An Examination of the Covid-19 Vaccine Rollout in Minnesota, USA

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Abstract

This project explored the Covid-19 vaccine rollout in the state of Minnesota, USA. Covid-19 has affected everyone around the world and when a vaccine was introduced, the next challenge was to understand who needed this vaccine first. This project analyzed the population of Minnesota at the county level at each phase of the vaccine rollout implemented by the State of Minnesota to see what counties most in need were and to see if there was enough coverage by vaccination sites to handle the rollout. Using GIS, this project also examined case rates, vaccination sites, and population data to determine areas around the state of Minnesota that were the most at-risk based on risk factors for Covid-19. There were counties identified with high case rates that were not included in the initial vaccine rollout and some sparsely covered areas in terms of vaccination sites. Overall, findings can be expressed to encourage conversation about the vaccine rollout in Minnesota and its approach and possible future changes to the strategy.

Introduction

This project explores Covid-19 and specifically how the Covid-19 vaccine was distributed at the beginning of 2021 when it was made available to the public. This project primarily examines the state of Minnesota and how the state organized who would receive these vaccines first, where there were locations to get vaccinated, and the distribution of the most at-risk populations around the state. Also, comparisons of other strategies from different states and countries were made to explore alternative approaches to the vaccine rollout. These different methods were used in combination to start a conversation on different public health strategies to be employed in future health emergencies.

Background

The risk of a pandemic has increased significantly in recent years due to climate change and globalization, and Covid-19 is the worst pandemic the world has seen since the Spanish Flu more than 100 years ago (Bradley, Marathe, Moese, Gropp, and Lopresti, 2021). The Covid-19 pandemic drastically altered the way of life globally since its initial inception back in late 2019. While it has been nearly 2 years as of date of this project, the United States and the world are still deep in a fight to slow down the spread of Covid-19. Ever since its initial outbreak, a vaccine was seen as the answer to slow the spread and eventually curtail the virus and return to a more recognized normalcy.

Creating a vaccine is the first step; the challenge is to distribute the vaccine, and it is recognized that choices must be made on who is first to receive the vaccines (Bertsimas, Diglakis, Jacquillat, and Previero, 2021). The United States,

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with guidance from the Advisory Committee on Immunization Practices (ACIP), created a phased approach to delivering the vaccine to the prioritized populations first. The states individually set standards of who was deemed the most at-risk populations, developed a plan of who was to receive the first of the vaccines using this ACIP approach, and set up additional phases based on age and other risk factors. Identifying the at-risk populations is one of the important factors to tackle; the other is where to set up and have places for these people to receive the vaccine. The location of vaccine sites can have a very large impact on the success of rolling out a vaccine during a pandemic. (Bertsimas *et al.,* 2021). The White House and the Biden Administration announced a goal to have a vaccination site within 5 miles of 90% of the US population (Chevalier, Schwartz, Su, and Williams, 2021).

This project explored the strategy put in place by the State of Minnesota to distribute the vaccines over the initial phases and compared that to other strategies implemented in different areas around the United States. Also, vaccine locations during this time were identified to see where at-risk populations are in comparison to vaccine locations.

Value of Research

The risk of pandemics is becoming increasingly high, so a plan needs to be well thought out before another potential health disaster strikes. Examining the process that Minnesota followed during the first few months of making the vaccine available is an important part of planning for future health emergencies. Even with a vaccine, Minnesota and the rest of the world are still seeing climbing numbers in Covid-19 illnesses through the fall of 2021. Table 1 summarizes the total number of cases, hospitalizations, and deaths in the state of Minnesota since the beginning of the pandemic.

Table 1. The total cases, hospitalizations, and deaths from Covid-19 in the state of Minnesota dating back to the beginning of the pandemic through October 19, 2021.

Minnesota Covid-19 Statistics To Date (10/19/2021)		
Total Cases	Total Hospitalizations	Total Deaths
763,915	40,000	8,457

At-risk populations may vary from emergency to emergency, but factors such as race, age, and socioeconomic background are common risk factors, regardless. Chevalier *et al.* (2021) explain in reference to these risk factors that in many states, federal and state vaccination sites do not provide adequate coverage to populations in low-income areas in the United States. Knowing where these populations are the most common in the state can help with future planning. And currently, while the pandemic is ongoing, can also ensure that the vaccination sites around the state are serving those populations and were placed in those areas during the rollout of the vaccine to help increase access.

Outside of Minnesota, different states and countries proposed other guidelines on who was eligible to receive the initial vaccines. For example, in Israel a higher emphasis was placed on the risk of higher hospitalization and death across all age groups in their initial rollout, compared to a higher emphasis of

targeting specific age groups (Cylus, Panteli, and Ginnekin, 2021).

