000 cases were identified. The third cluster was discovered in Dakota county during epidemiological weeks 17-19, where higher case counts occurred than expected (144 vs. 1,323). At weeks 18-21 a cluster of higher case counts than expected was centered around Colfax and Platte counties. The expected number of cases was predicted to be just over 271 cases between the two counties for those 4 weeks. However, 1,122 cases were identified. The fifth and final cluster was detected in Douglas county between weeks 20 and 33. Again, higher case counts were present during this time period than expected (7,055 vs. 10,475). Overall, and not surprisingly, case clustered appeared to follow testing clusters.

Similarly, to case clusters, there were 5 deaths clusters identified during the study period. The first cluster was centered around Hall county and also included Howard, Hamilton, and Adams counties. This cluster discovered increased deaths than the rest of the state at this time period. Only 12 deaths were expected, however those 4 counties had a total of 59 deaths related to COVID-19 infection within those 6 weeks. Cluster 2 had lower than expected deaths (9 vs. 43) between weeks 16 and 33, and consisted of the following counties: Antelope, Pierce, Wheeler, Madison, Knox, Boone, Holt, Wayne, Garfield, Greeley, Stanton, Cedar, Platte, Nance, Boyd, and Valley. The third cluster was centered around Thurston and Dakota counties during weeks 18-27. These two counties were only expected to have approximately 10 deaths during that time period, however, they reported having 45 deaths during that 10-week period. Douglas and Sarpy counties formed a cluster between epidemiological weeks 21 and 38, where a higher number of deaths was observed (217) than expected (141) when

compared to other geographical regions during this time period. The final cluster is represented by the following counties during weeks 49 and 50: Gage, Johnson, Pawnee, Jefferson, Saline, Lancaster, Otoe, Nemaha, Thayer, Seward, Fillmore, Richardson, Cass, and York. These 14 counties reported having 66 deaths during the 2-week period while only 34 deaths were expected.

All map trends and clusters can be viewed using the dashboard created through Tableau Public software. The dashboard illustrates testing, case, and death trends across the state of Nebraska at all epidemiological weeks in the study period. Age adjusted and actual trends can also be compared via the dashboard. All identified clusters are depicted on the respective test, cases, and deaths map and express the observed and expected values at that time compared to other geographical centroids. All maps are animated for viewing trends and clusters during at any of the epidemiological weeks of interest within the study period.

IV. Discussion

The COVID-19 pandemic persists after 1 year of the first known case in the state of Nebraska. The World Health Organization (12) has a system to best categorize different phases of an Influenza pandemic, and the same could likely be applied to the COVID-19 pandemic. There are 6 phases that traditionally accompany an influenza pandemic. Phase 1-3 vary from no virus circulating to sporadic cases popping up or the formation of small clusters. Phase 4 is representative of human-to-human transmission at the community level, meaning individuals are not always sure where they contracted the virus. Phase 5 is when community outbreaks are established in different locations

of the same region. Finally, Phase 6 is when outbreaks are occurring in different locations of various regions. In addition to the 6 Phases, there is a post-peak period where case counts begin dropping below peak levels. After the post-peak period, there is always a chance of a new wave period where cases begin rising again. The pandemic ends with a post-pandemic period where the number of cases has returned to normal, seasonal levels. The above phases could be condensed and applied to our experience in Nebraska. At the beginning of the study period, the state was in Phase 1 and 2 where no cases had yet been detected (Figure 2, Panel A). We entered Phase 3 and 4 during epidemiological week 19 (Figure 2, Panel B) where we began seeing outbreaks in specific counties like Dakota, Dawson, Colfax, and Saline counties which then transitioned into Phase 5 as we began to see cases in counties across the rest of the state. During epidemiological week 47 we transitioned into Phase 6, or the height of the pandemic, where there were high case rates throughout Nebraska (Figure 2, Panel C). At the end of the study period, epidemiological week 53, case counts, and testing rates began to decrease and return to pre-peak levels as vaccine production and administration began (Figure 2, Panel D).

Testing rates and case rates followed the same trend through the study period. A potential explanation of this is the utilization of targeted testing. Targeted testing is the process where testing event occur in areas that are known to have symptomatic or confirmed positive individuals with intentions of identifying positive people and quarantine their contacts to limit the spread of COVID-19 infection (13). The state of Nebraska in conjunction with Nebraska's National Guard began mass testing events at the middle of April 2020 as cases began popping up across the state (Figure 3 & 4,

Panel B). Hotspots in testing typically equated to hotspots in cases because of using a targeted testing approach(14). As testing availability increased and individuals could seek testing regardless of being symptomatic, case rates leveled out until the state collectively surged in cases around epidemiological week 47 (Figure 3 & 4, Panel C).

SaTScan software was able to detect clusters in all provided datasets. The first cluster detected in the test dataset (Figure 2), comprised of Douglas, Washington, Saunders, Sarpy, Cass, and Otoe counties during weeks 15-19, and was due to less than expected testing within that area, during that time period, when compared to the rest of the state. A potential cause of this cluster may be due to increased mass targeted testing in other parts of the state that may suppress testing rates within these 6 counties. The large test cluster identified between weeks 15-20 experienced higher rates of testing than the rest of the state. This cluster included the following counties that make up the North East/North Central/Central regions of Nebraska: Holt, Boyd, Rock, Wheeler, Garfield, Antelope, Knox, Loup, Keya Paha, Brown, Pierce, Valley, Greeley, Boone, Madison, Blaine, Cedar, Nance, Sherman, Wayne, Howard, Custer, Platte, Stanton, Merrick, Thomas, Dixon, Logan, Colfax, Polk, Cuming, Hall, Buffalo, Dakota, Hamilton, Cherry, Thurston, Butler, and Dawson. Within these 39 Nebraska counties, there are a total of 6 meat packing plant facilities, which all likely were a part of mass targeted testing events during that time period. The final cluster identified for testing was detected in Saline County between weeks 18-19. This cluster was identified because testing rates were higher there than other geographical locations at that time. Not surprisingly, there is another food manufacturing facility located Saline County where targeted testing has occurred within that timeframe (15)

