How do global trends in estimated polio cases correlate with immunization coverage and prevalence of open defecation across countries from 2000 to 2020?

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Project Write-Up

Primary Purpose & Methodology & Visualizations

NLP Analysis

This study examines the impact of immunization efforts and sanitation policies, particularly open defecation, on global polio prevalence, using data from the World Bank, WHO, and UNICEF. It integrates polio immunization rates, country-level open defecation rates, and estimated polio cases. Polio case estimates often underestimate actual cases due to unreported acute flaccid paralysis (AFP) and inadequate stool testing. Tebbens et al. addressed this by applying correction factors ranging from 7 (for poor surveillance) to 1.11 (for robust systems), based on non-polio AFP rates and stool sample adequacy. This approach, refined post-1995, improves global case estimates, even in countries not supported by the GPEI.

The NLP analysis of articles on polio emergence and eradication revealed key themes and gaps. Keywords like "vaccines" (55 mentions) and "immunization" (28 mentions) highlighted the focus on vaccination efforts, prompting us to prioritize immunization rates as a critical indicator. Sanitation-related keywords, such as "sanitation" (4 mentions), "sewage" (9 mentions), and the absence of "open defecation," suggested that while sanitation factors are less emphasized, they are still important in polio transmission, especially in areas with poor hygiene. This led us to include open defecation rates as an additional indicator. Based on these insights, our research question focuses on the interplay between immunization efforts and environmental factors in reducing polio cases.

Static Visualization using Altair:

Using three datasets on open defecation rates, immunization rates, and estimated polio cases from 2000–2020, we performed extensive data cleaning and transformation. This included reshaping the data, renaming variables, handling missing values, and merging datasets by country codes. Duplicate entries were removed for consistency. We focused on countries with persistently high polio cases by filtering the data to identify the top ten countries with the highest estimated polio cases. This enabled more targeted visualizations, with separate plots assessing immunization and open defecation rates. Bubble charts were used to represent these factors, as immunization and open defecation rates are percentages, while polio cases are absolute numbers, allowing for clearer analysis of correlations and trends.

i. Heatmap (Correlation of Open-defecation rates with estimated polio rates)
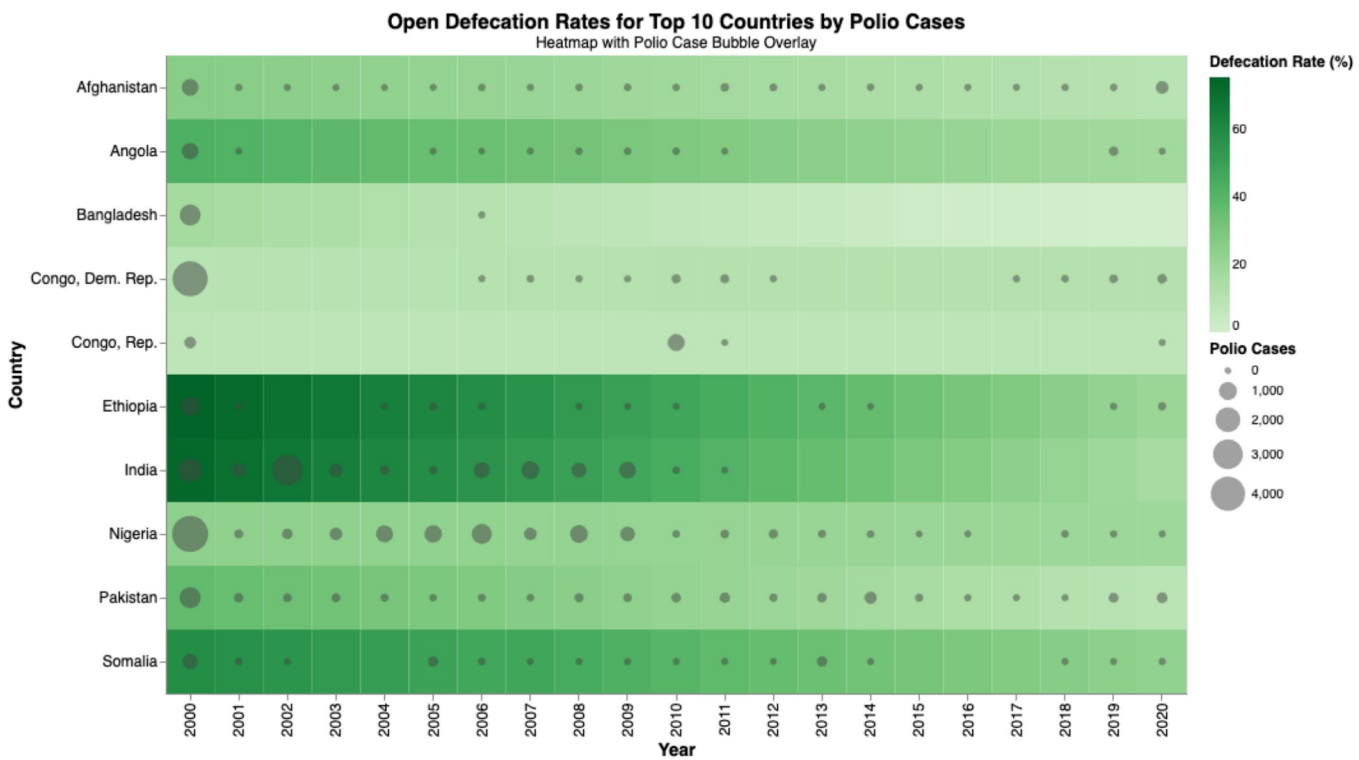
rates)

