Prevalence of Seasonal and Food Allergies in all U.S. States

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Abstract: *Seasonal and food allergies are medical conditions that over 100 million people experience in the United States. Pollution does have a correlation to allergies, but the relationship hasn't been fully defined yet. Previous studies have compared pollution and allergies between regions or singular states, but this paper expands on that by using data from every state. We'll compare the prevalence rates of all allergies and specific allergies between rural and urban states to see if there are any noteworthy differences. To do this, we used data from recent research papers containing the prevalence of food and seasonal allergies in individual states and combined them to compare the prevalence of allergies in the U.S. Results showed a very small positive correlation between seasonal allergies and rural states, but an even smaller negative correlation between seasonal allergies and urban states. For food allergies, there is a very slight positive correlation between them and urban and rural states. More research is needed to get a more thorough picture of the effects of pollution on allergies at a local level. Understanding the ties between pollution and allergies can help cities, governments, and community leaders improve their communities so fewer people can get allergies.*

Keywords: Seasonal allergies, food allergies, pollution, urban states, rural states

1. Introduction

Pollution is one of the most concerning problems worldwide, causing crop loss and climate change. It also produces many significant health problems, such as respiratory disease, diabetes, and cardiovascular diseases (Orru *et al.* 2017). Specifically, air pollution is caused by burning coal, diesel fuels, gasoline, and wood (Sierra-Vargas and Teran, 2012). Examples of high pollution cities are Beijing, Nanjing, Shanghai, Seoul, and Delhi (Krzyzanowski *et al.* 2014). One issue that has been associated with air pollution is allergies. Allergies affect millions of people yearly. Although pollution causes significant health problems, the connection with allergies is still unclear.

Allergies are the body's reaction to foreign substances. When an allergen (a substance that causes an immune response) enters the body, it causes the immune system to overreact and try to attack it with inflammatory responses (Johns Hopkins Medicine, 2024). This is why some people get an allergic reaction to certain foods or pets.

The relationship between allergies and pollution isn't fully understood yet. There have been other research papers that have looked at the prevalence of allergies in urban areas and rural areas, and most have found that there was an association between allergies and cities and an inverse association between allergies and rural regions (Patel *et al.* 2018). There have also been articles researching specific allergies, such as seasonal or food allergies, and their prevalence in rural/urban areas (Gupta *et al.* 2012).

The question we will be researching is: How has the prevalence of seasonal and food allergies in U.S. urban states changed compared to U.S. rural states? We are collecting data on food and seasonal allergies to see if one is more affected by urban/rural states than the other. We will also be researching the difference in prevalence rates in those same urban and rural states to see how much pollution affects allergies.

2. Materials/Methods

This study used previous research articles and data to find the prevalence of allergies in every state. The data was gathered from the PubMed database and Google Scholar. We searched for research papers published after 2011 related to food and seasonal allergy prevalence. Some keywords used were “prevalence of allergies,” “food allergy,” and “allergies in U.S. states.” We first made graphs of the prevalence of allergies in adults and children and then made graphs of the prevalence of each allergy type in adults and children who have allergies. After, we graphed all the rest of the data and put them onto data tables to compare and contrast the prevalence between urban and rural states. To define an urban and rural state, we used the population density of the states provided by the U.S. 2020 Census. We created criteria to classify which state is urban or rural. A state with a higher population density than the population density of the U.S. was considered urban. A state with a lower population density than the population density of the U.S. was considered rural. The population density of the U.S. is 93.8 (U.S. Department of Commerce - U.S. Census Bureau, 2020), meaning that any state with a higher or lower population density than 93.8 is considered either urban or rural.

3. Results:

Prevalence of allergies in U.S. population types 2021

To find general information on allergies, we started looking at the prevalence data of allergies throughout the entire population. We found that 66.7% of adults don’t have allergies, while 33.3% of adults do.

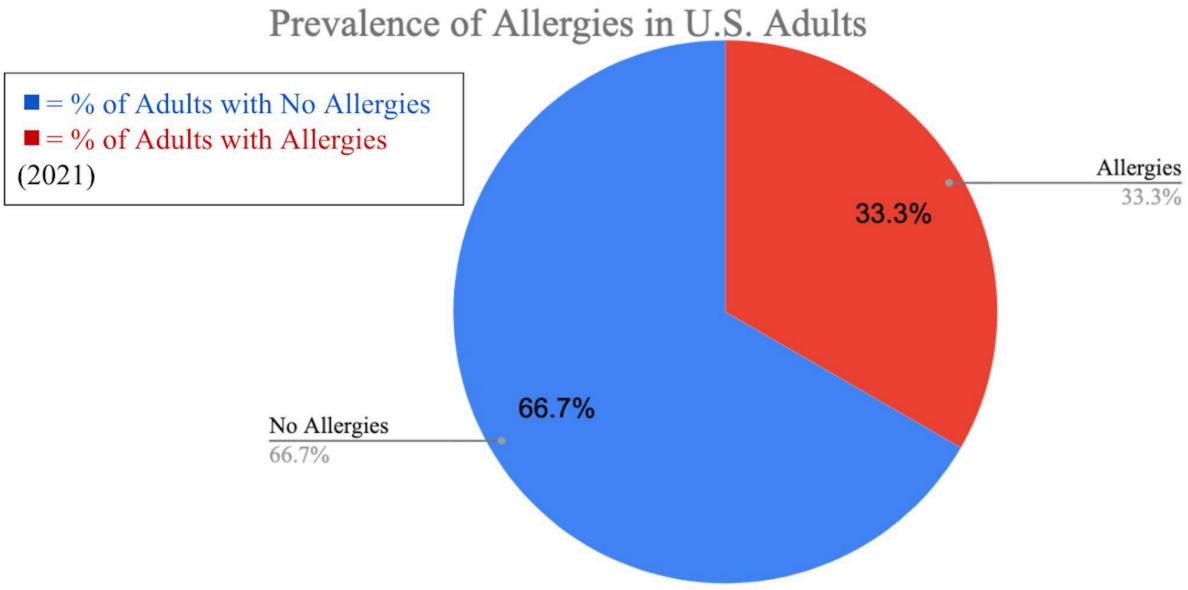

Figure 1: **Prevalence of allergies in U.S. adults**. Blue is the percentage of adults with no allergies in the U.S. Red is the percentage of adults with allergies in the U.S. This data is from the CDC (CDC – National Center for Health Statistics, 2023).

