# Predictive Modeling for Public Health Resource Allocation

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## Abstract

*When it comes to matters of life and death such as in the case of public health, timing can be the difference between a containment and a disaster. In the case of Bangladesh, a highly populated nation, having over 1,100 people per square kilometer, resilience of the health system is always at stake. The highly seasonal floods, heatwaves, outbreaks of infectious diseases, emergencies of mothers and babies, and a gradual increase in non-communicable diseases all vie over scarce beds, medicines, and personnel.*

Over the decades, most health governance in the country has been reactive: hospitals react when the wards are overcrowded, medicines are ordered when they run low, and staffing needs are met only at which point they become apparent. By early 2026, however, Bangladesh is undergoing a major paradigm shift, that is, reactive management into data-driven proactive governance. With the help of Machine Learning (ML) and predictive analytics, it is no longer the governmental health organizations that are counting patients; rather, they are predicting them.

The main point of this change is the District Health Information Software 2 (DHIS2) platform, which gathers routine health data of facilities nationwide. Previously as a reporting and monitoring tool, DHIS2 is emerging as a prophecy machine. By using more sophisticated statistical approaches, such as Bayesian log-linear models and time-series forecasting, researchers and data scientists are forecasting service volumes, trends of diseases and resources requirements in all eight administrative divisions. Rather than only using figures to rely on what was expected last year, the policymakers are now able to look at the forecasts of the number of patients to be expected in the months and the years ahead. The result of this shift is that it alters the logic of resource allocation, as it is no longer based on retrospective adjustment, but anticipatory planning.

Chronic bed shifts have been one of the most urgent issues of the healthcare system in Bangladesh. Occupancy rates (BOR) have been very high in hospitals beyond safe working levels especially in the secondary and tertiary hospitals. Over the last few years, the occupancy rates of most of the major hospitals

have been in the range of above 100 percent with a few of the hospitals operating in the range of 40 percent higher than what was intended. Crowded wards lead to poor infection control, burnout among health care workers and poor patient care. Predictive modeling provides an avenue to these pressures reduction. The projections up to 2025-2026 point to the outpatient visits increasing by over 30 percent in the country due to population growth, rise in health seeking behavior and coverage of services. Instead of relying on the fill of the corridors with patients, the administrators will be able to predict the peaks of the demand and can now change the number of beds, referral, and temporary expansion plans.

Regional forecasting has been of great benefit. Although Dhaka and Chattogram always show the highest utilization rates, based on the models, emerging high-risk areas that may not be revealed by the traditional reporting are found. As an example, it is estimated that there are likely to be high rates of low birth weight (LBW) births in certain areas, which is an indicator that more neonatal intensive care units are required in specific districts. This type of granular insight will allow the strategic relocation of incubators, specialised nursing personnel and maternal health resources ahead of crisis realisation. Rather than increasing capacity across the country uniformly, which is a financially infeasible policy, predictive modeling helps targeted interventions, which are based on evidence.

Predictive analytics is also defining the pharmaceutical and emergency supply chain management beyond the hardware infrastructure. Bangladesh health system is very delicate to seasonality. There are monsoon cycles of floods, heatwaves in the pre-monsoon, and post-flood outbreaks which cause cycles of spikes in waterborne and vector-borne diseases. When time-series models are used, like ARIMA, and when the meteorological data is incorporated, researchers are able to predict condition-specific surges several months before it occurs. Increases in the maximum temperatures which are expected to rise continuously in the next few decades have been statistically linked to diarrheal diseases peaks. In the case of 2026, these types of models allow the inclusion of oral rehydration salts (ORS), intravenous fluids, and antibiotics in vulnerable areas with heat before the peaks in the temperatures take place. This proactive logistics planning ensures that the stockouts are minimized, emergency procurement costs are minimized, and the timely treatment at the community level is achieved.

Predictive modeling is not only efficient but the value of predictive modeling directly intersects with health equity. Resource-constrained contexts are not only concerned with saving costs, but with creating equitable impact as well. Machine learning techniques are being employed more and more to predict the trends of under-five mortality and demonstrate the areas with slow development. Projections in the country indicate that the rates of child mortality will continue to decrease in the next few years. The gains are however skewed. The policy makers can target further outreach efforts, immunization and nutrition programs to underserved Upazila Health Complexes by mapping districts with slowest reductions. In this respect, predictive analytics would become a guideline of equity-based investment.

The other impact frontier is staffing optimization. Bangladesh has suffered a repetitive paradox wherein new facilities are built and, on the occasion there is high demand, the facilities lie idle because of lack of trained technicians/nurses to man them. Predictive tools assess pattern of patient loads by season, by type of service and by cluster of geographic location in order to offer optimum level of staffing. This kind of dynamic allocation minimizes both overstaffing and understaffing in periods of low demand and high demand respectively. With the alignment of human resource with the projected requirements, service delivery is facilitated and more receptive.