SaTScan identified 5 case clusters (Figure 3), which were similar to that of the test clusters. The initial cluster detected lower case counts than expected between epidemiological weeks 11 and 23 in the following counties: Richardson, Pawnee, Gage, Jefferson, Nemaha, Otoe, Lancaster, Cass, and Sarpy counties. This may be due to lower testing rates, as indicated by the space-time analysis for test clusters where Otoe, Sarpy, and Cass counties had less testing than expected when compared to the rest of the state. The second case cluster was identified at epidemiological weeks 14-18. The following counties demonstrated higher case counts than expected during this time period: Sherman, Howard, Dawson, Buffalo, Hall, Gosper, Phelps, Kearney, and Adams. There are 4 meat packing plant facilities within those 9 counties, all of which were experiencing outbreaks at that point in time (16). The third cluster, also a meat-packing plant related event, was identified in Dakota County during weeks 17-19. While this cluster was forming, Dakota County reporting having 3% of their entire county population infected with COVID-19 (17). Around the same time period, another cluster was identified in Colfax and Platte counties. Again, these two counties are home to a Cargill meat processing facility. Within one month, cases within these two counties increased in cases by over 4,600% (18). Douglas county comprised the last case cluster between epidemiological weeks 20 and 33. This cluster was identified because more cases were detected in that area, during that time, when compared to the rest of the state. This cluster is spread out through several weeks beginning Sunday, May 10th, 2020 and ending Saturday, August 15th, 2020. This was challenging to find a single event tied to the cluster. However, during this time testing did become more

widely available across the state, particularly in urban areas which may have contributed to increased case detection rates within Douglas County.

Cluster analysis for the death dataset identified 5 different clusters (Figure 4), starting with one that included Adams, Hall, Hamilton, and Howard counties during weeks 15-20. This cluster had more deaths than expected when compared to the rest of Nebraska during these weeks. It is likely that this cluster may also be related to meat-packing plant outbreaks in Hall and Adams counties. Central District Health Department reported having 14 deaths within that area during that time period. Approximately 40% of that region's cases were linked to local meat packing facilities, suggesting that deaths may follow a similar trend (19) The second cluster identified having a lower number of deaths report during weeks 16 to 33 compared to other Nebraska counties. This cluster is comprised of Antelope, Pierce, Wheeler, Madison, Knox, Boone, Holt, Wayne, Garfield, Greeley, Stanton, Cedar, Platte, Nance, Boyd, and Valley counties. With such a large cluster over the spread of 18 week, it is challenging to determine what the cause of the lack of deaths was during that time. It appears these counties were experiencing low levels of COVID-19 infection, indicating that COVID-19 may not have been circulated within that region, ultimately depicting a lower number of deaths related to COVID-19 infection. The third cluster identified occurred during week's 18-27 in Dakota and Thurston counties. Again, these two counties consist of meat packing plant communities that were affected by COVID-19 outbreaks. This death cluster follows shortly after the case cluster identified in this area, suggesting that the increased number of deaths may also be attributed to the meat packing plant outbreak in that area. It is unclear how many of the cases linked to that outbreak died

due to COVID-19 related complications. Douglas and Sarpy counties formed a death cluster during epidemiological weeks 21-38, also experiencing an increased number of deaths than other counties within the state. While it is challenging to pin-point a cause of this increase, it is suspected that infection amongst older populations was more prevalent during this time period due to outbreaks in long-term care facilities (20). It is well known that age is a risk factor for those diagnosed with COVID-19 infection, which may be at the root of this cluster. The fifth and final death cluster was identified near the end of the study period at weeks 49-50 in the Southeast corner of Nebraska. This cluster was comprised of the following counties, all of which reported having more deaths than expected: Gage, Johnson, Pawnee, Jefferson, Saline, Lancaster, Otoe, Nemaha, Thayer, Seward, Fillmore, Richardson, Cass, and York. There is little evidence suggesting why these counties may have had a spike in the number of deaths just before the turn of the New Year.

The dashboard created using Tableau Public software is a great tool to visualize how COVID-19 affected Nebraska. The dashboard was beneficial in observing change over time of case rates, death rates, and tests rates in comparison to the identified clusters. Being able to identify these trends may allow us to better forecast and plan for outbreaks in the future, and possibly prevent them from happening.

In summary, it is evident that many of the clusters related to COVID-19 tests, cases, and deaths were likely linked to outbreaks associated with meat packing plant and long-term care facilities. Some clusters were challenging to define, as they extended through numerous weeks amid the pandemic. No clusters for tests, cases, or deaths were identified for counties in the western half of Nebraska. This may be a result of limited

testing or spread due to differences in population density and general risk behavior. Overall, this project provided a lot of meaningful information regarding Nebraska's experience with the COVID-19 pandemic as well as visuals to best demonstrate how COVID-19 affected our communities and when it impacted us most.

V. Application of Public Health Competencies

This capstone project has exposed me to a variety of public health competencies. The primary core competency that this project focuses on is MPHF3: Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate. The use of biostatistics and computer programming is at the fore front of this project. Data compiling and preparation, descriptive statistical analysis, and biostatistical modeling are the basis of this project, all of which were conducted using two computer programming software techniques and displayed using Tableau Public. The two concentration competencies that are more representative of this project include BIOSMPH2 and BIOSMPH3. BIOSMPH2 is defined as the application of appropriate statistical methods for estimation and inference using a software package for data management, statistical analyses, and data presentation. This capstone project satisfies this competency through the application of appropriate statistical methods through the use of SAS coding language, SaTScan software, and Tableau Public Software. BIOSMPH3 is defined as the application of statistical methods for quality control and data cleaning to already collected data, verify assumptions of statistical tests and models, and implement appropriate methods to address any issues discovered. The data used for this project is already collected through Nebraska's Department of Health and Human Resources. This data required cleaning, transformation, and reorganization to best suit the needs of the analysis.

