Smart Mobility Analysis for Healthcare Access

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Abstract

Time in Dhaka is not the measure of productivity alone, but rather it is a condition of survival on the streets, which are labyrinthine. The relative distance between a cardiac patient in Old Dhaka, a garment worker in Mirpur or even a resident in Savar and the nearest tertiary hospital is sometimes not that big but the barrier that becomes hours long is an imaginary one. Poor pedestrian infrastructure, unplanned city growth, congestion and fragmented referral structures all lead to what urban health researchers are calling more and more often the Friction of the City.

In Bangladesh, where population density is one of the most congested globally and healthcare facilities are determined by unequal distribution, mobility is turned into a structure determinant of health by this friction. With the progression of 2026, mobility in the smart city is being redesigned through the application of Geographic Information Systems (GIS), routing algorithms, and real-time data analytics, with transport no longer being just an infrastructure problem; but a fundamental issue of public health.

The healthcare system in Bangladesh is quite centralized especially in tertiary level. The Dhaka district has a large concentration of specialized hospitals which attract patients throughout the country. This level of concentration implies that the population density is great, but the spatial accessibility analysis indicates severe inequalities. The measures of Access Population coverage (APC) show that millions of citizens are still outside the span of reasonable travel-time these days. Even more, there are approximately 6.4 million individuals who have to travel over three hours to access tertiary care facility, and 25.4 million who have to travel between two and three hours. In the case of trauma, obstetric emergencies, stroke or sepsis, such delays are often disastrous. This is not that there are no facilities, it is the distribution geography. In 46 of the districts there is no tertiary hospital at all, compelling the rural population to travel long distances comprising of both local transport and cross-river travel, as well as intercity buses before accessing definitive care.

This is aggravated by urban-rural imbalance. Although more than 90 percent of the urban population can

receive emergency care in 60 minutes by motorized transport, rural accessibility is much lower because of its low road density, seasonal flooding, and the sparse ambulance coverage. A more realistic explanation of these disparities can be given using GIS-based friction surface modeling. Friction surfaces are modeled with real world impediments such as the nature of the road, speed limits, levels of traffic, elevation, waterways, even seasonal impediments unlike straight-line distance calculations. In flood-prone areas such as in other cases, the monsoon may turn what was a one-hour journey into a nightmare of many hours. GIS then leaves abstract inequities converted into quantifiable and practical data by quantifying these variables. Policymakers can imagine which communities are outside the so-called golden hour to respond to the traumas and where the infrastructure improvements will provide the most significant returns in terms of saving lives.

Socioeconomic status has a strong connection with mobility inequity. Many times, the cost of transport defines whether one will seek care or not. In the case of low-income families, the cost of an ambulance or CNG (auto-rickshaw) during an emergency can be more than a daily or a weekly salary. As a result, families might not need treatment promptly or use slow and less dependable public transportation. Empirical studies have always indicated that people in high socioeconomic status are much more likely to use healthcare services once they are already sick, partially because of the increased access to personal mobility. This is not a mere financial but also a temporal imbalance, money buys time. Speed is directly proportional to the probability of survival in a critical illness.

The Pedestrian Paradox is another example of inequity. Many of the urban poor use walking as one of the main channels of transport. Still, in most Bangladeshi cities, there is the lack of pedestrian infrastructure which is disjointed, unsheltered, and in bad conditions. Even though most of the population has the potential of accessing a hospital within 60 minutes using their vehicles, only a small proportion of them will access the hospital within 30 minutes on foot. Unsafe crossings, lack of adequate road traffic controls such as curbing encroachment make the roads unsafe to the vulnerable road users. It poses a health hazard to the process of seeking care when the roads are rated with only a small percentage of pedestrian safety internationally. Therefore, the issue of access does not consist of the mere proximity to hospitals, but of the safety and viability of the path along which to go.

It is against this background that the transformation potential of computational routing algorithm is immense. Classical solutions to the shortest path problem like the Dijkstra algorithm and state of the art optimization models like the Vehicle Routing Problem with Time Windows (VRPTW) are being modified to fit the context of healthcare mobility planning. These applications take the place of non-interactive maps to dynamic optimization. Smart routing systems, using real-time traffic feeds, past congestion records and predictive analytics, are able to find the shortest path in distance, but the quickest path in the present. Simulations have been carried out in the arterial networks of Dhaka and they have shown that dynamic rerouting of emergency vehicles can save more than ten percent of the peak-hour travel time. By making

even slight cuts, in a city where ambulances tend to be gridlocked, they can save lives.