Nonetheless, there are no worries about the ethical complexity of integrating predictive modeling in the governance of the public health. When algorithms start to be used to make decisions about the bed placements, the medicines distribution, and the staff placement, key questions that emerge are: Who decides who to prioritize? What are the values implemented into optimization models? When an algorithm is written to produce a maximum total health benefit to the greatest number of individuals, it can always prefer densely populated metropolitan areas in which interventions produce statistically significant higher aggregate effect. Although this utilitarian orientation is effective, it poses a danger of marginalizing the rural population or the communities that have rare and expensive to treat illnesses. The efficiency when sought without ethical restraints will automatically support geographic and socioeconomic inequality.

The other important issue is the information bias cycle. Predictive models are based on historical information. In the event that some areas display a historic low service utilization not based on a need, but based on lack of access, this can be modeled as low demand. As a result, predictions would tend to suggest that less resources be allocated to these regions and a cycle of underinvestment would be maintained. As an example, when the districts such as Barisal or Sylhet record fewer visits to facilities relative to transportation barriers or cultural obstacles, an algorithm (trained on utilization data only) can predict the further low demand and assign resources to other areas. This forms the feed back loop where previous inequities define the future allocations.

In order to avoid these distortions, predictive systems need to include need-based indicators as well as utilization metrics. Forecasting models can be enhanced with socioeconomic vulnerability indices, rates of poverty, data on climate exposure, and demographic risk factors to make sure that they include the latent need and not the merely identified demand. Moreover, predictive models must be decision-support systems and not decision-makers. The ultimate responsibility should be placed on the health officials of the populace who will be able to contextualize the algorithmic advice to the wider social factuality. There is the element of human control which adds the element of ethical judgment, and it cannot be replicated by a model.

Since Bangladesh has been slowly incorporating computational forecasting in its system of governance, regional calibration has been a focus. The global models that have been imported to a particular country do

not tend to capture the local climatic variability, disease ecology, and socioeconomic patterns. The processes of the monsoon seasons, the geographical features of Bangladesh and its large urban population form epidemiological conditions unlike those of high-income nations. The models that are trained locally based on national datasets are necessary to perform accurate forecasting. Regional calibration makes sure that the predictions indicate the realities of the districts which Cox lived in, between Bazar and Kurigram.

Funding of data-driven preparedness is building up progressively. The proposed health budget 2025- 2026 indicates a gradual increment in allocation. Nonetheless, analytics capacity and digital infrastructure take time to invest. In addition to software platforms, Bangladesh requires a qualified digital workforce, that is, data scientists, epidemiologists, and health informaticians, who could turn model outputs into a policy that could be put into effect. It is important to have capacity-building programs at both national and divisional levels. The local health administrators should know not only what the forecasts suggest, but also the assumptions and limitations behind the forecasts.

It is also crucial to have transparency in the process of algorithms. The transparency of the criteria on resource distribution determines trust in automated systems in the eyes of the population. When people feel that opaque decisions are being made by the opaque digital oracles, then the adoption may be jeopardised. The way things work, the information that models utilize and the way that fairness is ensured should be talked about clearly, which would inspire confidence. Bias and performance independent audits should be used with large-scale deployment, as they help to hold accountable and improve continuously.

When done in a responsible manner, predictive modeling actually serves as the radar of an advanced health system. It gives the authorities time to pick the storms of disease even before they grow on the horizon. Planners can change course before it is too late rather than responding to overcrowded wards or running out of medicine. In the case of Bangladesh, with the heightened risk because of the environmental volatility and the population density, this foresight is priceless. It is not limited to technological sophistication as an end in itself, but to strategic fit of limited resources to expected demand.

This is because eventually, the predictive modeling approach to public health will not just succeed based on its statistical accuracy, but its role in improving resilience and equity. Once predictions make sure that there will be neonatal beds where low birth weights deliveries are in high demand, that ORS packets are delivered before diarrheal epidemics spread due to heat, and that the number of personnel matches the number of patients coming in, then algorithms will have done their work. Nevertheless, caution should be taken. Models need to be constantly improved, morally directed, and situational.

The principle according to which Bangladesh should proceed on its way to a more data-driven system of health governance should stay constant: technology must add to, not take over, human judgment. Predictive analytics has the ability to reveal the invisible patterns, but not to consider the ethical aspect of allocation

decisions. Coupling predictive modeling with ethical care would enable Bangladesh to turn the predictive modeling process into a means to enhance preparedness, as well as ensure that fairness is upheld. By so doing, all the hospital beds, all the vials of medicine and all of the healthcare workers can be placed not merely by chance, but by informed foresight--where they are most required.