VI. Human Subjects

The University of Nebraska Medical Center's Office of Regulatory Affairs determined this project does not constitute human subject research as defined at 45CFR46.102. Therefore, it is not subject to the federal regulations under the Institutional Review Board.

VII. Figures and Tables

Table 1: Description of Epidemiological Weeks

Epidemiological Week	Start Date	End Date
7	Sunday, February 9, 2020	Saturday, February 15, 2020
8	Sunday, February 16, 2020	Saturday, February 22, 2020
9	Sunday, February 23, 2020	Saturday, February 29, 2020
10	Sunday, March 1, 2020	Saturday, March 7, 2020
11	Sunday, March 8, 2020	Saturday, March 14, 2020
12	Sunday, March 15, 2020	Saturday, March 21, 2020
13	Sunday, March 22, 2020	Saturday, March 28, 2020
14	Sunday, March 29, 2020	Saturday, April 4, 2020
15	Sunday, April 5, 2020	Saturday, April 11, 2020
16	Sunday, April 12, 2020	Saturday, April 18, 2020
17	Sunday, April 19, 2020	Saturday, April 25, 2020
18	Sunday, April 26, 2020	Saturday, May 2, 2020
19	Sunday, May 3, 2020	Saturday, May 9, 2020
20	Sunday, May 10, 2020	Saturday, May 16, 2020
21	Sunday, May 17, 2020	Saturday, May 23, 2020
22	Sunday, May 24, 2020	Saturday, May 30, 2020
23	Sunday, May 31, 2020	Saturday, June 6, 2020
24	Sunday, June 7, 2020	Saturday, June 13, 2020
25	Sunday, June 14, 2020	Saturday, June 20, 2020
26	Sunday, June 21, 2020	Saturday, June 27, 2020
27	Sunday, June 28, 2020	Saturday, July 4, 2020
28	Sunday, July 5, 2020	Saturday, July 11, 2020
29	Sunday, July 12, 2020	Saturday, July 18, 2020
30	Sunday, July 19, 2020	Saturday, July 25, 2020
31	Sunday, July 26, 2020	Saturday, August 1, 2020
32	Sunday, August 2, 2020	Saturday, August 8, 2020
33	Sunday, August 9, 2020	Saturday, August 15, 2020
34	Sunday, August 16, 2020	Saturday, August 22, 2020
35	Sunday, August 23, 2020	Saturday, August 29, 2020
36	Sunday, August 30, 2020	Saturday, September 5, 2020
37	Sunday, September 6, 2020	Saturday, September 12, 2020
38	Sunday, September 13, 2020	Saturday, September 19, 2020
39	Sunday, September 20, 2020	Saturday, September 26, 2020
40	Sunday, September 27, 2020	Saturday, October 3, 2020
41	Sunday, October 4, 2020	Saturday, October 10, 2020
42	Sunday, October 11, 2020	Saturday, October 17, 2020

43	Sunday, October 18, 2020	Saturday, October 24, 2020
44	Sunday, October 25, 2020	Saturday, October 31, 2020
45	Sunday, November 1, 2020	Saturday, November 7, 2020
46	Sunday, November 8, 2020	Saturday, November 14, 2020
47	Sunday, November 15, 2020	Saturday, November 21, 2020
48	Sunday, November 22, 2020	Saturday, November 28, 2020
49	Sunday, November 29, 2020	Saturday, December 5, 2020
50	Sunday, December 6, 2020	Saturday, December 12, 2020
51	Sunday, December 13, 2020	Saturday, December 19, 2020
52	Sunday, December 20, 2020	Saturday, December 26, 2020
53	Sunday, December 27, 2020	Saturday, January 2, 2021

