HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 3 (2023)

The Effects of Obesity on COVID-19 Vaccination Rates and Efficacy

Marco Kurepa[1], Alan Bui[1], Jacob Gaisinsky[1], Wendy Zhang[1] and Adam Gaisinsky[2#]

[1]Vincent Massey Secondary School, Canada
[2]University of Windsor, Canada
[#]Advisor

ABSTRACT

Obesity rates and COVID-19 vaccination rates among Canadians are increasing, but whether they are correlated has not been studied (Statistics Canada). Additionally, the potential correlation between obesity and COVID-19 vaccine efficacy has not yet been formally concluded (Kipshidze et al.). Determining how obesity affects vaccination is necessary to assure that the obese population is fully and effectively immunized against the virus. Three important factors, mortality, infection, and vaccination rates, were compared across all Canadian provinces, testing the vaccine efficacy and hesitancy in areas with different obesity populations (Government of Canada). Linear regressions were performed to test for correlations between the vaccination factors and obesity. A Mann-Whitney U test was used to compare provinces with obesity percentages less than 24% against those greater than 24%. The results indicate a positive correlation between obesity and vaccination rates, as well as a significant difference in all factors between the low and high obese percentage populations. It can be concluded that the obese population does not require extra attention and is more receptive than average in terms of COVD-19 vaccination and protection.

Background

Vaccines have long been used to produce immunity and protect against disease. The novel Sars-CoV-2 virus or coronavirus that causes COVID-19 is the most recent virus to receive a vaccine (The College of Physicians of Philadelphia). There are many producers of unique COVID-19 vaccines including Pfizer-BioNTech, Moderna, Novavax, AstraZeneca, and Johnson & Johnson; however, the most effective and administered vaccines are messenger RNA (mRNA) vaccines (Government of Canada). When the vaccine is injected into the body, mRNA gets released and will begin instructing muscle cells to produce a harmless fragment of the spike protein found on the surface of Sars-CoV-2. Once the body recognizes the invasive protein, the immune system is activated, and the production of antibodies and other immune cells is triggered; this response is the same as the response to the real virus. The immune system learns how to fight against the spike proteins, and consequently, the Sars-CoV-2 virus which increases the probability of a successful recovery in the case of future Sars-CoV-2 infection (CDC).

It was discovered that the level of antibodies produced in immunocompromised patients in response to the COVID-19 vaccine was significantly less than average (Lee et al.). A reduced immune response is an indication of reduced efficacy. Because obesity negatively impacts the immune system, studies were done to test the effects of obesity on vaccine efficacy; however, further results are required to reach a consensus (Kipshidze et al.). The research is inconclusive, and obese individuals have not been classified as high-risk. Obesity has a history of causing health complications in conjunction with viral illnesses such as influenza, so it is hypothesized that it can create issues with the Sars-CoV-2 virus and vaccine as well (Kipshidze et al.). Determining the effects of obesity on COVID-19 vaccination efficacy will determine if these individuals have decreased immunity and increased mortality concerning the virus.

Additionally, obesity may influence vaccine hesitancy. Speculation on the effectiveness of the COVID-19 vaccine could deter overweight and obese individuals from vaccination (Townsend). Societal pressures and negative stigma around weight may also play a role in whether someone chooses to get immunized. Unvaccinated obese individuals are more likely to have severe complications because of Sars-CoV-2, so discovering whether this group is vaccine hesitant is vital (Townsend). Determining if there is a correlation between vaccine hesitancy and obesity will unveil if more resources should be spent to heighten the vaccination effort toward obese individuals.

Methods

Canadian provincial obesity data was taken from the 2020 census and was categorized based on self-reported BMI. The data contains provincial obese percentages, the percentage of obese people in each province's population. Participants reported their results through a survey and a BMI of greater than 35.00 was considered obese (Statistics Canada). Provincial COVID- 19 vaccination data, as of April 3, 2022, for fully vaccinated individuals were taken from the Government of Canada (Government of Canada). Vaccine efficacy was measured based on the rate of COVID-19 cases and the rate of death due to COVID-19. Increased efficacy was defined by decreased case and death rates. Efficacy information, as of April 3, 2022, was obtained through the Government of Canada (Government of Canada). Sexes were combined in all the data obtained. Census data was taken from subjects at least 18 years of age and vaccination data was obtained from individuals at least 12 years of age.