One thing to note is that although adults without allergies are still the majority, there is still a very big percentage of adults that have at least one allergy (CDC – National Center for Health Statistics, 2023).

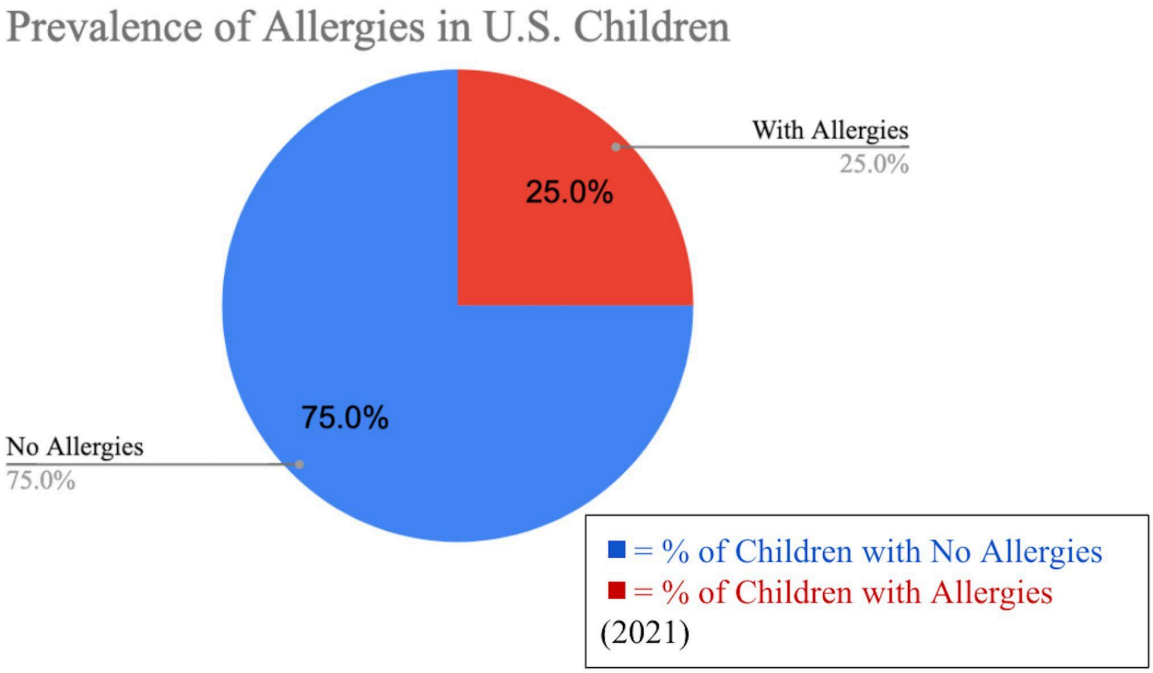

Figure 2: **Prevalence of allergies in U.S. children.** Blue is the percentage of children with no allergies in the U.S. Red is the percentage of children with allergies in the U.S. This data is from the CDC (CDC – National Center for Health Statistics, 2023).

Here, the data shows that 75% of children don't have allergies, compared to 25% of children who do have allergies. Interestingly, there is a big difference between the prevalence of adults with allergies compared to children with allergies (CDC – National Center for Health Statistics, 2023).

Prevalence of each allergy type in U.S. population types with allergies 2021

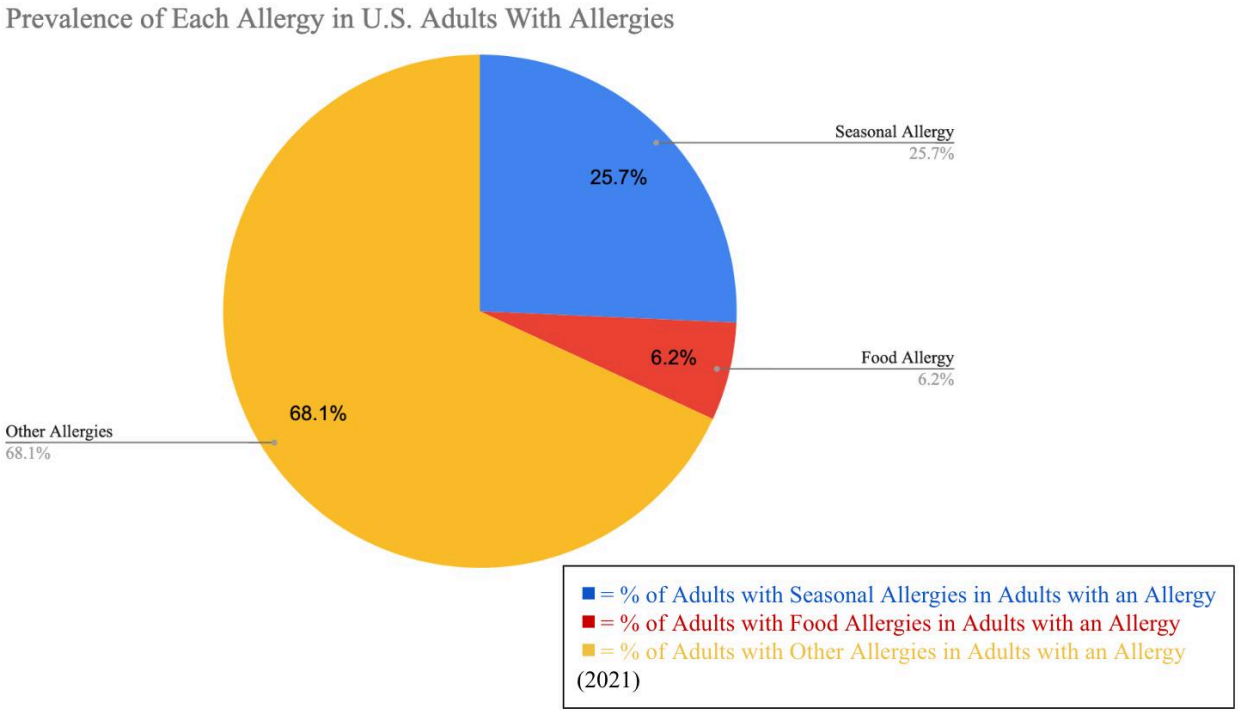

Figure 3: **Prevalence of each allergy in U.S. adults with allergies**. Blue is the percentage of adults with allergies that have a seasonal allergy. Red is the percentage of adults with allergies that have a food allergy. Yellow is the percentage of adults with allergies that have an allergy other than food or seasonal. This data is from the CDC (CDC – National Center for Health Statistics, 2023).