Figure 1: Actual vs. Age-Adjusted Test Rate

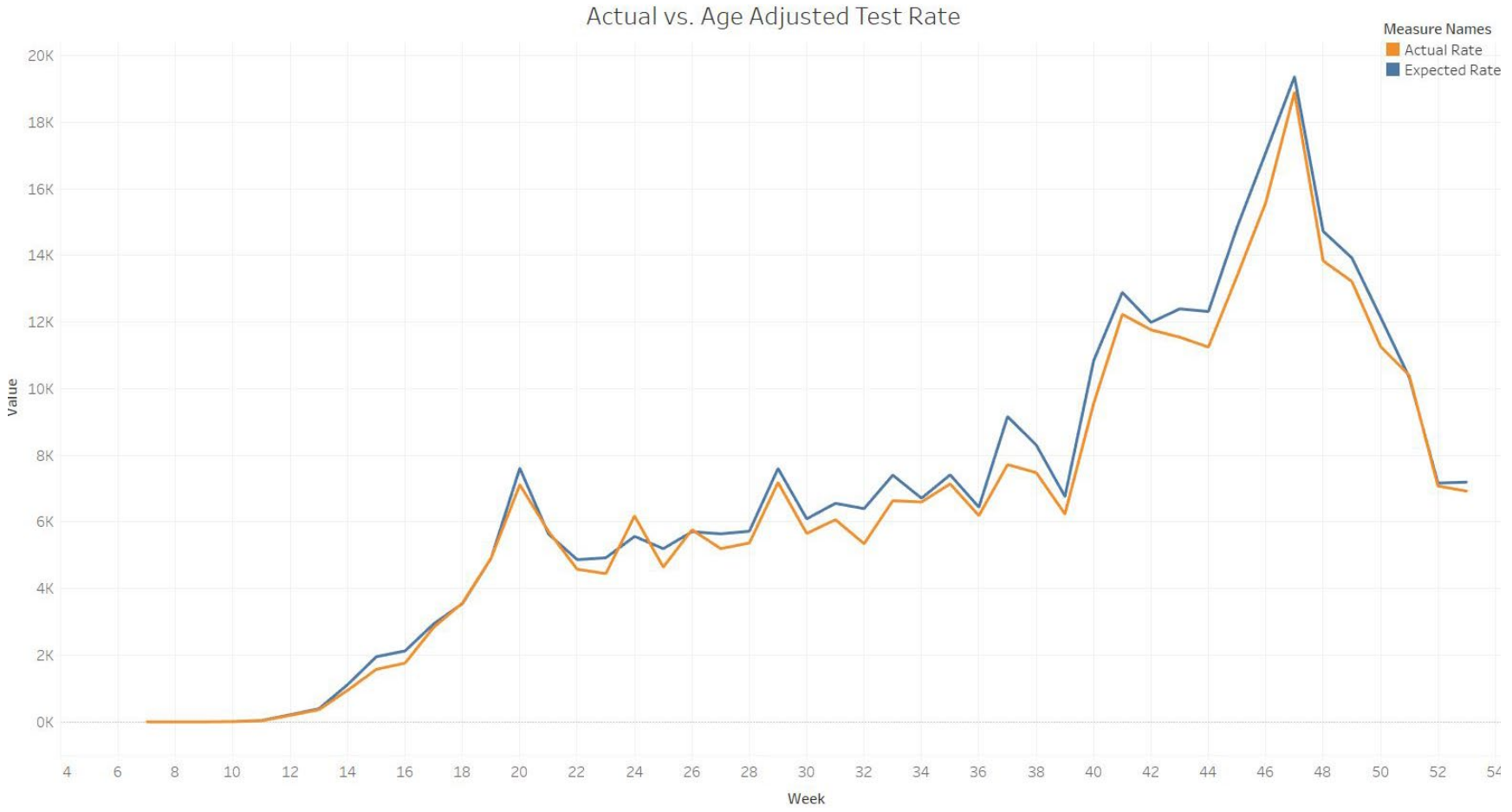


Figure 2: Test Rates per 10,000 people at epidemiological weeks 7, 19, 47, and 53.

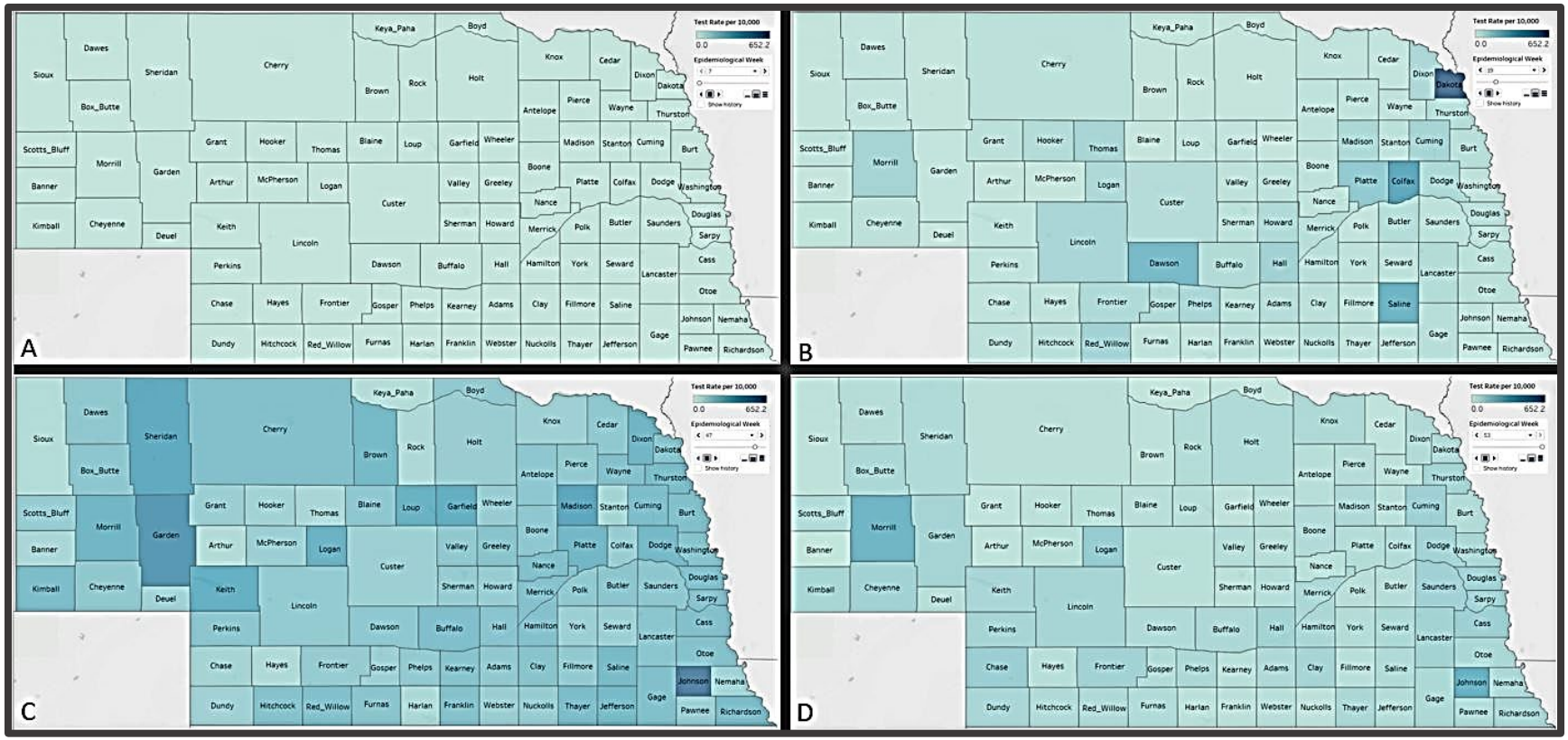


Figure 3: Case Rates per 10,000 people at epidemiological weeks 10, 19, 47, and 53.