Comparing different strategies and starting a conversation surrounding different methods of this rollout will help create plans and policies that can be put into place in an efficient manner.

Project Area

The primary focus area of this project is the state of Minnesota. Figure 1 shows the county boundaries in Minnesota. Most data in the project is aggregated at the county level. The project explores populations across the state based on certain risk factors and examines where they are most prevalent throughout the state. The locations where an individual can receive a vaccine in Minnesota will also be examined in comparison to the location of at-risk populations. Other states and countries were used as comparison and discussion points, but the primary data for this project was from Minnesota.

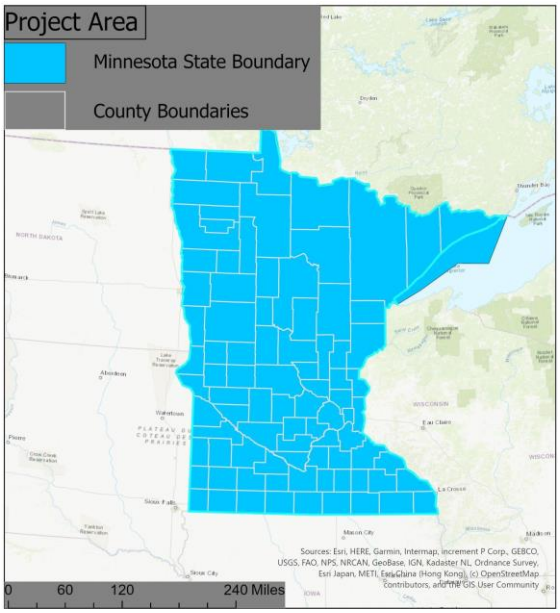

Figure 1 The study area for this project is the state of Minnesota. The state consists of 88 counties and most data was analyzed at the county level.

Summary

In this project, census data, from the Population Estimates Program from 2019 broken down by each county, was retrieved to show where at risk populations are in the state of Minnesota. Data on the workforce population was collected from Minnesota's Employment and Economic Development website. This is presented in a map that is overlaid with the vaccine locations across the state. This provides a visual of the plan the state had in response to the Covid-19 vaccine rollout.

Other case studies are presented that show what other states and countries did for their vaccine rollout. Their strategies are used as a comparison to what Minnesota did and provide discussion points moving forward. These case studies help evaluate other methods or policies that may further help the state of Minnesota as they battle Covid-19 and future health emergencies.

Methods

Introduction

Figure 2 details how the information was gathered and organized within ArcGIS Pro to perform analysis for each phase that was looked at in this project. There were two different focuses on data collection: the first focused on population and census data to gather data for each phase and the second was the vaccine location data. This section details on how all the data was collected and made ready to run the analysis, and the tools that were used.

Population and Census Data

The data used for this project is related to the first three phases that Minnesota

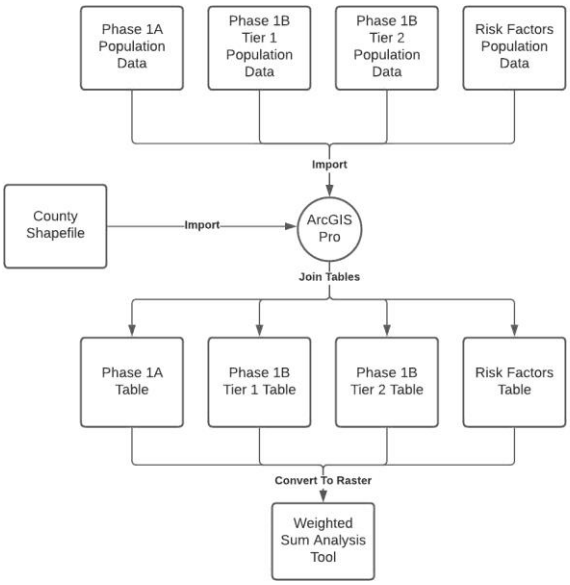

Figure 2. This graphic outlines how the data was organized for each phase to eventually be analyzed in the Weighted Analysis Tool. Each phase had its own population data in an excel file that was joined together with a Minnesota county shapefile in ArcGIS Pro. Each table was converted into a raster layer that was then run through the Weighted Sum Analysis Tool.

implemented for their vaccine rollout and another dataset that was created for this project derived from the highest risk factors identified for Covid-19. The Minnesota Department of Health released their guidelines of who would qualify to get these first rounds of the vaccine. All the census and population data were collected and organized at the county level to try to show its distribution most accurately across the state. The phase parameters are as followed (Minnesota Department of Health, 2021):

Phase 1A: The first phase of vaccine rollout targets healthcare personnel and residents of long-term health facilities.

