URBAN HEALTH ATLAS (UHA): **AN INTERACTIVE WEB-BASED TOOL FOR EVIDENCE-BASED HEALTHCARE PLANNING**

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Urban Health Atlas (UHA): an interactive web-based tool for evidence-based healthcare planning

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ACRONYMS

DBMS	Data Base Management System
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
FCDO	Foreign, Commonwealth & Development Office
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Global Positioning System
HMIS	Health Management Information System
HTML	Hypertext Markup Language
IDRC	International Development Research Centre
LMIC	Low- And Middle-Income Countries
MOH	Ministry of health
NGO	Non-Governmental Organization
UHA	Urban Health Atlas
WHO	World Health Organization

CONTENTS

EXECUTIVE SUMMARY

Bangladesh has a highly pluralistic urban health care delivery system that is disorganized, poorly regulated and difficult to navigate. This paper describes the development of the Urban Health Atlas (UHA), a web-based interactive data visualization tool designed to support evidence-based urban healthcare planning and decision-making in Bangladesh's pluralistic healthcare landscape.

A comprehensive GIS-based facility listing followed by a survey was conducted between 2013 and 2017 in nine cities and municipalities in Bangladesh. These data undergird the development of the tool, which is programmed to enable users (either health service planners or consumers) to obtain detailed information on the location and services offered by any operating health facility in the surveyed cities, their distribution relative to population density, and the shortest route to a desired facility from any location.

In displaying these data visually, UHA can indicate service gaps and duplication, has the potential to inform greater coordination between public, private and not-for-profit health sectors, and enable more equitable distribution and regulation of services. It shows promise as a means of facilitating evidence-based healthcare decision-making in rapidly urbanizing low- and middle-income country contexts.

CHAPTER 1

Introduction

An evidence-based approach supports health planners in making sound policies and programs and ensuring that maximum population health gains are achieved with optimum use of resources [1]. Such an approach is likely to make the decision-making process more consistent, improves the likelihood of achieving improved health outcomes, allows for the formulation of cost-effective solutions, and provides performance monitoring criteria to ensure continued learning and systems strengthening [2].

Data-driven health decision-making is increasingly becoming important in urban areas especially given the crowded healthcare market that characterizes these settings. The need for data informed healthcare planning is particularly urgent in the context of LMIC's experiencing rapid urbanization where population needs outpace the availability of quality services [3]. Population density and heterogeneity, substandard living conditions, stark intra-urban inequities in nutrition and health outcomes, climate change impacts and a dual burden of infectious and non-communicable diseases, including injury and violence, are characteristics of a highly complex urban health ecosystem [3]. In Bangladesh, this complexity is augmented by a fragmented urban healthcare delivery system that spans public, private, non-profit sector providers and multiple authorities, but lacks vertical and horizontal coordination, organized referral linkages, or effective systems of monitoring, or governance [4]. As there is no comprehensive health management information system (HMIS) that captures information from the private and non-governmental organizations (NGO) that constitute the lion's share of urban service provision, a large information gap remains regarding the service provision in urban areas [4]. Also lacking are routine urban health information systems that track mortality, morbidity, and health utilization indicators. While evidence suggests that these indicators are worse among the urban poor population residing in slums compared to the non-slum urban residents [5], these inequities are generally overlooked in large-scale survey data without consistent efforts to disaggregate data by socioeconomic status by geographic location i.e., formal vs. informal settlements [3]. If there is a dearth of credible and usable information and statistics, understanding the health needs, priority setting, rational allocation of resources, cost-effective program designing become difficult and the resultant policies and interventions are likely to be ineffective.

Geographic Information System (GIS) and related spatial analytic techniques are powerful tools that can support evidence-based decision making. GIS-based technologies have been used to describe the distribution of urban populations, health care organizations and underserved groups, and to relate these to measures of health outcome and healthcare access [6, 7]. By building a relationship between spatial and process or outcome data, merging multiple data layers, comparing outcomes from different options, forecasting into the future, GIS methods have assisted decision-makers in identifying when and how to respond in terms of policy and interventions [6, 7]. Geospatial tools have been used to enable informed decision-making in places like Kenya, Costa Rica, British Columbia [8].