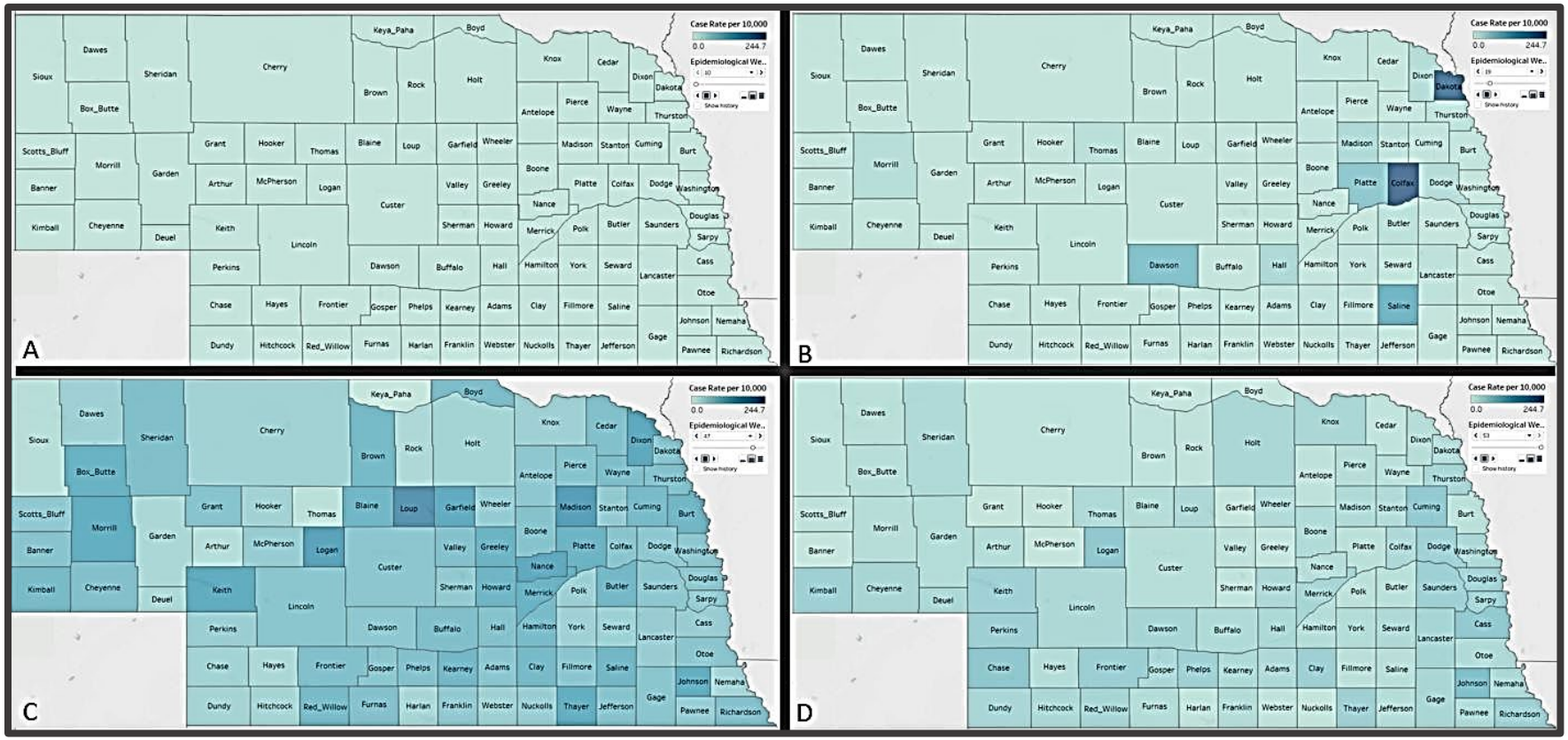


Figure 4: Death Rates per 10,000 people at epidemiological weeks 10, 19, 47, and 53.