Phase 1B Tier 1: Phase B is broken down into two tiers. The first-tier targets population over the age of 65, essential workers in the childcare/education industry, and those with underlying risk factors.

Phase 1B Tier 2: The second-tier targets people in the food service, agriculture, and manufacturing industries as well as underlying risk factors.

For this project, certain health risks were unable to be attained for the populations across counties. The health risk identifier that was used in the project was obesity as it is linked to several other Covid-19 risk factors and is a risk factor itself. Obesity, in fact, is linked to more severe cases even amongst younger patients, and other risk factors such as heart disease and diabetes highly increase the chance of severe cases and death (Sakharkar, Raut, Gujar, Pohekar, 2021).

Vaccine Location and Case Data

In addition to population and census data, this project collected the vaccination and Covid-19 data in the months of February-April of 2021.

The Minnesota Department of Health's website had a list of all vaccine locations. These locations were geocoded, and a 5-mile buffer was created to visualize the coverage these locations offered. The goal set by the Biden administration during this vaccine rollout was 90% of the population within 5 miles of a vaccine locations, so this 5-mile radius was used as the benchmark for coverage around Minnesota.

Covid-19 data was collected at three different levels: cases, deaths, and hospitalizations. These statistics were tracked for this project. In these datasets, this was evaluated over the months of February, March, and April. These months are when the vaccines would start taking their full effect, as the vaccines began to be administered at the end of 2020 and January of 2021. Over these three months, the data was collected for the state of

Minnesota as a whole. In each instance, data was converted to per 100,000 people to provide a bit more accurate comparison point as the population of each county will vary.

Analysis

For each of the three phases, the county data was joined together in ArcGIS Pro, a product from ESRI. For each phase a different map was created. In each phase, the county shapefile started as the base and each targeted population data was imported and joined together to have all the information for each county in one table for its analysis. In each map created, the tables containing all relevant data for each phase were converted to a single layer so they could be analyzed the Weighted Sum Analysis tool to show which counties of Minnesota contain the highest percentage of the population meeting the criteria for each phase. The Weighted Sum Analysis tool assigned a score to each county based on how prevalent those targeted populations were in each county. The highest scores were used to show the most at-risk counties in each phase.

Phase 1A: The two risk factors were population living in long-term health facilities and people who are in the healthcare industry. The tool was run with equal weight to healthcare personnel and residents of long-term health facilities by county that was evaluated for the most at-risk counties for this phase. Figure 3 shows the results of the weighted sum analysis tool for Phase 1A.

Phase 1B Tier 1: This phase focuses on populations over 65, workers in education, and adults with underlying risk factors. These three statistics were run with less emphasis put on the risk factor, obesity, as it is less representative of all

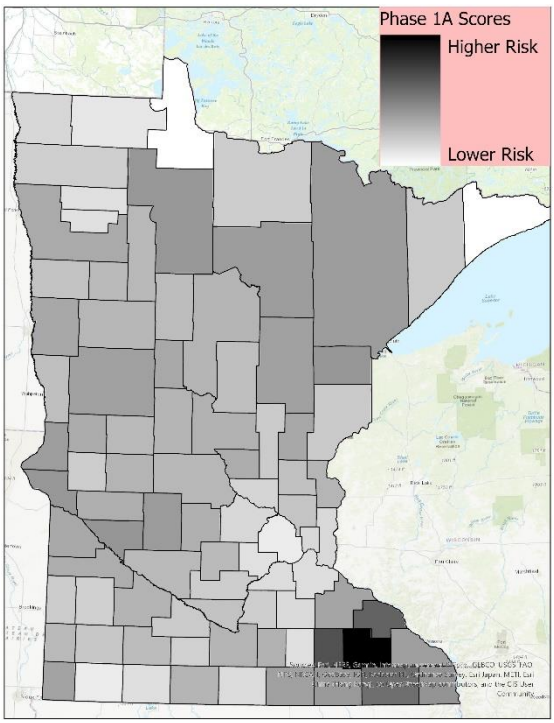

Figure 3. This graphic shows the scores of the Weighted Sum Analysis Tool for Phase 1A, which evaluated the population in long term health facilities and people who work in the healthcare industry. The counties with a higher percentage of those populations are shown in a darker shade.

risk factors but will still give an idea of where high-risk populations may be. In the Weighted Sum Analysis tool, population over 65 and workers in education each received 40% of the weight and the remainder went to obesity as our representative statistic for underlying risk factors. Figure 4 shows the breakdown of the scores for Phase 1B Tier 1.