For additional information, we wanted to include the prevalence of each allergy type in a specific population. The most prevalent allergies are “other allergies,” which are any allergies except for seasonal and food. The chart also shows us that a quarter of adults with allergies have seasonal allergies, while only 6.2% of adults with allergies have a food allergy (CDC – National Center for Health Statistics, 2023).

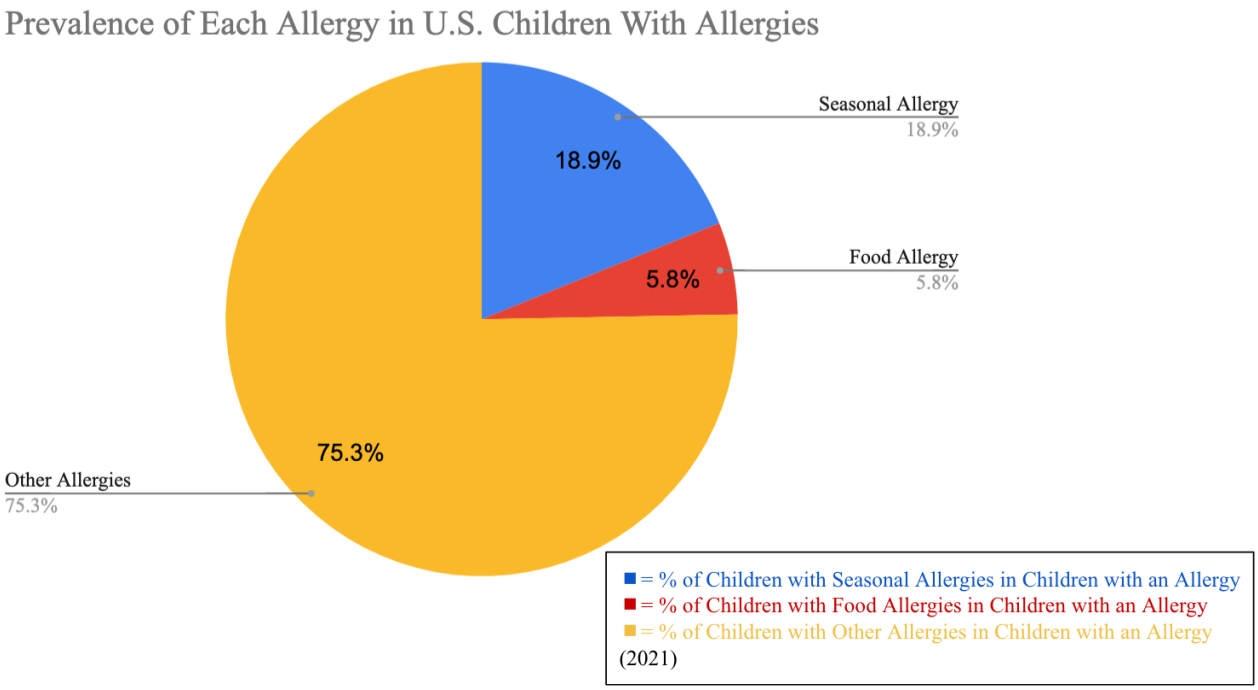

Figure 4: **Prevalence of each allergy in U.S. children with allergies**. Blue is the percentage of children with allergies that have a seasonal allergy. Red is the percentage of children with allergies that have a food allergy. Yellow is the percentage of children with allergies that have an allergy other than food or seasonal. This data is from the CDC (CDC – National Center for Health Statistics, 2023).

The data shows that 75% of children have allergies other than seasonal or food. 18.9% of children with allergies have seasonal allergies, while 5.8% have a food allergy. This chart isn't too different from the previous analysis, but there are two major differences. One difference is that the prevalence of seasonal allergies in children with allergies is a lot lower than the prevalence of seasonal allergies in adults with allergies. The other difference is that the prevalence of other allergies in children with allergies is a lot higher than the prevalence of other allergies in adults (CDC – National Center for Health Statistics, 2023).

Prevalence of allergies in U.S. regions 2005-2006

We then wanted to go more specific and see if geographical factors influence the prevalence of allergies, so we started to look at regions. We found that the South has a much higher prevalence of allergies than all the other regions.