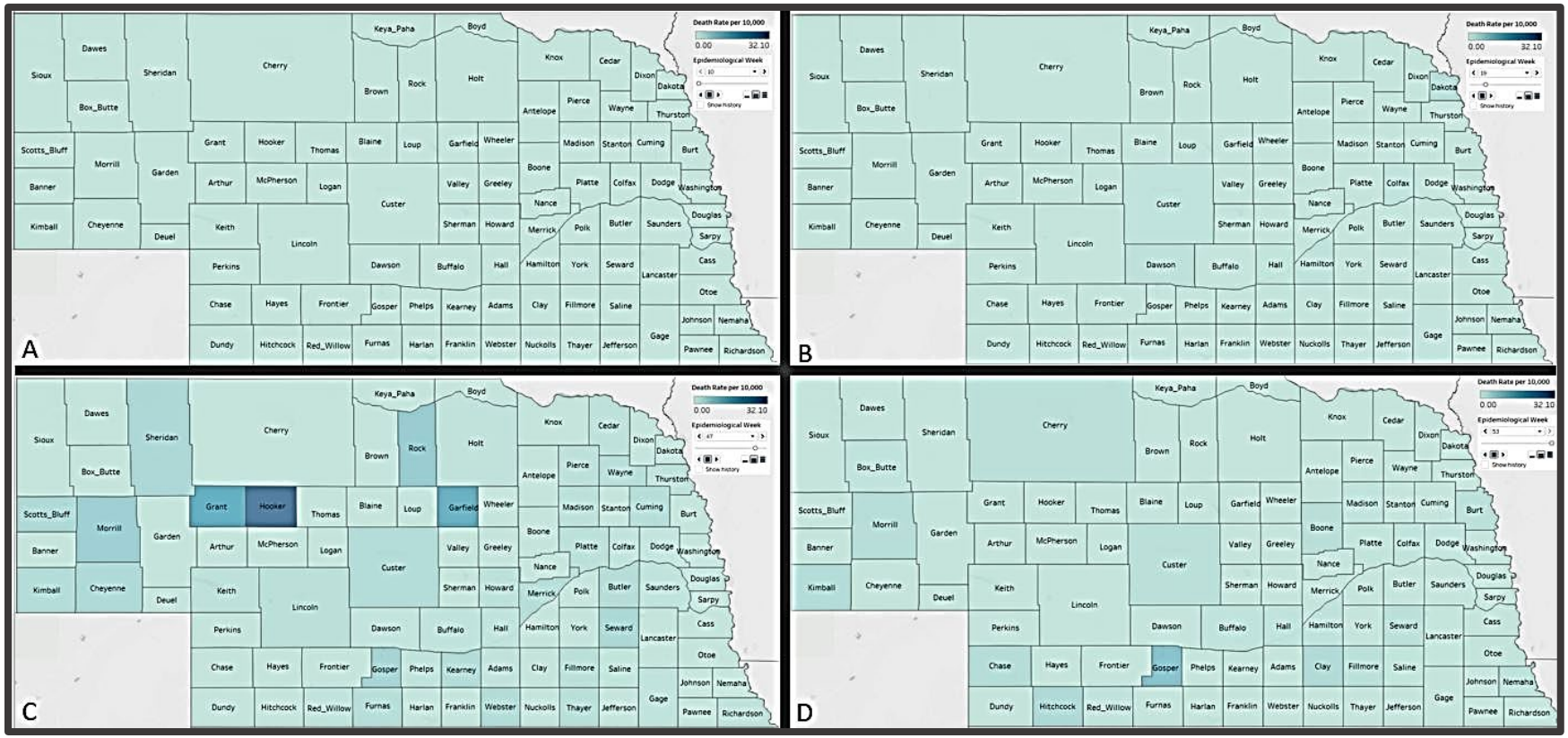


Figure 5: Identified Testing Clusters

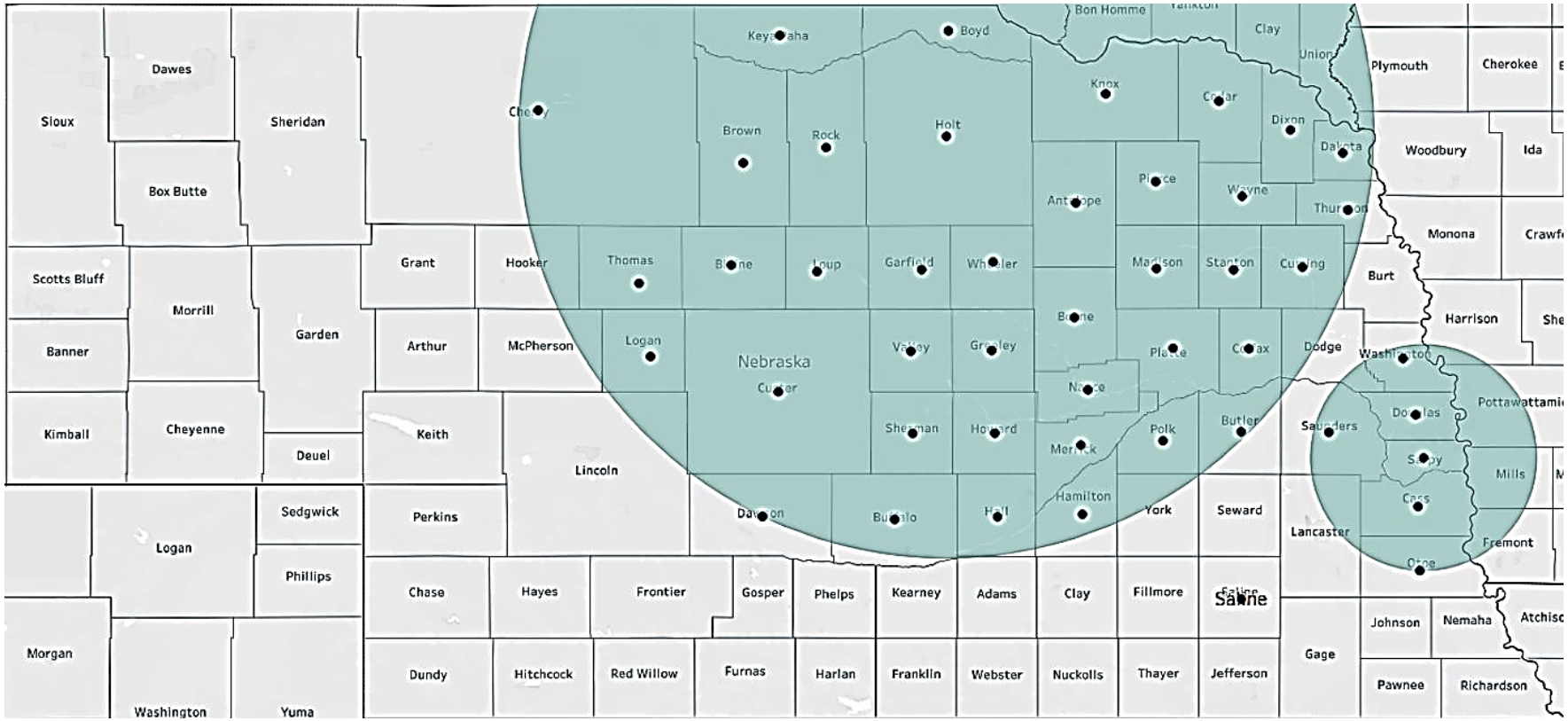


Figure 6: Identified Case Clusters.