Three linear regressions were performed between provincial obesity and provincial vaccination rates, death rates, and rate of cases respectively to calculate r-squared values. ANOVA tests were performed on each regression, and three p-values were calculated. Additionally, the provinces were segregated based on their populations having more or less than 24% obese individuals. A Mann-Whitney U test was performed on these groups for vaccination rates, death rates, and rate of cases, and their p-values were calculated. An α value of 0.05 was used to analyze all the p-values creating a 95% confidence interval.

The linear regressions and ANOVA tests were visualized and performed using Microsoft Excel 2019. The box plots and respective Mann-Whitney U tests were visualized and calculated in R Studio using R version 4.1.2.

Results

Table 1: The linear regression correlation coefficients as well as the ANOVA test p-values for all analyzed data sets (percent vaccinated, rate of death, and rate of cases) vs provincial obesity percentage.

	Percent Vaccinated vs Obesity Percentage	**Rate of Death vs Obesity Percentage**	**Rate of Cases vs Obesity Percentage**
Linear Regression (R-Squared Value)	0.68372	0.67806	0.71191
ANOVA (p-value)	0.0031713	0.0034157	0.0042463

Table 1 illustrates the results of the linear regressions and ANOVA test. All three R-squared values were found to be around 0.7, indicative of a moderate to a strong linear correlation between vaccination and obesity percentage, death rate and obesity percentage, and rate of cases and obesity percentage. Vaccination and obesity were positively correlated, while death rate and obesity, as well as case rate and obesity, were negatively correlated. The p-values for the ANOVA tests were statistically significant with all p-values less than $\alpha = 0.05$ ($0.0031713 < 0.05$, $0.0034157 < 0.05$, $0.0042463 < 0.05$). There is a significant difference between the vaccination, death, and case rates for each province.

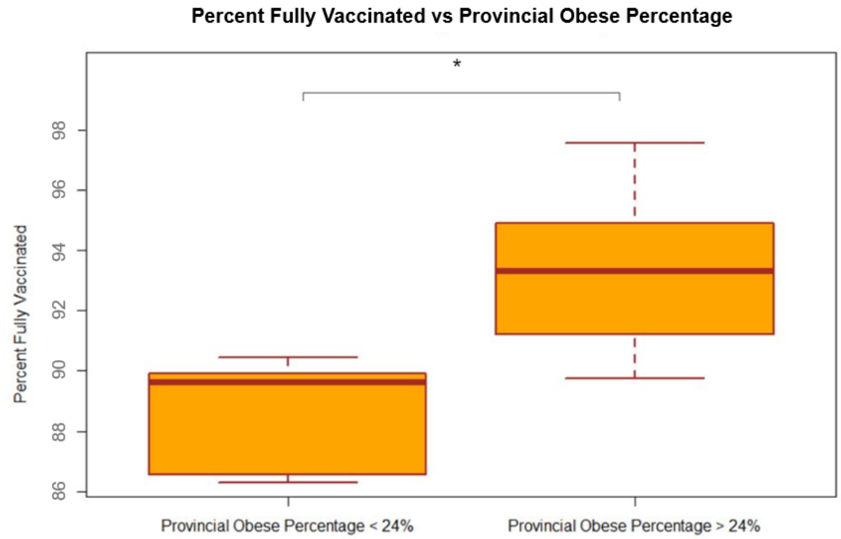

Figure 1: Boxplot of percentage of population over the age of 18 that is fully vaccinated and their distribution across obesity levels. The significant p-value was obtained through a Mann-Whitney U test ($p < 0.05$).

Figure 1 visualises the difference between vaccination percentages of provinces with low and high percentages of obese people. The results were statistically significant as the calculated p-value using the Mann-Whitney U test was less than $\alpha = 0.05$ ($0.01587 < 0.05$).