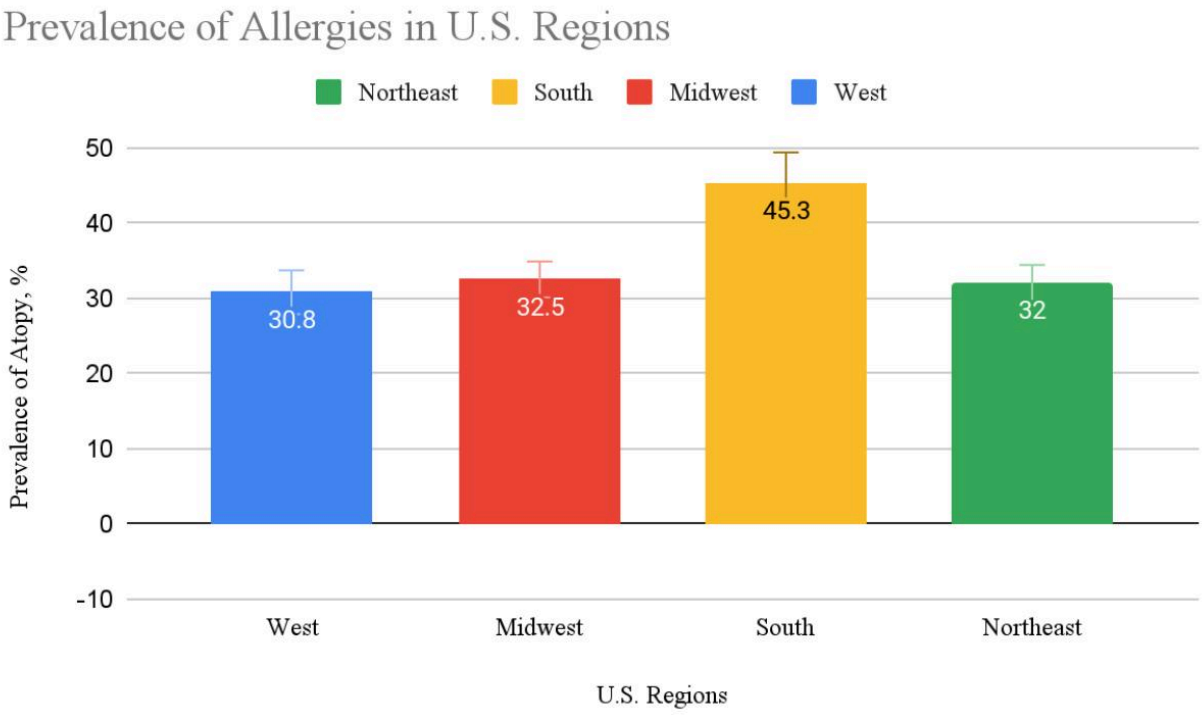

Figure 5: **Prevalence of allergies in U.S. regions**. Blue is the prevalence of allergies in the West. Red is the prevalence of allergies in the Midwest. Yellow is the prevalence of allergies in the South. Green is the prevalence of allergies in the Northeast. On the y-axis is the prevalence of atopy by percent across the four major U.S. regions. This data is from the 2005-2006 NHANES (Salo *et al.* 2014).

Table 1: This includes every U.S. region ordered by its latitude. It also has the prevalence of atopy in percent with its standard error (Salo *et al.* 2014).

Region	Prevalence of Atopy, %	Standard Error
West	30.8	2.9
Midwest	32.5	2.38
South	45.3	4.08
Northeast	32	2.42

The graph and the table are both showing the percentage of the prevalence of atopy, the tendency to have a response to allergic reactions (Justiz-Vaillant *et al.* 2024). The regions are based on the classical definitions of the four main U.S. regions. As shown, the South clearly has the highest prevalence of allergies, with more than 10% higher prevalence of allergies than any other region. The West, Midwest, and Northeast have very similar percentages (Salo *et al.* 2014).

Hay fever prevalence % in U.S. states 2006-2007

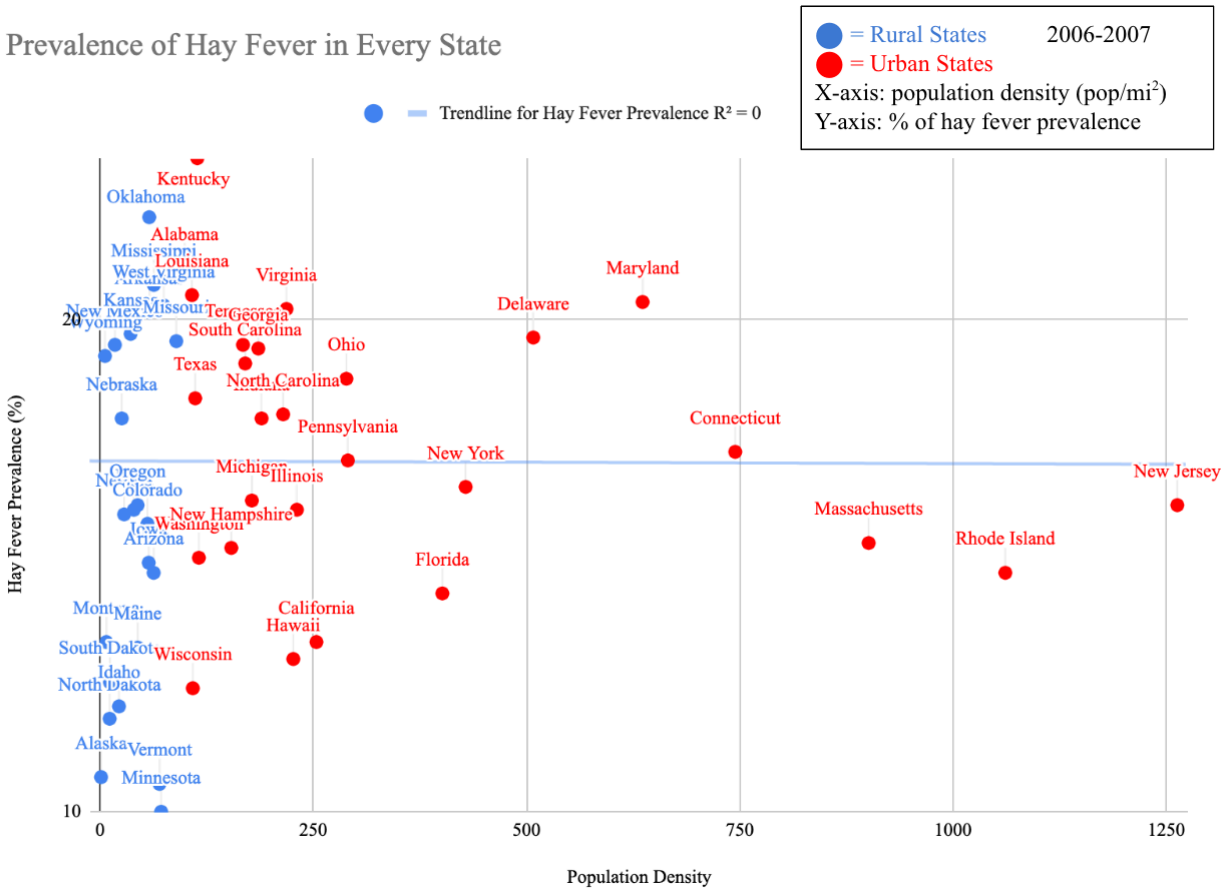

Figure 6: **Prevalence of hay fever in every state.** Blue is every rural state in the U.S. Red is every urban state in the U.S. The data is from “Association between climate (Silverberg *et al.* 2015).