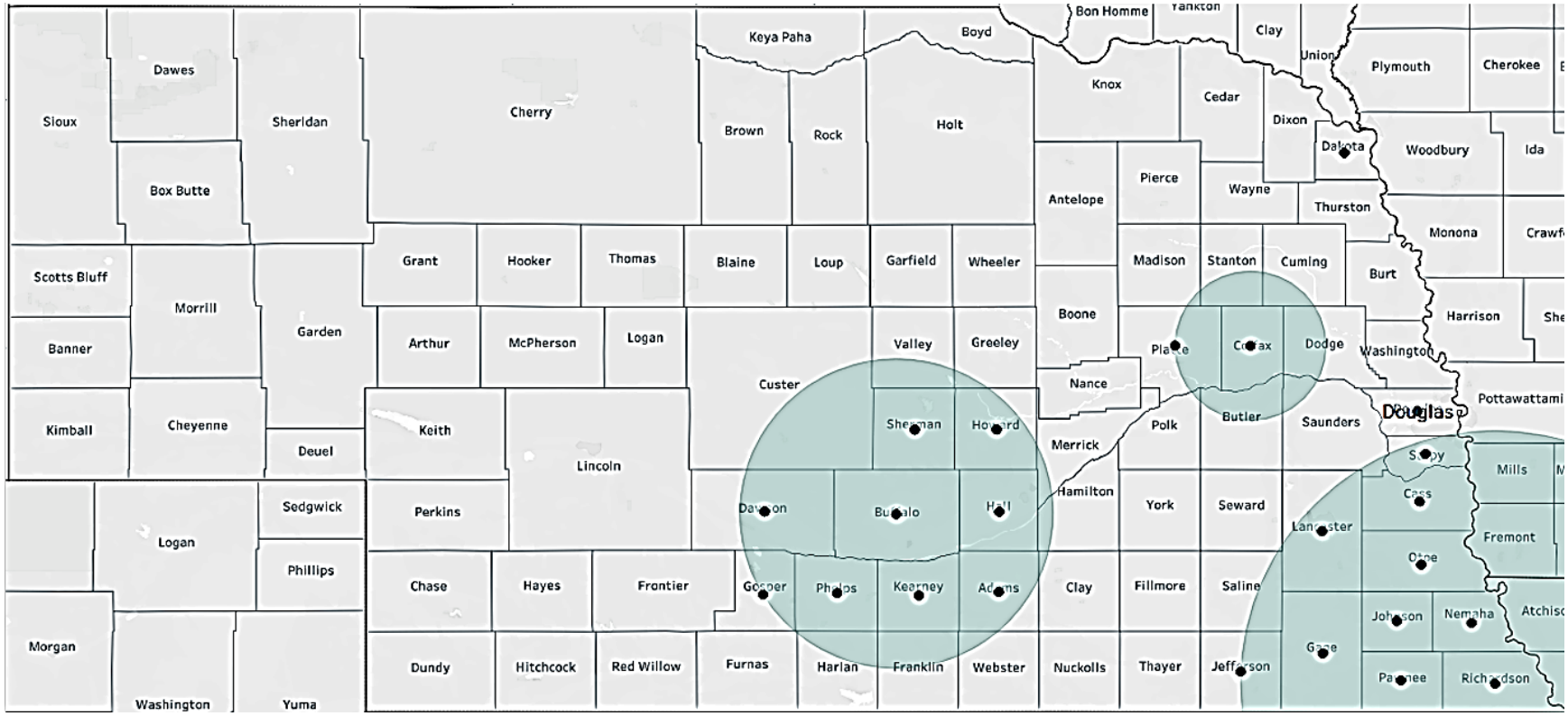
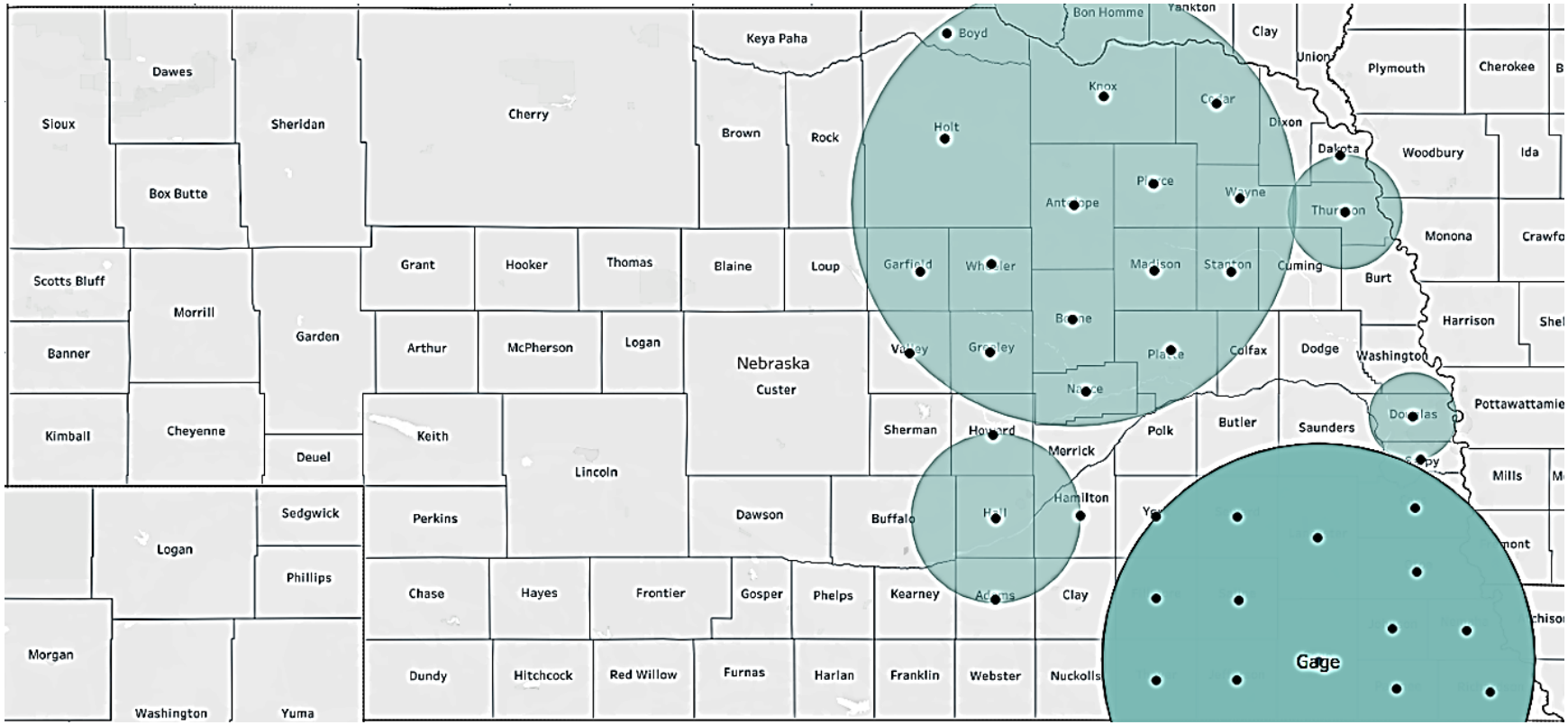


Figure 7: Identified Death Clusters.