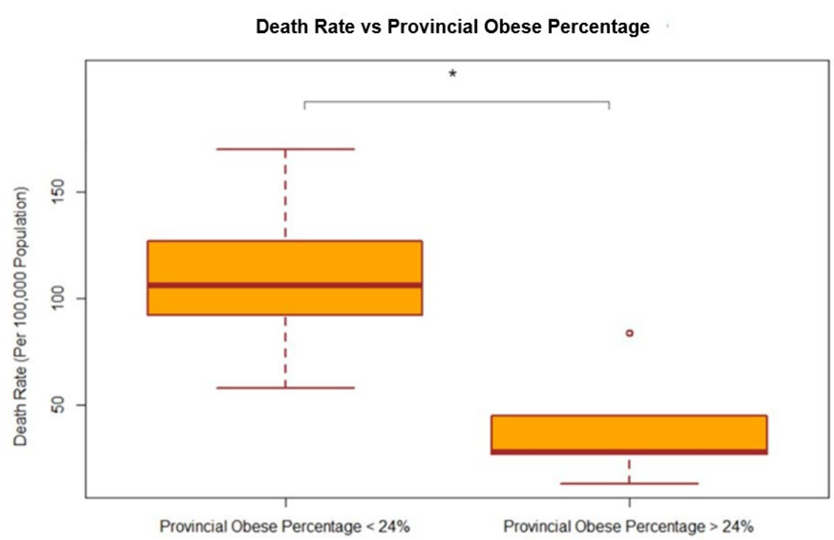

Figure 2: Boxplot of the distribution of the number of COVID-19 related deaths per 100,000 people for different levels of obesity. The significant p-value was obtained through a Mann-Whitney U test ($p < 0.05$).

Figure 2 illustrates the distribution of provincial death rate in relation to obesity levels. The difference between the groups was statistically significant with a p-value calculated using a Mann-Whitney U test that was less than $\alpha = 0.05$ ($0.01587 < 0.05$).

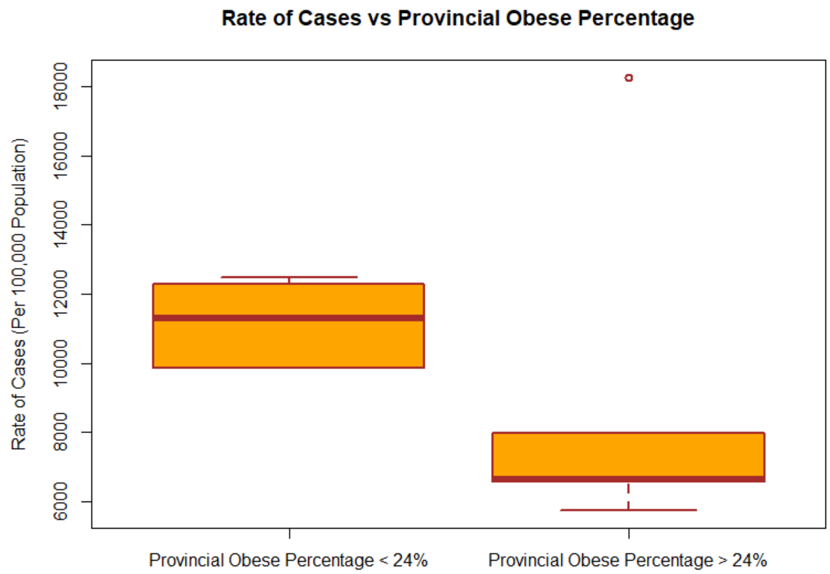

Figure 3: Boxplot of the rate of COVID-19 cases across different obesity levels. The significant p-value was obtained through a Mann-Whitney U test ($p < 0.05$).

Figure 3 visualizes the difference between the rate of COVID-19 cases between varying obesity levels. The difference is not statistically significant because the calculated p-value from a Mann-Whitney U test was greater than $\alpha = 0.05$ ($0.1508 > 0.05$).