Similar to these efforts, a web-based geospatial tool, the 'Urban Health Atlas' (UHA) has been developed to capture health facility location and service information in seven city corporations and two municipalities in Bangladesh [9]. To the best of our knowledge, this is the only tool that comprehensively lists all facilities in urban areas inclusive of the massive private (for profit) sector [9]. For policymakers, health managers, service providers this tool provides information on the shortest route between facilities to plan effective referral; enables visualization of service coverage by population density at the lowest administrative level to inform the location of healthcare facilities; and supports the generation of graphs and charts based on underlying data [10]. UHA has been widely consulted by NGOs, municipalities and urban primary care development projects in efforts to optimally locate urban health services relative to existing supply and population health needs. This paper documents the development process of UHA and its various features as a guide for similar efforts in other health systems settings.

CHAPTER 2

Materials and Methods

The development of UHA involved a two-step process. The first step was to create a master facility list similar to what is advocated by the WHO [11] for ensuring better governance in terms of systematic reporting and monitoring, while the second step involved the development of the UHA user interface.

In order to create the master facility list, an in-house mobile application was developed to assist data collection. Using this app, trained field workers registered the name and geographic coordinates of each health facility in a designated geographic area. To avoid position inaccuracy, satellite images and administrative boundaries were used as the base map in the mobile application. After listing, facilities were surveyed to collect detailed service information including the type of health facility, management entity, facility focus, services offered, service hours, and the type and qualifications of providers. GPS coordinates and related facility data were then linked to the Urban Health Atlas (UHA). This data visualization tool is architecturally segmented into three tiers: (i) a presentation tier that arrays data in a visual and quantifiable manner using Javascript, HTML, and CSS; (ii) a middle or business tier which processes commands from the presentation tier by accessing data in response to user input and/or conducting different calculations, and (iii) a database tier which accesses the database management system (DBMS) using PHP and MySql, and includes detailed facility information including GPS coordinates, road networks, administrative boundaries, and population census data. The platform also allows the layering or integration of other datasets. For instance, we incorporated data from the Bangladesh Population and Housing Census [12] to enable the calculation of facility density relative to population density in a specific area. Finally, Google Analytics [13] was integrated into the platform to track user numbers, locations, time of visit, type of device used, most visited pages of the website etc. Filtering parameters were also captured using Firebase, a cloud database service from Google.

CHAPTER 3

Results

The various features and functions of the atlas are described below using the example of Dhaka City and its combined constituent administrative areas of Dhaka South City Corporation (DSCC) and Dhaka North City Corporation (DNCC).

3.1. USER INTERFACE & DISTRIBUTION OF FACILITIES

The UHA tool is available at www.urbanhealthatlas.com in Bangla or English versions. The opening page introduces the tool and its development, main features and functionalities (Figure 1).