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19. 237 coronavirus cases tied to JBS beef plant in Grand Island; disease specialists are touring plants | State and Regional News | omaha.com [Internet]. [cited 2021 Apr 12]. Available from: https://omaha.com/state-and-regional/237-coronavirus-cases-tied-to-jbs-beef-plant-in-grand-island-disease-specialists-are-touring/article_2894db56-913a-5c61-a065-6860a8ae50ad.html

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IX. Biography & CV

Makayla Schissel is a Master of Public Health student at the University of Nebraska Medical Center. Although her studies and much of her experience are focused on biostatistics, she has resumed numerous roles related to epidemiology, policy development, and environmental health since she began her Master's experience. Ms. Schissel obtained her Bachelor of Science degree in Molecular Biology, as well as a minor in Public Health through the University of Nebraska—Kearney in 2019. Ms. Schissel commenced her Master's studies through work in an environmental health laboratory under the direction of Todd Wyatt, Ph.D. Her research focused on defining inflammatory and repair mechanisms of the lung due to hog barn dust exposure. In January of 2020, she began work as a graduate assistant through the Nebraska Department of Health and Human Services. Originally, the position was geared toward data analysis of the Childhood Lead Poisoning Prevention Program. Shortly thereafter, the COVID-19 pandemic began where Makayla assisted numerous local health departments and the Nebraska Public Health Lab in their fight against COVID-19. Ms. Schissel is currently employed through Three Rivers Public Health Department where she serves as their Public Health Data Analyst and is assisting in the coordination of COVID-19 vaccine administration in Dodge, Saunders, and Washington counties. In her free time, Makayla enjoys traveling to new places with her husband, spending time with family, and taking long walks with her two dogs, Bella and Mia.

MAKAYLA SCHISSEL

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Omaha, NE 68104

EDUCATION

MPH University of Nebraska Medical Center — Expected May 2021
College of Public Health, Omaha, NE
Biostatistics

- Design of Medical Health Studies
- Biostatics I and II
- Public Health Environment/Society
- Introduction to Epidemiology
- SAS Programming

BS University of Nebraska at Kearney, Molecular Biology — May 2019
Minored in Public Health

- Immunology
- Molecular Biology
- Organic Chemistry

PROFESSIONAL EXPERIENCE

Three Rivers Public Health Department — Oct 2020-Present
Fremont, Nebraska
Public Health Data Analyst

- Analysis of data using SAS
- Data demonstration
- Vaccination clinic conduction
- Contact-tracing and case investigations

Nebraska Department of Health and Human Services — Jan 2020-Oct 2020
Lincoln, Nebraska
Graduate Assistant

- Analysis of data using Epi Info, SAS, and SPSS
- Collection of data associated with environmental and occupational health grants
- COVID-19 activities
  - Data entry
  - Test result processing
  - Contact tracing
  - Community survey analysis

Two Rivers Public Health Department — 2015-2017
Kearney, NE
Community Health Worker (June 2016-May 2017)
Volunteer (September 2015-June 2016)

- Compilation and analysis of jurisdiction-wide BRFSS data

- Experience working under Heath Hub, VetSET, and the National Diabetes Prevention Program grants
- Development of a breast cancer health advocacy group through Breast Cancer Prevention Partners

RESEARCH EXPERIENCE

Kim Carlson Lab, University of Nebraska at Kearney 2015-2019
Undergraduate Researcher

- RNA Extractions, DNA Extractions, and Polymerase Chain Reaction
- Study of viral and microbial interactions in *Drosophila melanogaster*
- Data collection and analysis
- Experimental design

Todd Wyatt Lab, University of Nebraska Medical Center 5/17-8/17
INBRE Scholar

- Cell culture, ELISA
- Characterizing macrophage responses to hog dust exposure
- Data collection

Todd Wyatt Lab, University of Nebraska Medical Center 5/19-3/20
Student Worker

- Cell culture, ELISA, qPCR, kinase activity assay, animal handling, some Western blot
- Characterizing macrophage responses to hog dust exposure
- Data collection
- Experimental design

PUBLICATIONS AND AWARDS

INBRE Scholars Program
5/17-5/19, INBRE Scholars Program. To: **Makayla Nemecek**, Mentor: K.A. Carlson, Ph.D.

PHEAST Program
5/17-5/19, PHEAST Program. To: **Makayla Nemecek**, Advisor: Peggy Abels, M.S.

University of Nebraska Foundation Kuhl Testamentary Trust Fund
5/19-5/20, $10,000 Research Grant. To: **Makayla Nemecek,** Advisor: Todd Wyatt, Ph.D.

Chandra, D., **Nemecek, M.**, DeVasure, J. M., Romberger, D. J., Poole, J. A., & Wyatt, T. A. (2018). Organic Dust Induced Lung Injury and Repair: Bi-Directional Regulation by TNF Alpha and IL-10. In *A105. DUST AND PARTICULATE MATTER EXPOSURE* (pp. A2569-A2569). American Thoracic Society.

T. A. Wyatt, **M. Nemecek**, D. Chandra, J. M. DeVasure, A. J. Nelson, D. J. Romberger & J. A. Poole (2020) Organic dust-induced lung injury and repair: Bi-directional regulation by TNFα and IL-10, Journal of Immunotoxicology, 17:1, 153-162, DOI: 10.1080/1547691X.2020.1776428

PROFESSIONAL TRAINING

Public Health Workshop
University of Nebraska Medical Center, May 2017

Mental Health First Aide Certification
Behavioral Health Education Center of Nebraska, January 2017

Community Health Worker Training
Department of Health and Human Services, 2017

- Not completed due to scheduling conflicts

PROFESSIONAL SERVICE

Organization for Research and Creative Activity
President, 2017-2019

Tutor for Elementary and Highschool Students
Kearney, NE, 2017-2019

Peer Health Club
Member, 2016-2017

PROFESSIONAL AFFILIATIONS

Sigma Xi Research Honor Society, 2016-2019