

Analyzing Measles Vaccination Rates Across U.S. Elementary Schools (2017-2019)

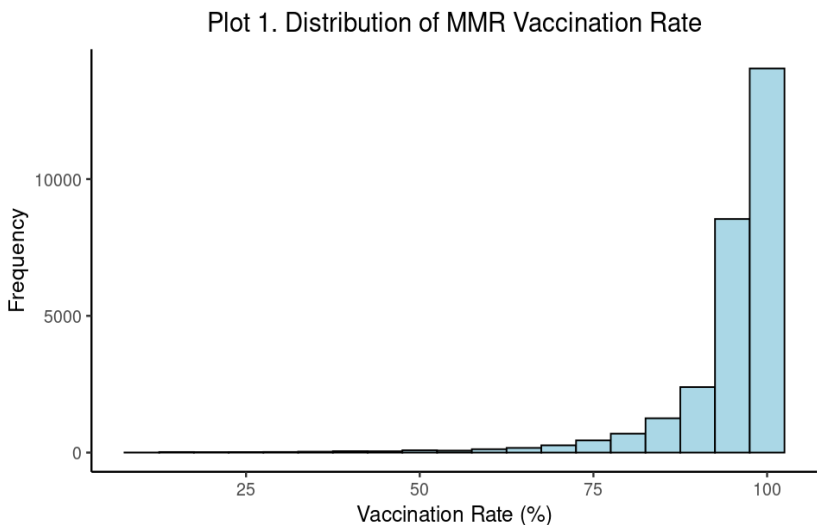
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Measles is a highly contagious viral disease that spreads quickly through coughing and sneezing, causing fever and a distinctive rash. The MMR vaccine, which protects against measles, mumps, and rubella, is critical in preventing measles. In 2019, the U.S. reported 1,249 measles cases, with 89% involving individuals who were either unvaccinated or had an unknown vaccination status[1]. The Centers for Disease Control and Prevention (CDC) strongly recommends that every child receive the MMR vaccine and when more than 95% of people in a community are vaccinated, most individuals are protected through herd immunity[2]. The analysis about the measles vaccination across U.S. elementary schools was based on a dataset collected by the Wall Street Journal with voluntary responses from 46,411 elementary schools across 32 U.S. states from 2017 to 2019. The dataset includes key variables such as the students' MMR vaccination rate, which was converted into a categorical variable with that greater and equal to 95% and lower than 95%, the type of school (public, private, or charter), and the proportion of students exempted from vaccination for medical, personal, or religious reasons. We want to assess if the majority (over 80%) of U.S. elementary schools with the MMR vaccination rates 95% or above, and examine whether there is a relationship between school types and MMR vaccination rate.

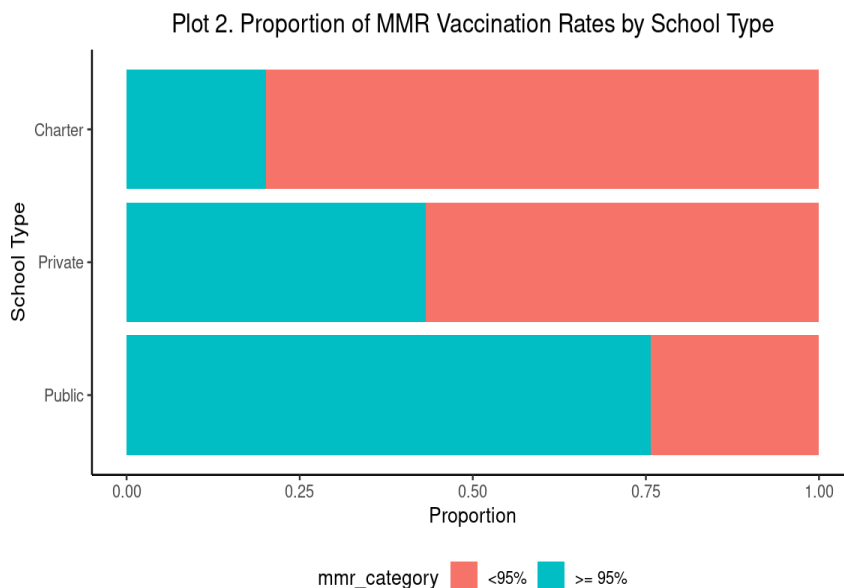
After assigning the unnormal -1% and lower than 10% vaccination rate to NAs. Plot 1 shows that the distribution of MMR vaccination rate is left-skewed with the most over 90%. We use the one-proportion hypothesis test to check the first question. Our null hypothesis is that the proportion of elementary schools in the U.S. with an MMR vaccination rate of at least 95% is 80%, while the alternative hypothesis is the proportion is less than 80%.

The conditions are met, as each elementary school is independent, and we have $np_0 = 12104$ and $n(1-p_0) = 3026$, all greater than 10. The confidence interval of our parameter is from 71.05% to 72.11%. The test statistic is -6.7986. Since our p-value is $5.284e-12$. Since p-value is less than 0.05, we will reject null hypothesis, the conclusion is we have enough evidence that the true proportion of elementary schools in the US with MMR vaccination rate higher than 95% is less than 80%.

Additionally, we use the chi-squared test to examine whether there is a relationship between school type and vaccination rate. The null hypothesis is that school type and vaccination rate are independent, while the alternative hypothesis is that they are not independent. The conditions for



independence and expected counts are also satisfied. Our test statistic is 520.1772. Our p-value is 1.109063e-113. Since p-value is less than 0.05, we will reject the null hypothesis. We have enough evidence that school type and MMR vaccination rate are not independent of each other.



Since the dataset relies on voluntary participation, it could introduce some response bias. One main limitation of this study is that exemption data does not account for charter schools, which could significantly influence the overall analysis and conclusions. Without including charter schools, the study cannot fully generalize vaccination behaviors across all school types. Addressing this gap in future research is crucial. Investigating the

underlying reasons behind the lower vaccination rates observed in charter schools could provide valuable, actionable insights. Such research could help policymakers develop targeted interventions and strategies to address vaccination disparities, ultimately improving community health and moving closer to the WHO's 95% vaccination goal.

Comparison	Test Statistic	Lower CI	Upper CI	p-value
Public - Private	13.56	0.094	0.129	$< 2.2e^{-16}$
Private - Charter	13.24	0.379	0.501	$< 2.2e^{-16}$
Public - Charter	19.97	0.493	0.611	$< 2.2e^{-16}$

[1] Patel M, Lee AD, Clemmons NS, et al. National Update on Measles Cases and Outbreaks — United States, January 1–October 1, 2019. MMWR Morb Mortal Wkly Rep 2019;68:893–896. DOI: <http://dx.doi.org/10.15585/mmwr.mm6840e2>.

[2] <https://www.cdc.gov/measles/data-research/index.html>