ii. Bubblemap (Correlation of polio immunization rates with estimated polio cases)
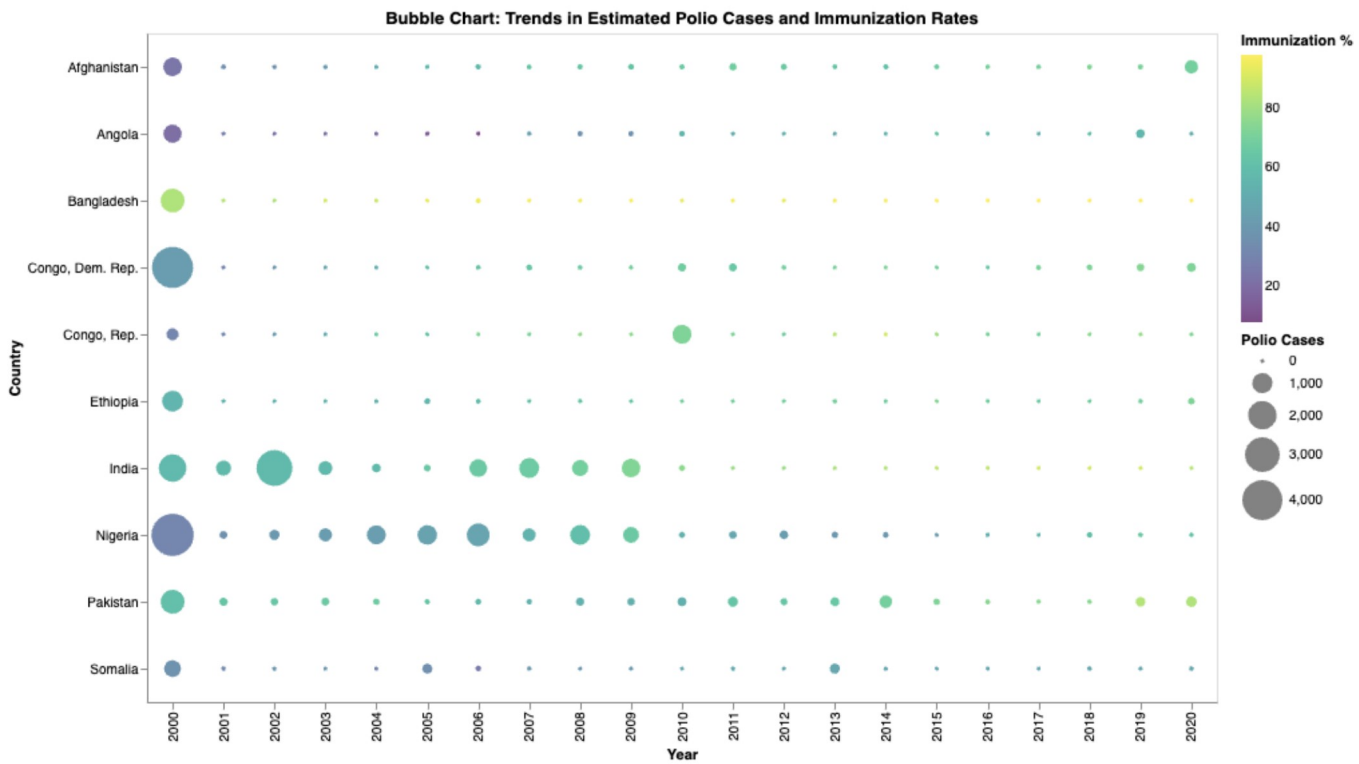
i. The heatmap shows trends in open defecation rates and their potential link to polio cases in the top 10 countries reporting polio over time. Darker green shades indicate higher open defecation rates, while lighter shades represent lower rates. A bubble chart overlays this, with bubble size reflecting