We are using hay fever as a proxy for seasonal allergies since research on the prevalence of seasonal allergies isn’t well reported. For this analysis, we used one research paper that included the prevalence of hay fever in every state. The population density data came from the 2020 U.S. Census (U.S. Department of Commerce - U.S. Census Bureau, 2020). The table shows the exact percentages for all the states. The trendline for this graph (or the R^2) is 0.

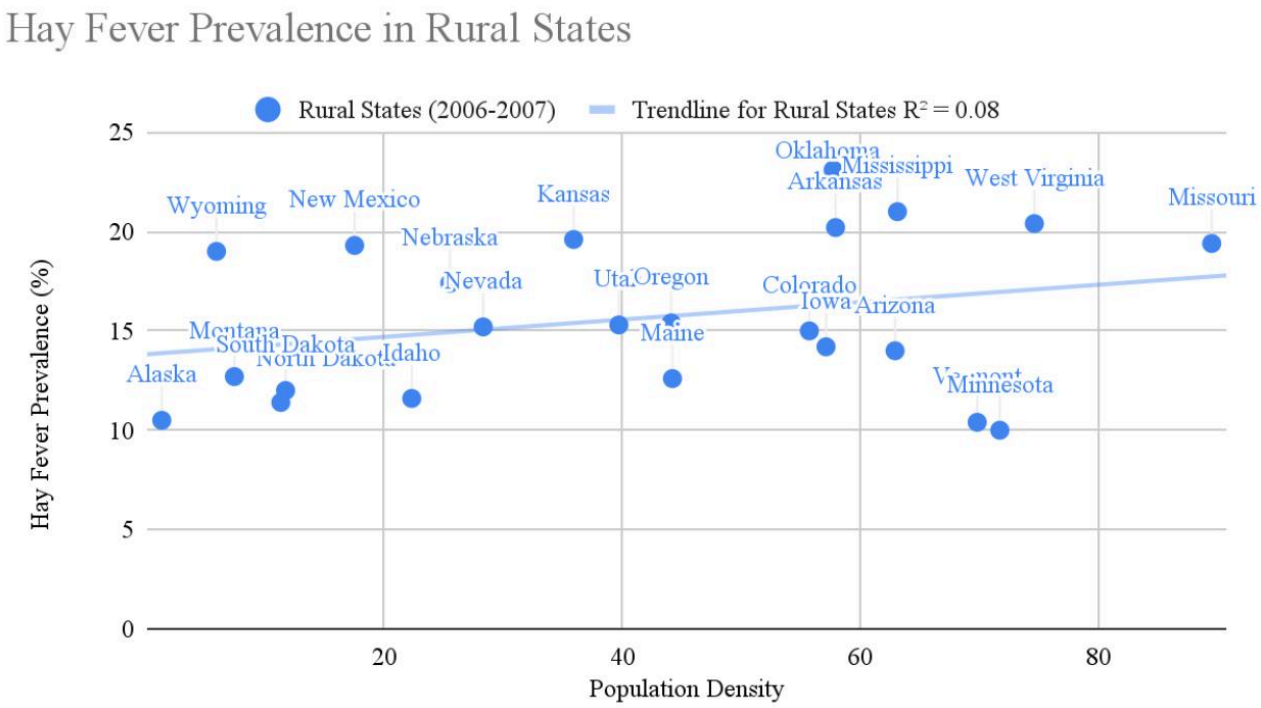

Figure 7: Hay fever prevalence in rural states. A scatterplot showcasing the prevalence of hay fever in only rural states. The data is from the "Association between climate factors, pollen counts, and childhood hay fever prevalence in the United States" (Silverberg *et al.* 2015).

After seeing the results of the previous dataset, we wanted to look specifically and see if there was a prevalence between the population density and the prevalence of hay fever in only states classified as rural (based on our definition). The graph shows a slight positive correlation between population density and the prevalence of hay fever in rural states, which wouldn't have been found if urban states had been included in the chart as well.