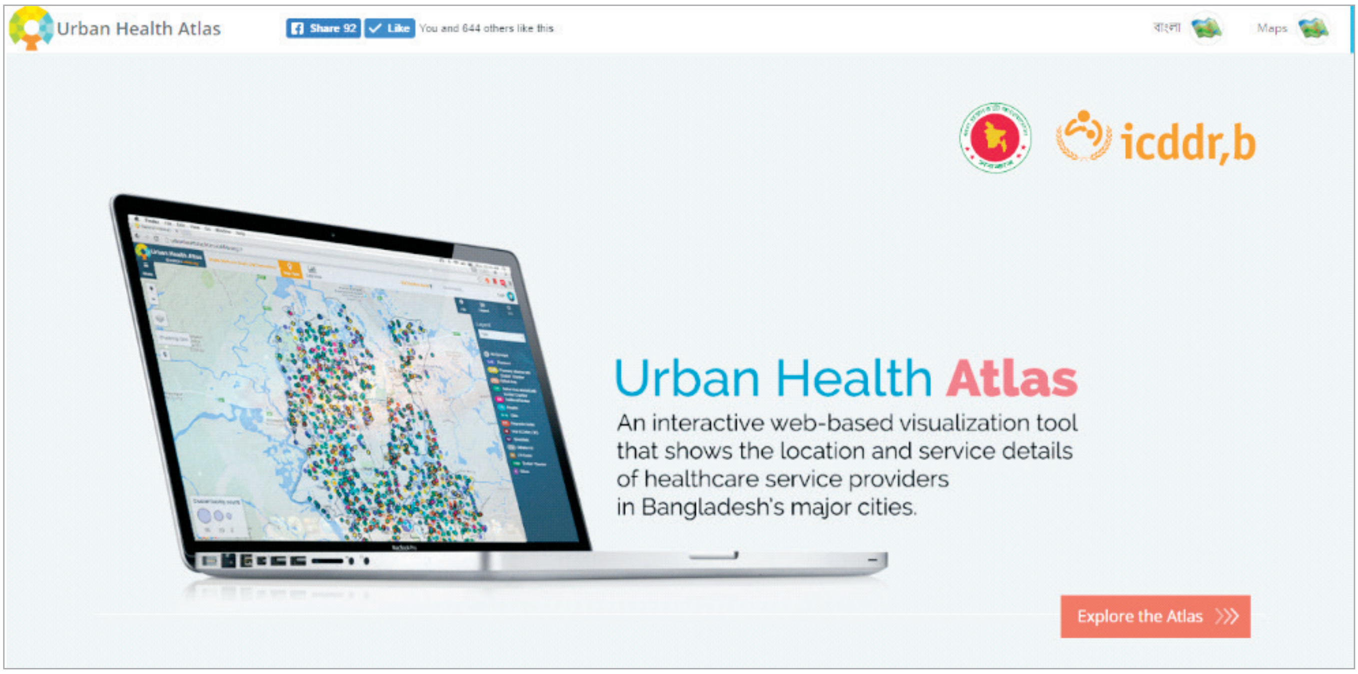

Figure 1: Opening page of UHA (partial image)

The ‘ explore the atlas’ option directs the user to a map of Bangladesh indicating areas covered by the tool as small blue circles (see Figure 2).

Selecting a blue circle will open up the map of that city/municipality. The ensuing page visualizes the distribution of facilities in the specific municipality or city corporation area on the map. The information can be viewed in tabular format by clicking ‘data view’ (Figure 3a) or as a map in ‘map view’ (Figure 3b).

The ‘data view’ function presents detailed facility information for whatever area is selected. It is also possible to download the table in excel format. If a user clicks on ‘location on app’, the system will redirect the user to the map with that particular facility selected. A detailed record for each facility selected is obtained by clicking on ‘facility info’ such as the number of specialists, list of services, cost of selected services, whether there is free provision for the poor and other observations pertinent to that facility (if any). A search option is located just above the table allowing users to search for any facility by its name or address. It is also possible to sort facilities alphabetically by clicking on any of the table headers.

The user interface has a ‘menu’ tab on the left-hand side offering functionalities like coverage area, nearest facility,