Phase 1B Tier 2: The final phase from Minnesota's vaccine rollout plan that was looked at workers in the food service, agriculture, and manufacturing industries as well as underlying risk factors. The 3 industries were weighted equally with less emphasis on obesity, again, as it is a more general indicator of underlying health conditions. Thirty percent (30%) of the weight was applied to each industry and the remaining 10% was applied to obesity. The results are presented in Figure 5.

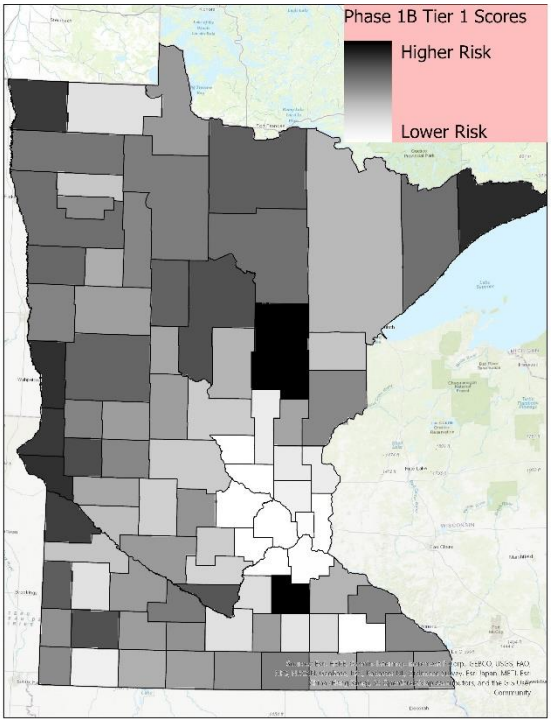

Figure 4. This graphic shows the scores of the Weighted Sum Analysis Tool for Phase 1B Tier 1, which evaluated the population of people over 65, those who work in education, and underlying risk factors. The counties with a higher percentage of those populations are shown in a darker shade.

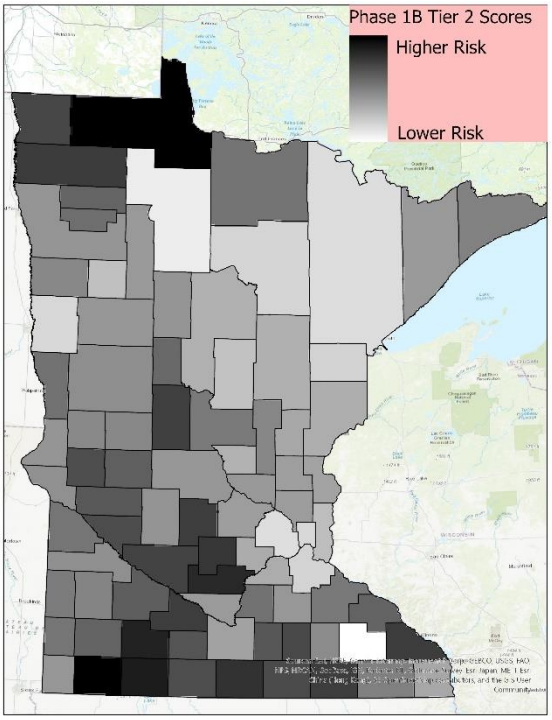

Figure 5. This graphic shows the scores of the Weighted Sum Analysis Tool for Phase 1B Tier 2, which evaluated workers in the food service, agriculture, and manufacturing industries as well as underlying risk factors. The counties with a higher percentage of those populations are shown in a darker shade.

The final analysis was of the risk factors for the highest case and death count that were identified from sources. The factors that were evaluated at a county level were the percent of population in poverty, Black population, Hispanic population, population over 65, and obesity. Obesity and population over the age of 65 are risk factors that were directly identified by the state of Minnesota. However, underserved communities face challenges in receiving vaccines due to a limited number of resources and access to a means to receive a vaccine, and they need to be identified so they can receive necessary help (Barna, 2021). Howatt (2021) references the Minnesota Department of Health data, which explains that in the state of Minnesota there is a distinct inequity of vaccinations to Black, Hispanic, and Asian populations with Hispanic populations showing the largest gap in that inequity across the state as they make up 4.8% of the population but had only received 1.7% of the state's vaccines. Black Americans have COVID-19 mortality rates twice as high compared to White Americans (Galea, Ettman, Abdalla, 2020). Based on this identification of other high-risk factors, the tool was run with equal weight of 20% across all 5 statistics, percent of population in poverty, Black population, Hispanic population, population over 65, and obesity. The results can be found in Figure 6 below.

The highest scores from the weighted sum analysis for each phase, which are displayed in black in each figure, were then selected out into their own dataset with the vaccine locations and the 5-mile buffer to see what areas in these

counties are covered. Each county is displaying their case rate per 100,000 people for the months of February-April.