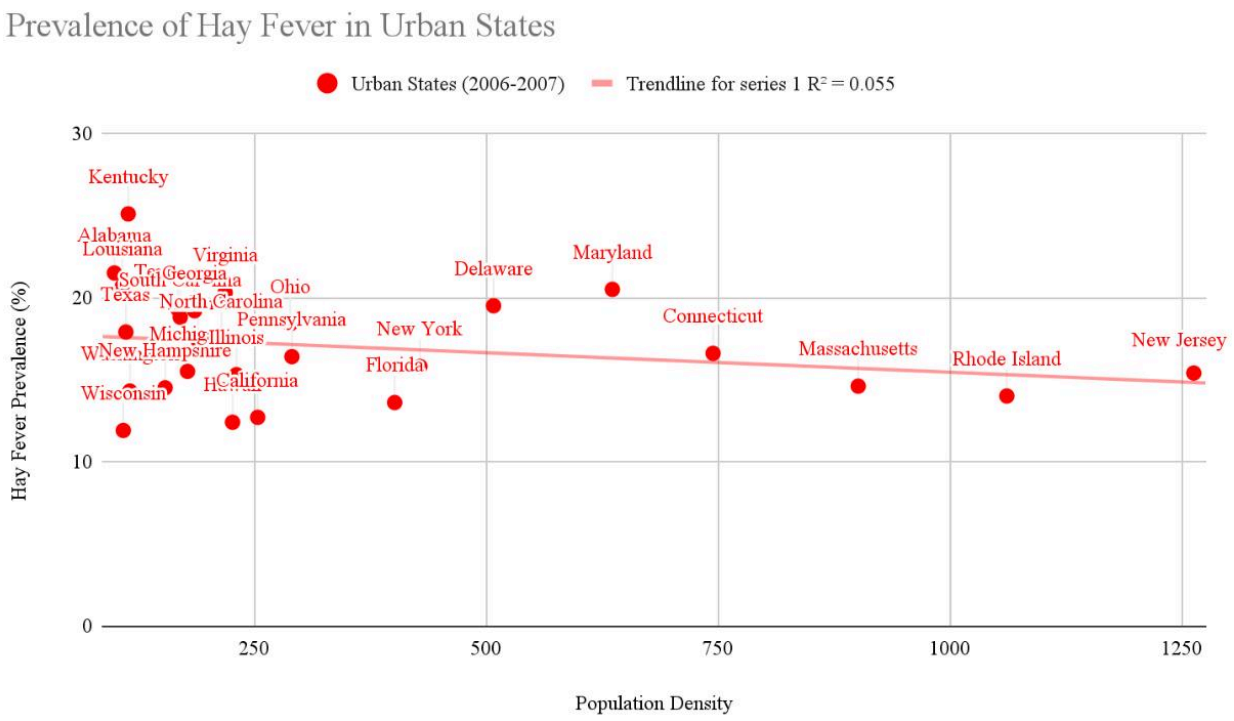

Figure 8: Prevalence of hay fever in urban states. A scatterplot showcasing the prevalence of hay fever in only urban states. The data is from the "Association between climate factors, pollen counts, and childhood hay fever prevalence in the United States" (Silverberg *et al.* 2015).

This is the same graph but for urban states. There is another slight correlation, although smaller than the correlation in rural states. Interestingly, this correlation is negative, while for rural states, it was positive. Some states have a considerable population density, but most urban states (Silverberg *et al.* 2015).

Food allergy prevalence % in U.S. states 2009-2010

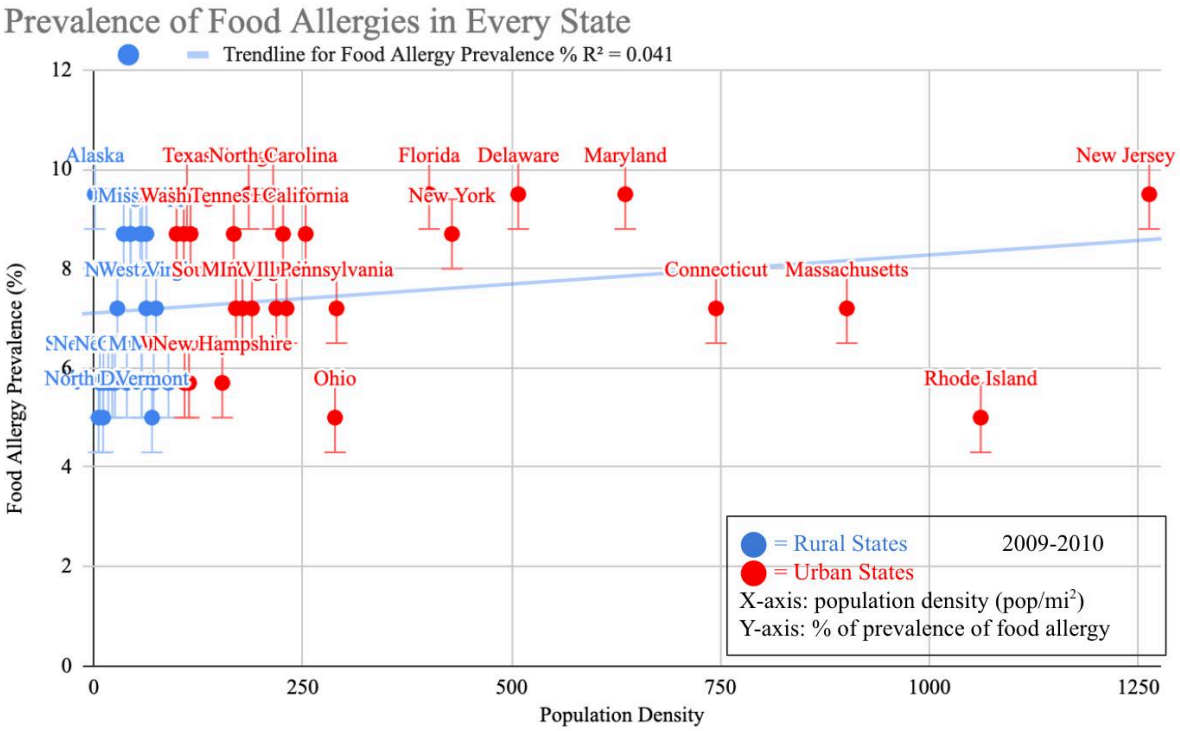

Figure 9: Prevalence of food allergies in every state. Blue is every rural state in the U.S. Red is every urban state in the U.S. The data is from “Geographic variability of childhood food allergy in the United States” (Gupta *et al.* 2012).

The food allergy prevalence percentages aren’t exact, hence why there are error bars 0.7% above and below the value of each state's prevalence. States with a 5% prevalence might have a lower prevalence percentage than that, while states with a 9.5% prevalence might have a higher prevalence percentage than that. The trendline (R^2) for this graph is 0.041.