Discussion

From Table 1 a moderate to strong positive linear correlation between COVID-19 vaccinations and obesity can be drawn. This can be seen in Figure 1 as the provinces with higher obese percentages had significantly higher vaccination percentages. An explanation for this discrepancy is that obese people are more pressured to get vaccinated than people with an average BMI. Obese people visit the hospital far more frequently than average and are constantly conversing with medical professionals (Folmann et al.). Pressure from doctors may cause a higher proportion of these individuals to get vaccinated. Additionally, obese people are generally less healthy, on more medications than average, and more trusting of the medical system (Konkel). Thus, many of the main causes of vaccine hesitancy such as distrust and reliance on physiological immunity would not be as prevalent in this group (FPM).

There was a moderate to a strong negative linear correlation between COVID-19-related deaths and obesity, and COVID-19 cases and obesity as seen in Table 1. Additionally, visualized in Figure 2, the provinces with higher percentages of obesity had significantly lower death rates. No difference was found in terms of case rates, as seen in Figure 3. Vaccine efficacy was defined by the proportionate number of deaths and infections with a lower number being indicative of higher efficacy. The data analysis showed that provinces with a greater obese population had at least average vaccine efficacy. It was expected that obese people with weaker immune systems would not be able to produce an adequate immune response to the vaccine, but the data did not support this result (Kipshidze et al.). A plausible explanation for why obesity did not decrease efficacy could lie in the results from Figure 1; provinces with higher levels of obesity had a higher proportion of immunized individuals. Because obesity was positively correlated to vaccinations and vaccination results in increased protection against Sars-CoV-2, the more obese provinces were sufficiently protected against the virus (Government of Canada).

Based on the findings, it can be concluded that the COVID-19 vaccine is at least equally as effective in obese patients compared to average patients. If the vaccine was ineffective in obese individuals, there would have been a positive correlation between death or case rates and obesity; however, neither positive correlation was discovered. In addition, it was found that obese populations are more likely to be vaccinated than average. Thus, we can reject the null hypothesis that obesity does not affect vaccination rates; however, we fail to reject the null hypothesis of no difference in terms of vaccine efficacy. These findings indicate that obese individuals get at least average levels of protection from the vaccine. They are also not a target for vaccination campaigns and their increased risk factors in terms of serious sickness is being adequately controlled.

A limitation of this analysis is the scope of the data. The data was taken at a provincial level, so when scaled down to the individual, results may vary. Further research is required to conclusively determine the effects of obesity on COVID-19 vaccine efficacy and receptiveness; however, the analyses performed strongly suggest a correlation. Additionally, extraneous variables could have affected our results such as quality of life and socioeconomic status. Lower socioeconomic status is correlated with lower vaccine acceptance (Caspi). The socioeconomic status of the provinces could have influenced their respective vaccination rates. Also, the definition for vaccine efficacy could have been more accurate if antibody production data was included. Antibody levels are correlated with virus protection (Reynolds). The results would be more compelling if the physiological tests agreed with the practical data used.

Despite the limitations, the analyses illustrated that the obese population is more receptive to getting the COVID-19 vaccine which is effective at protecting them from the virus. Future studies could attempt to discover the reason behind this correlation or study similar immunocompromised groups such as the elderly and individuals with organ transplants. The trend of individuals that are more exposed to healthcare and doctors having higher vaccination rates should be explored. Learning about what affects vaccine hesitancy can help to improve the general tactics employed to increase vaccine receptivity.

Conclusion

Positive correlations were discovered between obesity and vaccination rates, and obesity and vaccine efficacy. The Mann-Whitney U tests showed a significant difference ($p < 0.05$) in vaccine hesitancy, but not efficacy, across low and high obese percentage populations in Canada. Provinces with higher concentrations of obesity had a higher vaccination rate. Thus, the null hypothesis that COVID-19 vaccination rates were unaffected by obesity rates was rejected. There was not enough evidence to support a reduction in vaccine efficacy because of obesity. It can be concluded that higher obesity rates tend to lead to decreased vaccine hesitancy; however, further study on larger populations is necessary to determine whether obesity is a factor that affects COVID-19 infection and mortality rates. Furthermore, other immunocompromised audiences such as elderly, overweight, and cancer patients should be studied in the future to see if similar patterns are observed in terms of decreased vaccine hesitancy. The obese population does not require additional healthcare attention as they are less prone to vaccine hesitancy, and no relevant change in COVID-19 vaccine efficacy was observed.