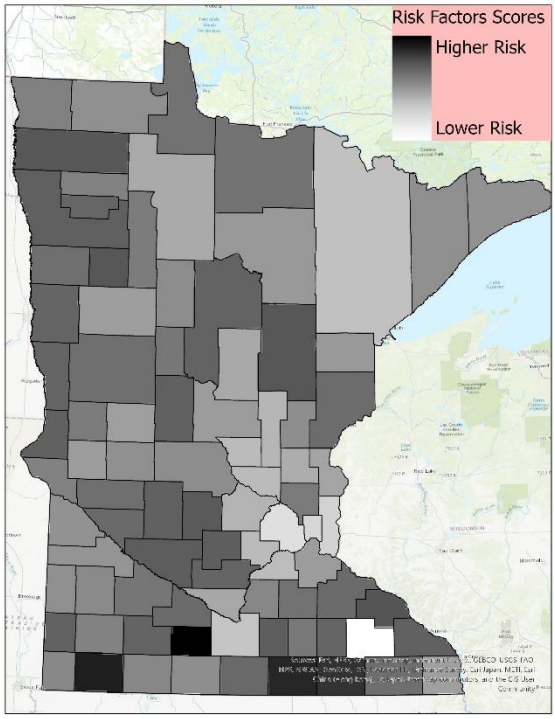

Figure 6. This graphic shows the scores of the Weighted Sum Analysis Tool this project's own risk factor analysis, factoring in the population distribution of people in poverty, Black population, Hispanic population, population over 65, and obesity. The counties with a higher percentage of those populations are shown in a darker shade.

Results

Vaccine Location Coverage and Case Rates

This project explored the coverage of all the vaccine locations, with a buffer of 5 miles, to examine which areas may not have met the goal set by the US Government at the beginning of 2021. Figure 7 shows the distribution of vaccine locations and the counties cases per 100,000 people with darker shades indicating higher case rates.

As expected, the Twin Cities area does have the most coverage, as about 60% of the population lives there. Examining the top counties in terms of case rate, there are a lot of areas within those counties that do not meet this goal. However, it is to be noted that a lot of the areas outside of the major cities are quite rural.

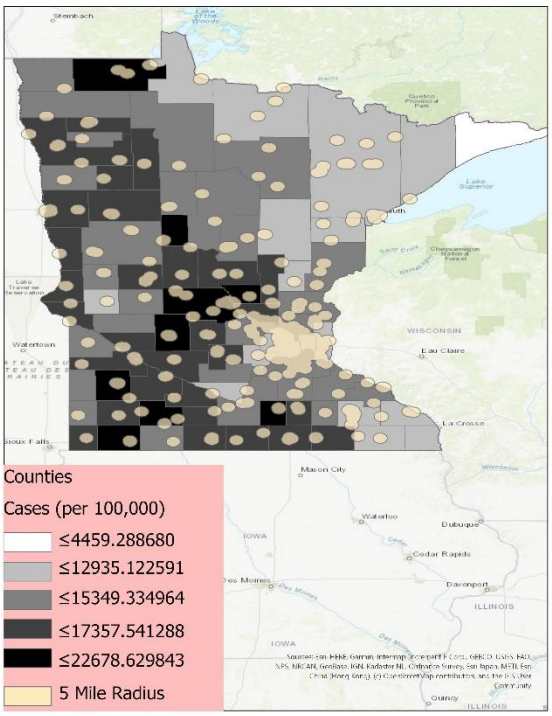

Figure 7. This graphic shows the case rates for all the counties between the months of February and April of 2021. The darker shades indicate higher case rates. The yellow buffer shows a 5-mile radius from all the vaccine locations around the state.

Phase 1A

This project looked at each phase of the rollout and examined the cases per 100,000 people in relation with each other with the darker colored counties showing the highest case rates and the vaccine location coverage for the most at-risk counties for each phase of the rollout. Phase 1A of the vaccine rollout focused on population living in long term health facilities and people who are in the healthcare industry. The counties that scored the highest, which would need the

most attention, were the counties of Wabasha, Dodge, and Olmsted. The counties with the lowest scores were Nobles, Lake of the Woods, Jackson, and the counties in the Twin Cities Metro. Figure 8 shows the case rates and vaccine coverage for those counties.