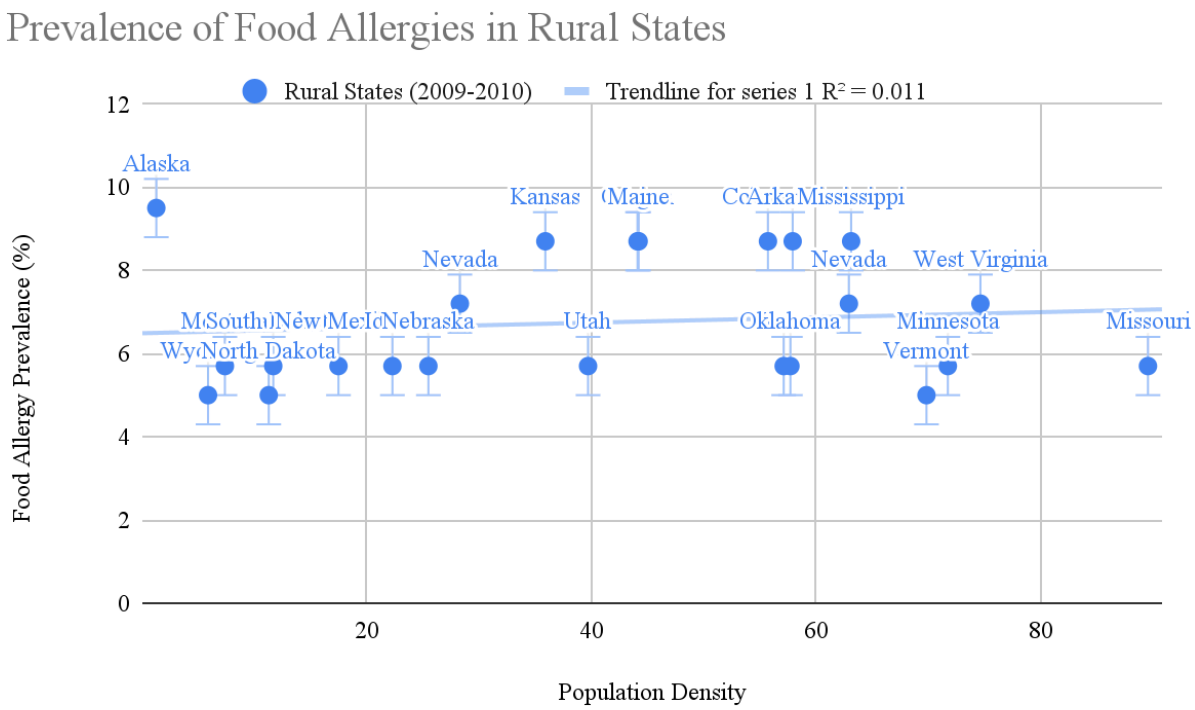

Figure 10: Prevalence of food allergies in rural states. A scatterplot showcasing the prevalence of food allergies in only rural states. The data is from "Geographic variability of childhood food allergy in the United States" (Gupta *et al.* 2012).

We used the same strategy as with the seasonal allergy data: to analyze only rural or urban states to see if there is a correlation that can't be found when all the states are in one dataset. This graph shows the prevalence of food allergy only in rural states. There is a minimal positive correlation, but not as noticeable as for seasonal allergies in rural states.

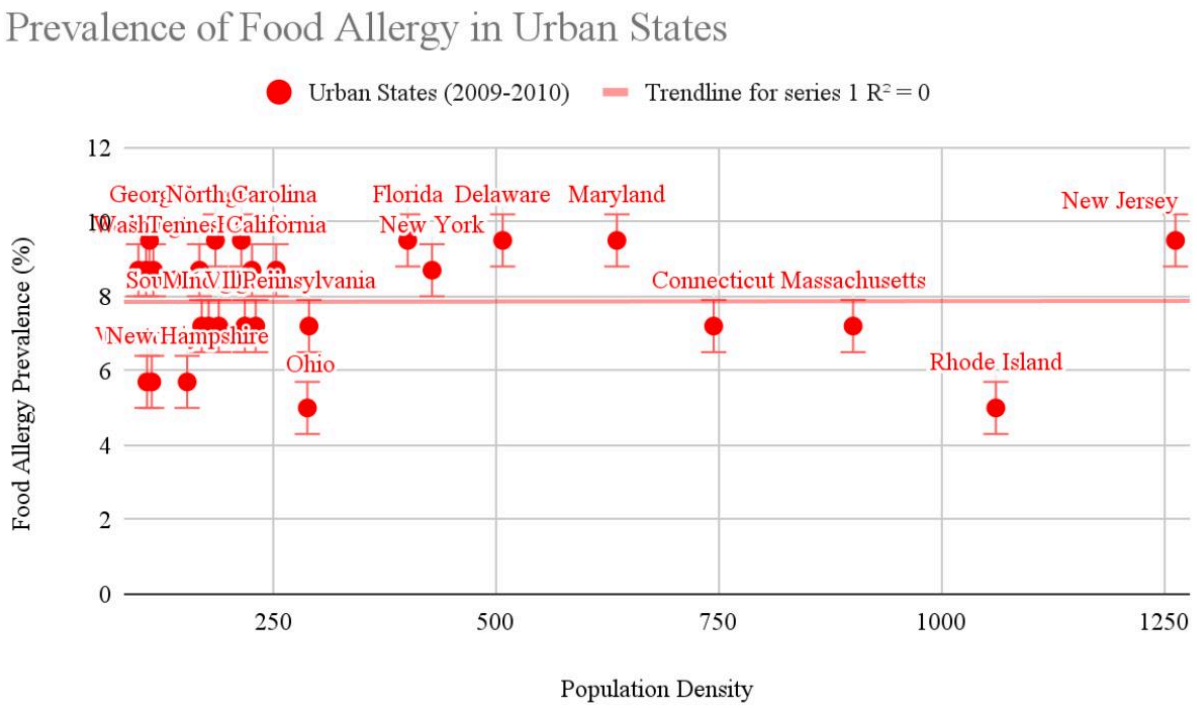

Figure 11: Prevalence of food allergies in urban states. A scatterplot showcasing the prevalence of food allergies in urban states. The data is from "Geographic variability of childhood food allergy in the United States" (Gupta *et al.* 2012).

This data shows no correlation between population density and the prevalence of food allergy in urban states. This is important to note, as every other dataset had some sort of correlation, even if it was minor.

4. Discussion/Conclusion:

The first four graphs include the prevalence of allergies in two groups: children and adults. The prevalence of total allergies and seasonal allergies for children is much lower than for adults, but other allergies are higher in children than adults. This means more children are getting "other allergies" more often than adults. One reason for this could be because as technology has improved, we've been able to identify and diagnose more different types of allergies in children. Another reason for this could be because adults have lived longer, meaning that they have had more time to develop an allergy than children do.