while lighter shades represent lower rates. A bubble chart overlays this, with bubble size reflecting the number of estimated polio cases. Countries like India and Ethiopia, which had high open defecation rates, have seen significant declines. However, the bubble size does not always align with reductions in open defecation. For example, while India saw both lower open defecation rates and polio cases, Pakistan and Afghanistan, despite improvements in sanitation, remain polio-endemic.

ii. To examine the correlation between immunization rates and estimated polio cases, we created a bubble chart where bubble color represents immunization rates, and bubble size reflects the average number of estimated polio cases. Countries in green and yellow, with high immunization rates, have seen significant declines or eradication of cases. In contrast, countries in purple and blue, with lower immunization rates, continue to experience outbreaks. While cases have declined in all 10 countries over the past two decades, Pakistan and Afghanistan remain endemic, with low immunization rates likely contributing to this persistence.

Shiny App

The dynamic plot - dashboard provides a visualization and analysis tool for tracking health and sanitation indicators world-wide. It allows users to select a country and choose from three key outcomes: Immunization Percentage, Estimated Polio Cases, and Defecation Rate. The displayed line plot shows the trend over time for the selected outcome from 2000 to 2020. Additionally, a data table below the graph presents detailed yearly values for the indicators, offering users a quick overview of the underlying data.

Limitations

Efforts to combat polio are hindered by underreporting, data inaccuracies, and limited contextual understanding. National data aggregation obscures regional disparities and outbreak hotspots, impeding targeted interventions. Critical gaps remain in research on conflict, water insecurity, climate change, and cultural drivers of vaccine hesitancy in at-risk regions. Addressing these challenges is crucial for developing effective, localized eradication strategies.

Conclusions & Policy Implications

While there is a positive correlation between immunization rates and polio cases, highlighting the critical role of vaccination in combating the disease, the lack of a direct correlation between open defecation rates and polio cases suggests that other factors may influence disease transmission. Additionally, the emergence of vaccine-derived polio presents a new challenge for global eradication efforts, emphasizing the need for sustained immunization campaigns and robust public health strategies.Global polio eradication requires a comprehensive approach. Vaccination coverage must exceed 95%, with both oral and injectable vaccines to prevent vaccine-derived cases. Behavioral interventions, including awareness campaigns and partnerships, are key to addressing vaccine hesitancy. Sanitation improvements, such as safe waste disposal and clean water access, are also vital. Rebuilding infrastructure in conflict zones and providing immunization in refugee camps are necessary. Global coordination is crucial to harmonize vaccination efforts, share knowledge, and support low-income countries. A multi-pronged strategy addressing immunization, sanitation, and socio-political barriers is essential for a polio-free future.