Data-Driven Analysis of Vaccine Uptake Disparities

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Abstract

Bangladesh has long been celebrated as a global "immunization miracle," maintaining high routine coverage for decades and consistently meeting or surpassing WHO targets. Yet, as we examine the landscape in 2026, it becomes clear that this success is unevenly distributed. The challenge is no longer merely about vaccine availability; it is about understanding the subtle behavioral inequalities that determine whether a child receives all recommended doses on time.

Vaccine uptake in Bangladesh now reflects a complex interplay of geographic barriers, socioeconomic factors, digital misinformation, and trust dynamics, creating gaps that are particularly visible among urban slums, marginalized rural communities, and socioeconomically vulnerable populations. Leveraging data science and advanced clustering models, public health researchers are moving beyond generic, nationwide campaigns to a more nuanced, evidence-based approach, revealing the determinants of vaccine hesitancy and the opportunities for targeted intervention.

The quantitative reality of 2025–2026 highlights both the progress and the persistent disparities. Nationally, coverage for the third dose of the DTP vaccine (DTP3) remains impressively high at approximately 98%, reflecting decades of routine immunization campaigns. However, these figures conceal critical "last mile" challenges. Urban slums, contrary to expectations, often lag behind rural areas in vaccination coverage. Recent surveys show that full immunization coverage in slums such as Korail and Kamrangirchar can be as low as 79%, whereas many rural communities reach 85% coverage. Within urban regions, the "Zero-Dose" phenomenon—where children have not received even a single vaccine dose—is prevalent in marginalized populations. In Rangpur City Corporation, for example, clusters have been identified in which only 70% of children are fully immunized. These communities typically comprise extremely low-income households, often lacking permanent addresses or regular access to healthcare facilities. The implications are clear: without precise targeting, even robust immunization programs risk leaving the most vulnerable behind.

Dropout rates between successive doses of vaccines also reveal systemic gaps. In Dhaka, the difference

between MCV1 and MCV2 coverage is nearly 5.5%. Regression analysis shows that children of homemaker mothers in slums are 4.84 times more likely to drop out compared to children of working mothers, likely due to a combination of limited social support, rigid clinic schedules, and long waiting times. Such behavioral and structural factors underscore the inadequacy of generic messaging campaigns; understanding the underlying drivers of vaccine hesitancy is critical to closing the gap.

To identify these drivers, researchers have applied a combination of logistic regression and K-means clustering on national immunization datasets. This approach enables the isolation of key predictors of vaccine refusal, delay, or dropout, ranging from digital misinformation to socio-economic barriers. One of the most prominent factors in 2026 is the role of the “infodemic”—the spread of digital misinformation—which has emerged as a measurable behavioral determinant of vaccination decisions. Anomaly detection applied to social media and messaging platforms reveals that while over 97% of mothers acknowledge the importance of routine vaccines, 57% express specific fears about new vaccines, such as the Typhoid Conjugate Vaccine or COVID-19 boosters. These fears are often fueled by online rumors or unverified peer narratives, reflecting a “wait-and-see” sentiment in otherwise supportive communities. Data further demonstrates that transparent communication regarding a vaccine’s origin, safety profile, and regulatory approvals can improve acceptance by 9.1% among hesitant groups, highlighting the tangible impact of trustworthy information on vaccine uptake.

Socioeconomic barriers compound the challenge of vaccination. Clustering analyses reveal that factors such as time, cost, and access are as significant as trust. In Korail slum, for instance, 75.9% of parents who report waiting more than 15 minutes at a clinic subsequently fail to complete the full vaccine schedule. Households with monthly incomes below 18,000 BDT are significantly more likely to have incomplete immunization records, with an odds ratio of 2.16. The combination of time pressures, economic vulnerability, and digital exclusion creates structural friction that prevents otherwise willing caregivers from completing vaccination schedules.

Framing vaccine uptake as a behavioral inequality allows for the design of precise, data-driven interventions. Instead of focusing solely on vaccine supply, the goal becomes delivering confidence and trust alongside medical products. One strategy is micro-targeted communication for high-risk urban settlements. By leveraging predictive analytics, public health authorities can adjust vaccination schedules, deploy mobile immunization teams, and send targeted reminders to caregivers in real time. These interventions directly address the high dropout rates and geographic barriers identified in regression models.

Digital marginalization remains a major obstacle, particularly in rural areas. While smartphone ownership is high, with approximately 84% of rural residents possessing a device, only a fraction—around 2%—demonstrate sufficient digital literacy to independently verify health information online. To bridge this gap, human-led digital interventions have been implemented, wherein health workers use digital tools during

home visits to demonstrate vaccine safety and efficacy. Testimonials from trusted figures, displayed on tablets or smartphones, reinforce credibility and increase parental confidence in the vaccination process.

Community and religious trust also play a decisive role in vaccine acceptance. Data from high-risk regions such as Cox's Bazar confirms that integrating local leaders—imams, majhis, and other respected community figures—as "trust ambassadors" significantly boosts coverage. In areas where these leaders actively participate in awareness campaigns and accompany health workers to households, immunization coverage has increased to over 86%, demonstrating the effectiveness of culturally sensitive engagement. Human-led interventions combined with technology-driven targeting allow authorities to reach communities previously resistant or marginalized.

These findings underscore a critical paradigm shift: achieving universal vaccination is not only a matter of logistics and supply but also of behavioral insight and trust-building. Data-driven analysis enables policymakers to move beyond uniform strategies and implement tailored interventions that reflect the lived realities of diverse communities. By mapping vaccine uptake disparities at a granular level, health authorities can allocate resources more efficiently, prioritize interventions in underserved areas, and monitor the impact of communication strategies in real time.

Furthermore, the integration of AI and predictive analytics into immunization programs facilitates rapid identification of emerging "zero-dose" clusters. Such real-time monitoring allows for the agile deployment of mobile vaccination teams, community outreach programs, and local awareness campaigns, ensuring that gaps are addressed before they translate into outbreaks. Equally important, this approach ensures that interventions are equitable: resources are directed to the communities most in need, rather than being disproportionately concentrated in areas with historically high coverage.

Ultimately, the pursuit of equitable vaccine coverage in Bangladesh reflects broader principles of health justice. The same tools that identify coverage gaps also reveal the underlying drivers of behavioral inequality, enabling interventions that are both targeted and culturally appropriate. In urban slums, this may mean extending clinic hours, deploying mobile teams, and leveraging trusted local leaders. In rural communities, it may involve digital demonstrations combined with home visits, tailored messaging in local dialects, and engagement with social influencers within the village context. Each intervention is informed by data, calibrated for impact, and responsive to community dynamics.

In conclusion, the vaccination landscape in Bangladesh in 2026 illustrates that medical supply alone is insufficient to achieve universal coverage. Vaccine uptake is fundamentally a behavioral and social challenge. By harnessing the power of data science, regression analysis, and AI-driven clustering, public health authorities can identify disparities, address the behavioral determinants of hesitancy, and implement interventions that build trust and confidence. Whether in a high-rise apartment in Banani or a tin-shed home

in Korail, the ultimate goal is the same: to ensure that every child receives the full suite of life-saving vaccines. The path to a truly healthy nation lies not only in the vaccine’s formulation but in the trust and engagement cultivated within communities—a lesson that data-driven public health strategies in Bangladesh are increasingly making concrete.