References

All timelines overview. (n.d.). Timeline | History of Vaccines. Retrieved April 19, 2022, from https://www.historyofvaccines.org/timeline/all

Caspi, G., Dayan, A., Eshal, Y., Liverant-Taub, S., Twig, G., Shalit, U., Lewis, Y., Shina, A., Caspi, O. (2021, June 7). *Socioeconomic disparities and COVID-19 vaccination acceptance: a nationwide ecology* study. Clinical Microbiology and Infection. Retrieved April 19, 2022, from https://pubmed.ncbi.nlm.nih.gov/34111591/

Centers for Disease Control and Prevention. (2022, January 4). *Understanding mrna COVID-19 vaccines*. Retrieved April 19, 2022, from https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/mrna.html

Covid-19 Daily Epidemiology update. (2021, May 28). Government of Canada. Retrieved April 19, 2022, from https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html?stat=rate&measure=deaths&map=pt#a2

Covid-19 vaccination coverage in Canada. (2021, March 26). Government of Canada. Retrieved April 19, 2022, from https://health-infobase.canada.ca/covid-19/vaccination-coverage/

Eniola, K., Sykes, J. (2021, April 27). *Four reasons for COVID-19 vaccine hesitancy among health care workers, and ways to counter them.* AAFP. Retrieved April 19, 2022, from https://www.aafp.org/journals/fpm/blogs/inpractice/entry/countering_vaccine__hesitancy. html

Folmann, N. B., Bossen, K. S., Willaing, I., Sørensen, J., Andersen, J. S., Ladelund, S., Jørgensen, T. (2007). *PubMed*. Retrieved April 19, 2022, from https://pubmed.ncbi.nlm.nih.gov/19548557/

Government of Canada. (2022, April 11). *COVID-19: Effectiveness and benefits of vaccination.* Retrieved April 19, 2022, from https://www.canada.ca/en/public-health/services/diseases/coronavirus-disease-covid-19/vaccines/effectiveness-benefits-vaccination.html

Health characteristics, annual estimates. (2021, September 8). Statistics Canada. Retrieved April 19, 2022, from https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310009601

Kipshidze, N., Kipshidze, N., & Fried, M. (2021, April 8). *Covid-19 vaccines: Special considerations for the obese population*. Nation Library of Medicine. Retrieved April 19, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8029603/#CR13

Konkel, L. (2011, December 2). *Obese people use more meds: study*. Reuters. Retrieved April 19,2022, from https://www.reuters.com/article/us-obese-idUSTRE7B11Y820111202

Lee, A. R. Y. B., Wong, S. Y., Chai, L. Y. A., Lee, S. C., Lee, M. X., Muthiah, M. D., Tay, S. H., Teo, C. B., Tan, B. K. J., Chan, Y. H., Sundar, R., & Soon, Y. Y. (2022, March 2). *Efficacy of covid-19 vaccines in immunocompromised patients: Systematic review and meta-analysis*. Retrieved April 19, 2022, from https://www.bmj.com/content/376/bmj-2021-068632

Overweight and obese adults, 2018. (2019, June 25). Statistics Canada. Retrieved April 19, 2022, from https://www150.statcan.gc.ca/n1/pub/82-625-x/2019001/article/00005-eng.htm

Reynold, S. (2021, December 7). *Measuring protection after COVID-19* vaccination. National Institutes of Health. Retrieved April 19, 2022, from https://www.nih.gov/news-events/nih-research-matters/measuring-protection-after-covid-19-vaccination #:~:text=In%20people%20who%20received%20two,vaccines%20against%20COVID%2D19%20variants

Townsend, M. J., Kyle, T. K., & Stanford, F. C. (2021, March 23). *Covid-19 vaccination and obesity: Optimism and challenges*. Obesity (Silver Spring, Md.). Retrieved April 19, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7990687/