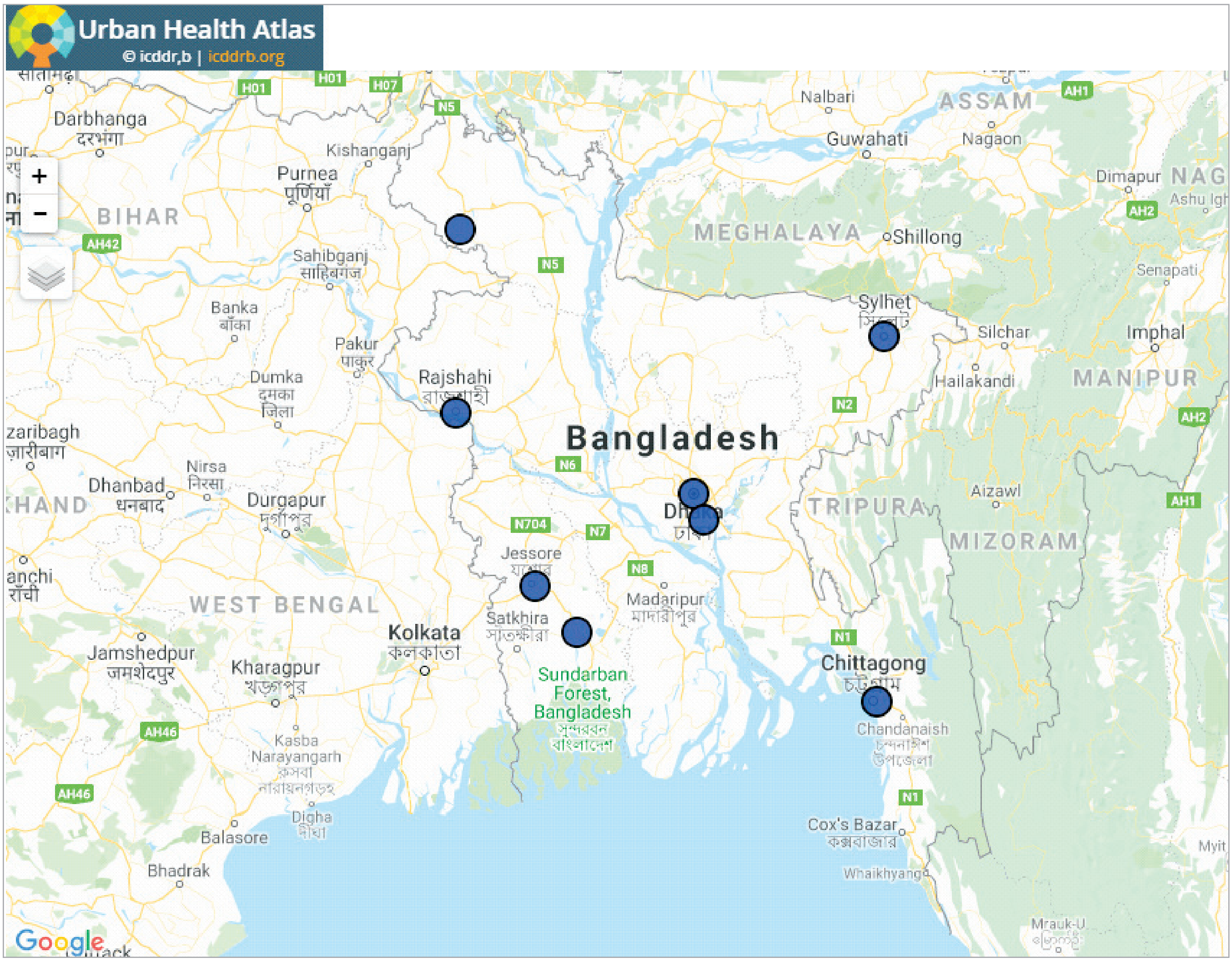

Figure 2: Cities and municipalities covered by the UHA tool

and choropleth view, and an 'info' tab on the right side of the screen (Figure 3a). The 'info' tab has both 'legend' and 'filter' options so the user can further specify their search. Filters are available for city corporation, ward, and various facility attributes.

Users can also view the facilities as 'clusters' (Figure 4) which offers a more condensed view of facility distribution. For example, by choosing the option 'ward wise' under clustering, the number of facilities in a specific ward (urban administrative area) is displayed. Supply-side users like policy or decision-makers can explore these features to understand the distribution pattern of health facilities within wards, or across the city.