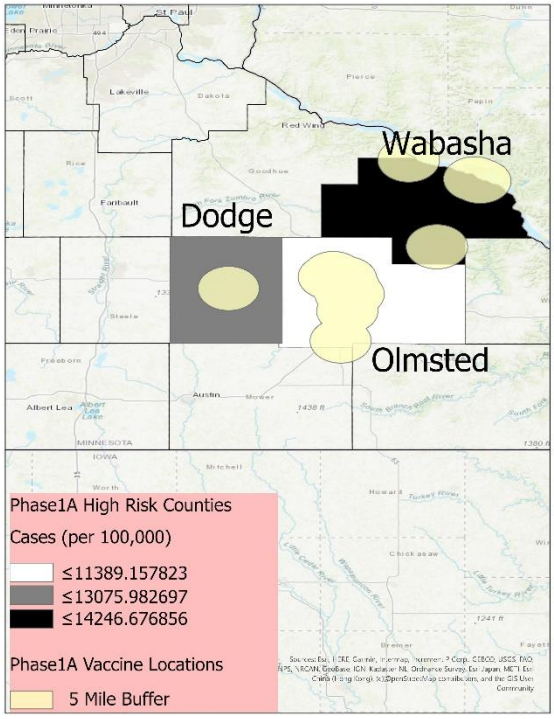

Figure 8. This graphic shows the top at risk counties for the Phase 1A rollout of the vaccine in Minnesota. Wabasha, Dodge, and Olmsted counties located in the southeastern part of the state were indicated as most at risk. The counties are broken down by case rate per 100,000 people between February-April and showing their vaccine location coverage in yellow.

Phase 1B Tier 1

Phase 1B Tier 1 targeted populations over 65, workers in education, and adults with underlying risk factors. The high-risk areas for Phase 1B were the counties of Aitkin, Rice, and the counties along the very west, central part of Minnesota. The lowest scores were the Twin Cities counties, Olmsted, Scott, and Nobles. Figure 9 displays their case rate along with their vaccine location radius.

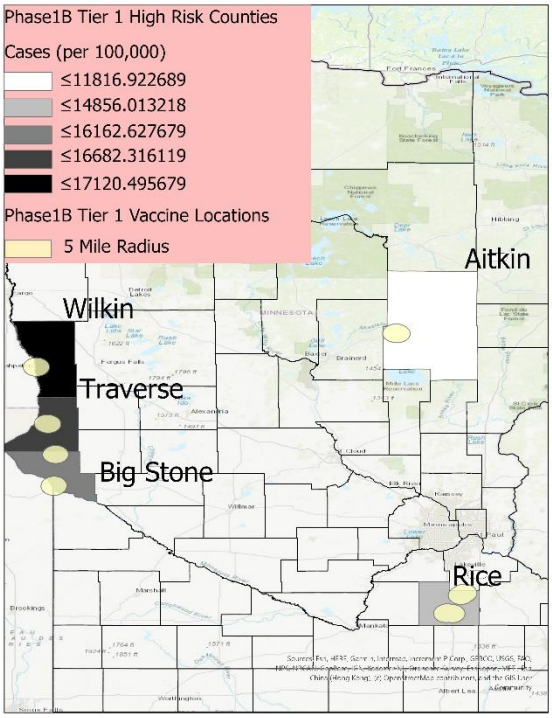

Figure 9. This graphic shows the top at risk counties for the Phase 1B Tier 1 rollout of the vaccine in Minnesota. Aitkin, Rice, Big Stone, Traverse, and Wilkin counties were indicated as most at risk. The counties are broken down by case rate per 100,000 people between February-April and showing their vaccine location coverage in yellow.

Phase 1B Tier 2

Phase 1B Tier 2 targeted workers in the food service, agriculture, and manufacturing industries as well as underlying risk factors. The highest risk areas were Roseau, Nobles, Cottonwood, and Lake of the Woods. The lowest scores were the Twin Cities metro counties, Olmstead, St Louis, and Itasca. Figure 10 shows the high-risk counties for Phase 1B Tier 2.

Risk Factors Analysis

Independent of the Minnesota phased rollout of the vaccine, this project

examined another population group for vaccines based off other risk factors. This analysis looked at the population in