Scenario modelling builds the arguments on the use of data based planning. GIS systems also provide options of what-if analysis, which can be used to test infrastructure interventions prior to physical implementation. As an illustration, the introduction of special emergency lanes on certain corridors could be modeled to estimate the decrease in the ambulance travel time on average. It is also possible to simulate the embedding of the need to maximize the importance of emergency vehicles in traffic signals, also known as the so-called green channel systems, to measure the amount of possible saved lives. Policymakers are able to assess cost-benefit trade-offs in a new level of precision that means that scarce public resources are allocated to interventions that have quantifiable health effect.

In addition to emergency response in the city, smart mobility analytics are transforming the rural health outreach. CHWs are the pillars of the primary healthcare system of Bangladesh, especially in the impoverished regions. Nevertheless, non-efficient routing usually takes up large parts of their working time. The route optimization models in GIS are able to group household visits rationally, minimizing the redundancy of travel and maximizing the amount of time to be spent with the patients. Research has demonstrated that optimal routing can reduce the overall travel time by about a quarter, which means that CHWs would be able to reach more households without necessarily hiring more workers. Such resource-constrained settings benefit directly from such efficiency gains in terms of increased coverage.

The predictive traffic modeling helps to improve preparedness further. The congestion surges during the festival, political events, or seasonal migration can be predicted with the help of machine learning systems developed on the experience of the past years. By incorporating these predictions into ambulance dispatch systems, one will be able to preempt the occurrence of bottlenecks. Gradually, with the progress of data, these systems get more precise, creating a responsive mobility ecosystem that is adjusting to the urban rhythms and no longer reacts to them.

Significantly, smart mobility analysis redefines urban planning as the public health advocacy. It has always been proved that the shorter the time spent on traveling to trauma centers, the higher the chances of saving the life of a critically injured person. Even the loss of ten minutes can significantly increase chances of survival even in highly populated megalopolises. Therefore, transport infrastructure is more than a convenience, it is a clinical intervention on a scale. Morbidity and mortality impact of every flyover, signal upgrading, or special lane can be incorporated into decision-making on urban design, and health equity is built into the urban design.

Another similar imperative is the decentralization of tertiary services. Although it is possible to reduce the delays through the optimization of transport, structural inequity still exists because specialized facilities are concentrated in one district. GIS accessibility map is the visual evidence that comes out strongly in favor of

strategic location of new tertiary centers in underserved districts. Through decentralization of travel-time in the country, this systemic dependence on long-distance transfers of emergency care is reduced and healthcare resilience is distributed more fairly.

Planning which is equity-based also requires investing in pedestrian and public transit infrastructure. The availability of safe sidewalks, controlled crossings, and safe bus systems can be seen as lifelines in terms of mobility by lower-income populations. These areas can be upgraded and effectively increase access to healthcare by a significant margin without building a new hospital. As an example, improving the last-mile connectivity between bus terminals and district hospitals can save important minutes of traveling by thousands of patients on a daily basis. With such a scenario, even minor infrastructural upgrades can pay health dividends in a disproportionate manner.

Governance and coordination should, however, be associated with technological innovation. Smart mobility systems demand the exchange of data among traffic officials, hospital systems, ambulatory, and city planners. Interoperable platforms provide a smooth communication- between emergency call centres to real time navigation systems. Clear data governance structures are very necessary to ensure that the society is not betrayed and privacy is preserved, particularly where mobility data is involved to sensitive health information. There should be ethical protection to all technological deployments.

With the rapid urbanization, climate resilience further enriches smart mobility as Bangladesh moves towards this direction. Both road networks and healthcare facilities are at risk of flooding as well as extreme heat and infrastructural degradation. Vulnerability mapping of routes at risk of seasonal disruption can be done using GIS which can then inform investment in transport corridors that are resistant to climate changes. Planners are able to maintain continuity of care in the hand of a disaster by foreseeing environmental shocks.

However, in the end, smart mobility analysis brings down to a bare truth that healthcare access is as mobile as it is medicine. Hospitals can be prepared with experienced clinicians and sophisticated equipment, but as long as patients are not in a position to go through the city maze to access them before it is too late then the services are sadly underutilised. Formulating the friction that exists in the urban streets and the country roads, data-based models indicate the way to the transformation. They turn abstract inequities into space measures, turn traffic flows into chances of survival and infrastructure design into community health.

In 2026, Bangladesh will be at the crossroads of technology and urbanization. The Smart mobility research provides a roadmap of matching these tracks with health equity. By using GIS mapping, predictive routing, decentralized facility planning, and fair infrastructure investment, the country will be in a position to transform the overcrowded corridors into corridors of care. Data is laying the road to recovery, literally. Once mobility is made intelligent, coordinated and inclusive, cities transform into bridges instead of a wall-

so that no life is lost due to the fact that the trip to the hospital would have taken too long.