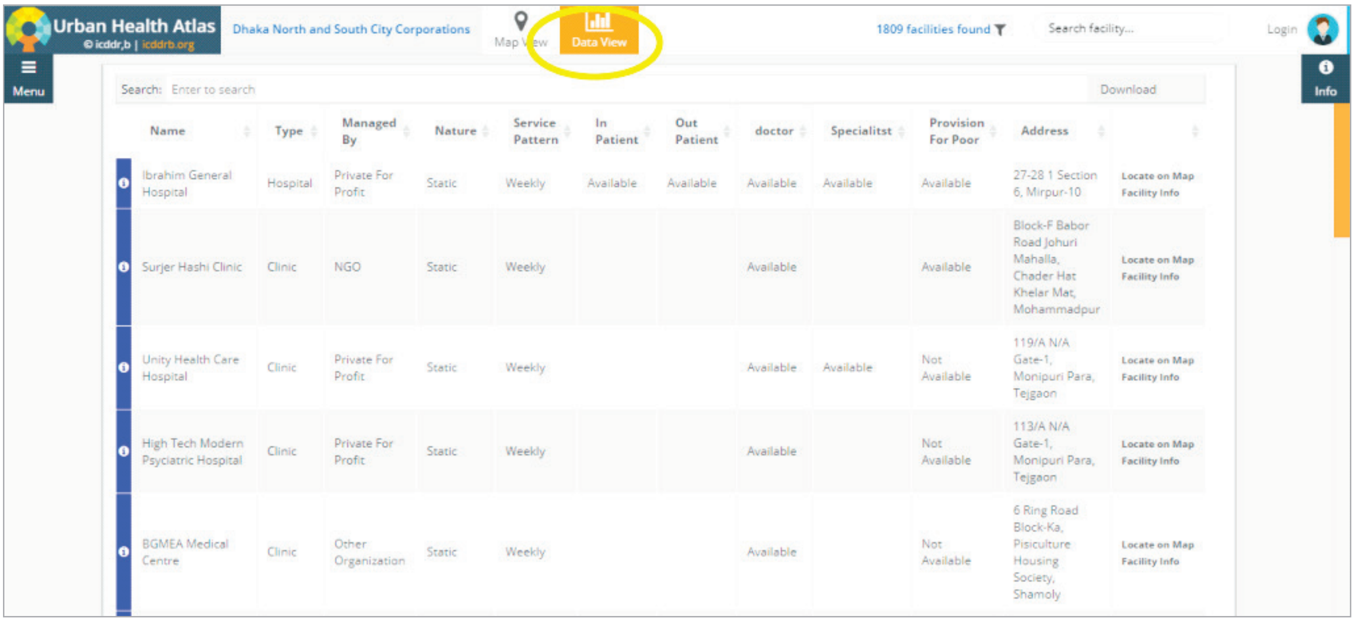

Figure 3a: Data view

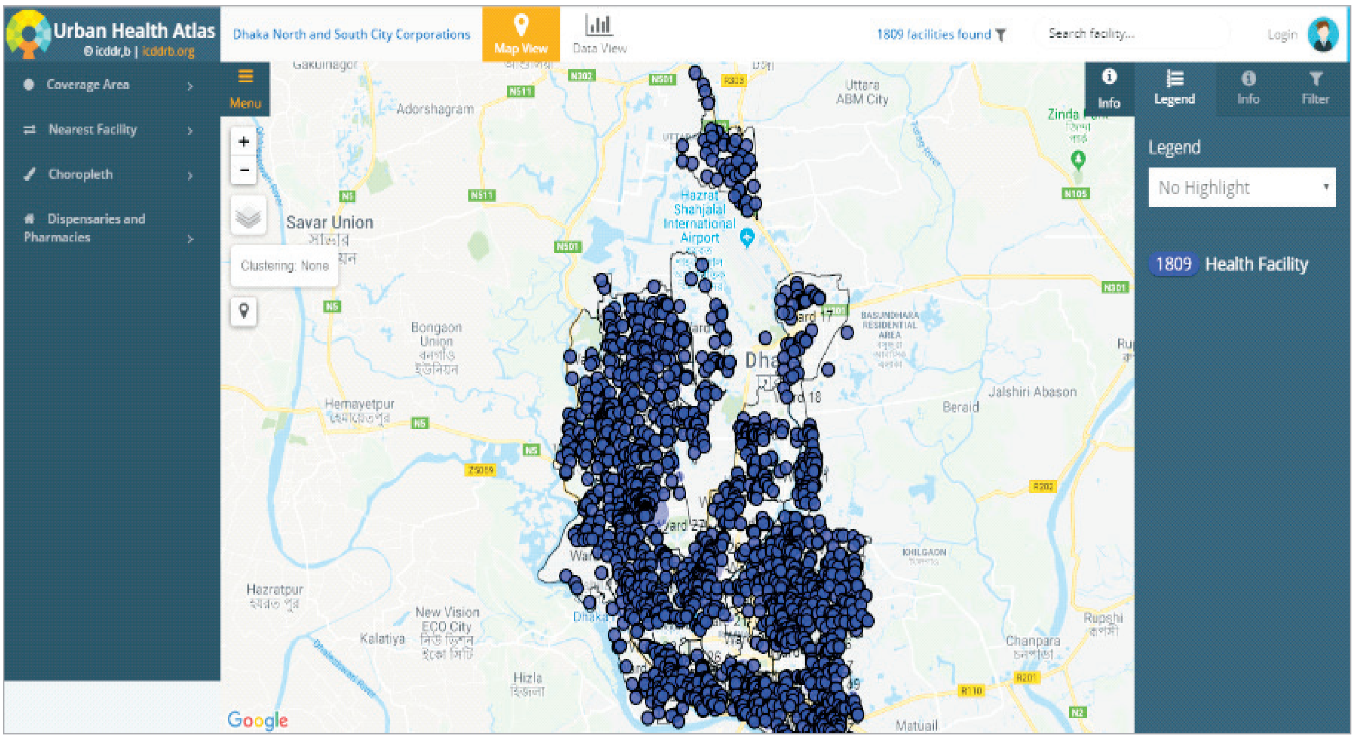

Figure 3b: Distribution of health facilities under a city corporation/municipality [map view]