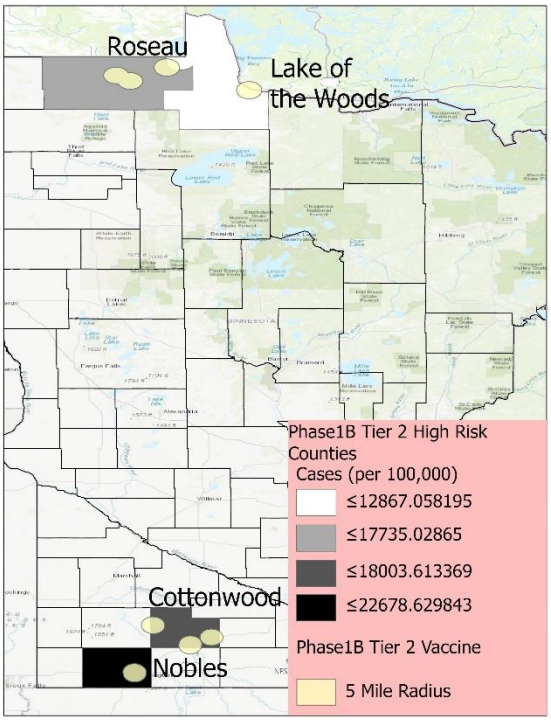

Figure 10. This graphic shows the top at risk counties for the Phase 1B Tier 2 rollout of the vaccine in Minnesota. Roseau, Lake of the Woods, Cottonwood, and Nobles counties were indicated as most at risk. The counties are broken down by case rate per 100,000 people between February-April and showing their vaccine location coverage in yellow.

poverty, Black population, Hispanic population, population over 65, and obesity. Figure 11 shows the case rate per 100,000 people and the vaccine radius of the vaccine. The counties from this analysis that were based on this identification of other high-risk factors, the tool was run, and the highest risk counties based on this analysis were Nobles, Watonwan, Freeborn, Mower, and McLeod counties. The lowest scores were Hennepin, Ramsey, and Olmstead counties.

Discussion

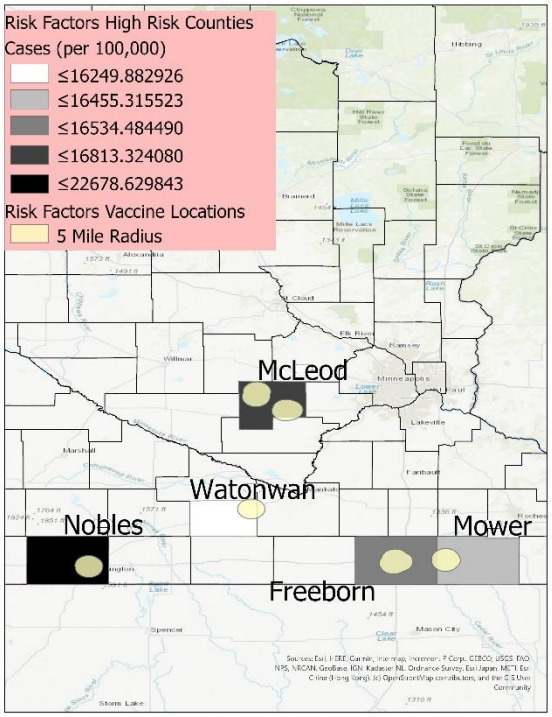

Figure 11. This graphic shows the top at risk counties for the Risk Factor analysis this project looked at for this project. Mcleod, Watonwan, Nobles, Freeborn, and Mower counties were indicated as most at risk. The counties are broken down by case rate per 100,000 people between February-April and showing their vaccine location coverage in yellow.

Phase Analysis

The analysis run on each phase is a projection of which counties had higher percentages of priority populations for the vaccines. The state average was 14,953 cases per 100,000 people. Table 2 and Table 3 show cases per 100,000 for several highlighted counties identified in this project. Table 2 shows the 10 counties with the highest case rates. Table 3 identifies the counties that were deemed the most at risk during each phase and have listed their case rate to compare to the state average, 14,953.

As the tables show, the phase 1A counties that were identified as high-risk all have lower than average case rates. The

Phase 1B tiers do mostly have counties that are over the state average of cases. And finally, looking at the risk factors identified in this project, all those counties do have higher than average case rate.

Another aspect that this project looked at was the vaccine location coverage throughout the state and within each at-risk county for each phase. The only counties that had full coverage were in the Twin Cities metropolitan area. Outside of that, most counties had just a handful of vaccine locations that did not provide the full coverage, but due to the lack of the most accurate population location data cannot confirm that it does not fall within the threshold of 90% of the population.

Table 2. This table shows the ten counties with the highest case rates between the months of February and April in 2021. Those bolded are counties that were identified in this project as at-risk counties during the initial vaccine rollout for Minnesota.

County	Cases (Per 100,000)
Nobles	**22,678**
Kandiyohi	19,480
Lyon	18,344
Benton	18,313
Wadena	18,029
Cottonwood	18,003
Waseca	17,948
Roseau	**17,735**
Stearns	17,666
Rock	17,357

Table 3. This table show the counties that were deemed the most at risk for each phase of the vaccine rollout and has their case rates listed between February-April. Those in bold are higher than the average of the state, which was 14,953.