The next graph showed the prevalence of allergies in every major region of the U.S. Interestingly, the South region was much higher than the other regions. This tells us that there is likely a major factor contributing to the high prevalence rate.

The following two major graphs (food and seasonal allergy prevalence graph for all states) highlight the prevalence of specific allergies in every state. The first graph includes the prevalence of hay fever and food allergies.

There are two specific graphs for each significant graph, counting up to 4 total graphs for rural and urban state prevalences. The first two graphs show the prevalences of seasonal allergies in urban states and rural states in their group. The first graph shows a positive correlation in the prevalence of seasonal allergies in rural states. This makes sense, as more pollution/urbanity should result in a higher prevalence of seasonal allergies (Patel *et al.* 2018). The graph for urban states shows a slight negative correlation in the prevalence of seasonal allergies. This means that as urban states become more urban, the prevalence of seasonal allergies becomes smaller. This is likely due to the graph being skewed right, while the rural graph was much more balanced overall.

The other two graphs showcase the prevalence of food allergies, specifically in urban states and rural states. The rural state graph shows a minimal positive correlation in the prevalence of food allergies, while the urban state graph shows no correlation. This could be because pollution, or how urban a state is, might not affect the prevalence of food allergies as much as it does for seasonal allergies.

As shown by the data in both graphs, there wasn't a significant correlation between the prevalence of allergies in urban and rural states. This means that pollution may not have as significant of an effect on the prevalence of allergies as previously thought. This could be for a multitude of reasons. One could be that the scope of this research needed to be narrower, as no state is just urban or just rural but is mixed with both rural and urban areas. For example, Rhode Island is completely different from Texas, but they are both classified as urban. It's hard to compare these states and see if the difference in the prevalence of allergies is from pollution or a different factor since the states are so different. Another reason could also be that population density isn't the best way to determine if a state is rural or urban. A final reason might be because the data on total prevalence of different allergies throughout every state isn't available to the public, resulting in us using older and more unreliable data.

Overall, the effects of pollution on allergies are still unclear, but steps are being taken to get us closer to the answer. More research will still need to be done at a less broad scale, such as every county in the country, to determine if there is a correlation between the prevalence of allergies in urban and rural areas.

Supplementary Data:

Table S1: Prevalence of seasonal allergies in all U.S. states 2006-2007 (Silverberg et al. 2015)

The table includes every state ordered by its population density and shows the prevalence of hay fever in percent.

States	Population Density (pop/mi^2)	Hay Fever Prevalence (%)
Alaska	1.3	10.5
Wyoming	5.9	19
Montana	7.4	12.7
North Dakota	11.3	11.4

South Dakota	11.7	12
New Mexico	17.5	19.3
Idaho	22.3	11.6
Nebraska	25.5	17.4
Nevada	28.3	15.2
Kansas	35.9	19.6
Utah	39.7	15.3
Oregon	44.1	15.4
Maine	44.2	12.6
Colorado	55.7	15
Iowa	57.1	14.2
Oklahoma	57.7	23.1
Arkansas	57.9	20.2
Arizona	62.9	14
Mississippi	63.1	21
Vermont	69.8	10.4
Minnesota	71.7	10
West Virginia	74.6	20.4
Missouri	89.5	19.4
Alabama	99.2	21.5
Louisiana	107.8	20.7
Wisconsin	108.8	11.9
Texas	111.6	17.9
Kentucky	114.1	25.1
Washington	115.9	14.3
New Hampshire	153.9	14.5
Tennessee	167.6	19.3
South Carolina	170.2	18.8
Michigan	178	15.5
Georgia	185.6	19.2
Indiana	189.4	17.4
North Carolina	214.7	17.5
Virginia	218.6	20.3
Hawaii	226.6	12.4

Illinois	230.8	15.3
California	253.7	12.7
Ohio	288.8	18.4
Pennsylvania	290.6	16.4
Florida	401.4	13.6
New York	428.7	15.8
Delaware	508	19.5
Maryland	636.1	20.5
Connecticut	744.7	16.6
Massachusetts	901.2	14.6
Rhode Island	1061.4	14
New Jersey	1263	15.4

Table S2: Food allergy prevalence % in all U.S. states 2009-2010 (Gupta et al. 2012)

Table includes every state ordered by its population density. It also has the prevalence of food allergies in percent.

States	Population Density (pop/mi^2)	Food Allergy Prevalence %
Alaska	1.3	9.5
Wyoming	5.9	5
Montana	7.4	5.7
North Dakota	11.3	5
South Dakota	11.7	5.7
New Mexico	17.5	5.7
Idaho	22.3	5.7
Nebraska	25.5	5.7
Nevada	28.3	7.2
Kansas	35.9	8.7
Utah	39.7	5.7
Oregon	44.1	8.7
Maine	44.2	8.7
Colorado	55.7	8.7

Iowa	57.1	5.7
Oklahoma	57.7	5.7
Arkansas	57.9	8.7
Arizona	62.9	7.2
Mississippi	63.1	8.7
Vermont	69.8	5
Minnesota	71.7	5.7
West Virginia	74.6	7.2
Missouri	89.5	5.7
Alabama	99.2	8.7
Louisiana	107.8	8.7
Wisconsin	108.8	5.7
Texas	111.6	9.5
Kentucky	114.1	5.7
Washington	115.9	8.7
New Hampshire	153.9	5.7
Tennessee	167.6	8.7
South Carolina	170.2	7.2
Michigan	178	7.2
Georgia	185.6	9.5
Indiana	189.4	7.2
North Carolina	214.7	9.5
Virginia	218.6	7.2
Hawaii	226.6	8.7
Illinois	230.8	7.2
California	253.7	8.7
Ohio	288.8	5
Pennsylvania	290.6	7.2
Florida	401.4	9.5
New York	428.7	8.7
Delaware	508	9.5
Maryland	636.1	9.5
Connecticut	744.7	7.2
Massachusetts	901.2	7.2

Rhode Island	1061.4	5
New Jersey	1263	9.5

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