Phase	County	Cases (Per 100,000)
1A		
	Wabasha	14,246
	Dodge	13,075
	Olmstead	11,389
1B Tier 1		
	Wilken	**17,120**
	Traverse	**16,682**
	Big Stone	**16,162**
	Rice	14,856
	Aitkin	11,816
1B Tier 2		
	Nobles	**22,678**
	Cottonwood	**18,003**
	Roseau	**17,735**
	Lake of the Woods	12,867
Project's Risk Factors		
	Nobles	**22,678**
	McLeod	**16,813**
	Freeborn	**16,534**
	Mower	**16,455**

Trends

Throughout the analysis for this project, there was one constant factor in each phase, and that was the lower score for the counties near the Twin Cities. Despite the low scores, there will need to be an obvious emphasis of resources to this area since roughly 60% of the population lives in those counties. Knowing this, this project acts more as a secondary view of where vaccine resources should be allocated. Some of the counties that were deemed high risk, such as Big Stone and Traverse, only have several thousand people in the entire county. It is important to note that the population centers will be the focus of vaccine resources, but there must be some allocation to the smaller counties as well to make the vaccines more accessible to those living in smaller communities.

Other Vaccine Strategies

The plan Minnesota followed as far as vaccine rollout is concerned closely follows the one that the United States and ACIP outlined for all states to follow. However, there have been different approaches to rollout of the Covid-19

vaccine, and there have been several case studies that have investigated these strategies and their successes. For example, one country that had a lot of success in their Covid-19 vaccination plan has been Israel due to their ability to reach a wide array of at-risk populations in their initial phase of their vaccine rollout.

Comparing their strategy to what states like Minnesota did, the main difference is the phased approach and who qualified to get the vaccine first. Israel had a lower threshold for those who qualified for the initial phase of the rollout. People over aged 60, those with pre-existing medical conditions, nursing home residents, and front-line health workers were all included in their first phase of the rollout (Cylus *et al*., 2021). Cylus *et al.* continue to say that many countries across Europe had quite a different approach to determine which populations were eligible for the vaccine.

This project's own hypothetical risk factor phase that was analyzed included populations over 65 as well as other populations that were deemed high risk, such as Black and Hispanic populations. In a project done by the University of Minnesota, Black populations in Minnesota represented roughly 25% of hospitalizations while only representing around 7% of the population (Mandic, Georgiou, and Sen, 2020).

Hispanic populations see a similar trend. In May 2020, before a vaccine had even been introduced, 22% of Covid cases were Hispanic people. In comparison, only about 5% of the Minnesota population is Hispanic (Gil, Marcelin, Zuniga-Blanco, Marquez, Mathew, Piggot, 2020).

Sources of Error

When evaluating the results, there were some areas to note that could lead to different outcomes. More populous areas were deemed to not be at risk, largely due to the metrics that were used were divided by the total populations and compared to more sparsely populated counties they would have the lower scores on the weighted sum tool.

Another issue that may cause some disparities is the lack of health risks evaluated in this project. Obesity was applied as a representative statistic for health risks as it was the most accessible across the counties of Minnesota. Other underlying risk factors include liver disease, diabetes, lung diseases, heart problems, those who are immunocompromised, and those who have chronic renal disease treated with dialysis (Sakharkar *et al.*, 2021). Those statistics at the county level were not available for this project, so the obesity rate was used to represent underlying health risks.

The vaccine locations in this project that were used were from a database that is constantly updated. The vaccine location data was obtained in October of 2021, around 10 months after the period examined in this project. Not all of these vaccine locations were operational in the early months of 2021 so there is a possibility of the coverage being inaccurate in some regions as they may not have had a vaccine location at the time that was examined. There were also other popup or temporary vaccine locations were available for a few weeks or months that were no longer listed so that would cause some inaccuracies based on when the data was collected.

Conclusions

The Covid-19 pandemic is an unprecedented medical disaster that has affected the entire planet. When a vaccine

was introduced, the next problem was to figure out the most efficient way to deliver it to the people who needed it the most. Across the world, different countries and regions have implemented their own strategies. Every case project is different as each country, and even state, faces their own situations and challenges.

This project examined specifically the state of Minnesota and how they targeted certain populations in each phase of the vaccine rollout. After looking at all of the vaccine locations in the state, it is clear to see that there are quite a few places around the state that are not near a vaccine location site. Also, after analyzing the targeted populations for each phase of the vaccine, it was concluded that there were counties identified by this project's own risk factor analysis that were not included in the targeted populations from Minnesota's phased approach that was analyzed by the weighted sum tool.

This project looked objectively at Minnesota's vaccine rollout and its goal was to start a conversation of different strategies that had been used in other parts of the country and the world. 'The Covid-10 pandemic is ongoing, and new variants and diseases still loom, so it is important to look at other strategies to see if any of those methods would be beneficial moving forward to assist with planning for future health emergencies.

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