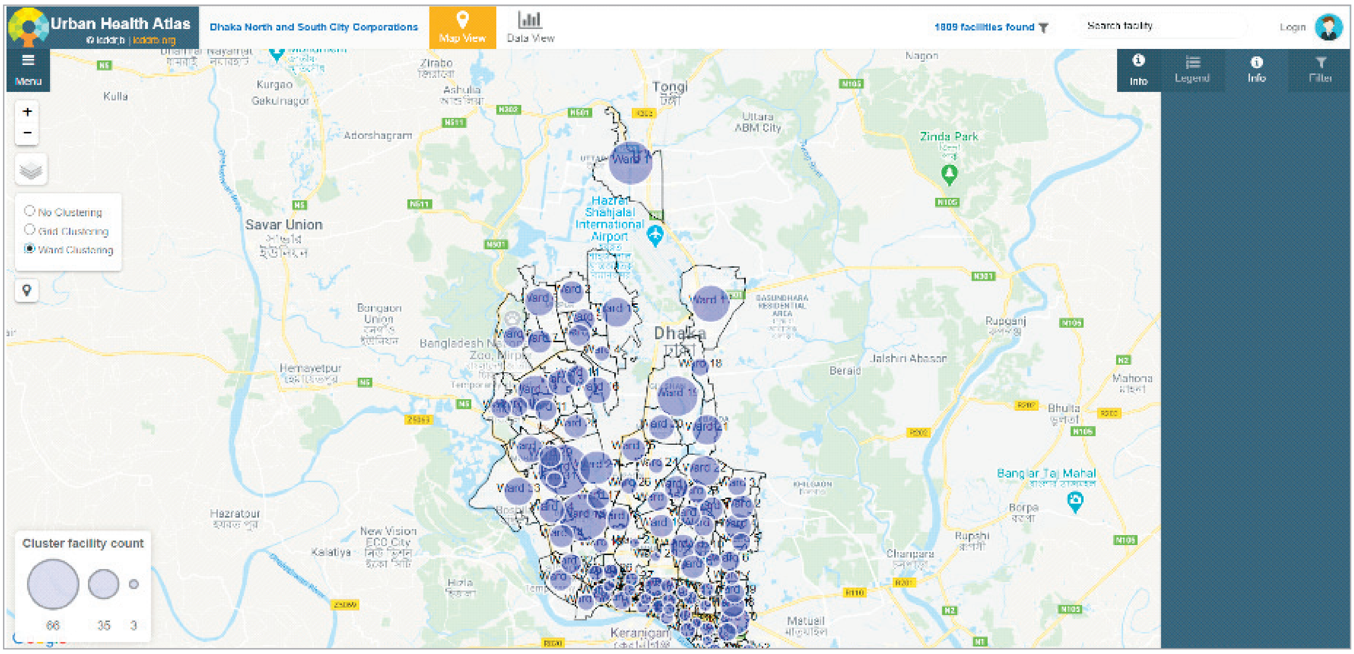

Figure 4: Clustering

3.2. FACILITY INFORMATION

In the map view, detailed information on health facilities can be obtained by clicking the 'info' tab just below the search box. Information includes the designated management entity of the facility (public contracted-out, public only, public autonomous, private for-profit, NGO), the type of facility (tertiary hospital, clinic etc.), services offered, number of beds and doctors, presence of specialist's departments, in-patient and outpatient facilities, and if provisions are available for poor patients. Each option can be explored using the dropdown list found in the 'legend'. A 'filter' option has also been provided in the info panel to assist the user in tailoring their search. For example, health consumers could use this feature to explore facility options as per health needs and preferred location.

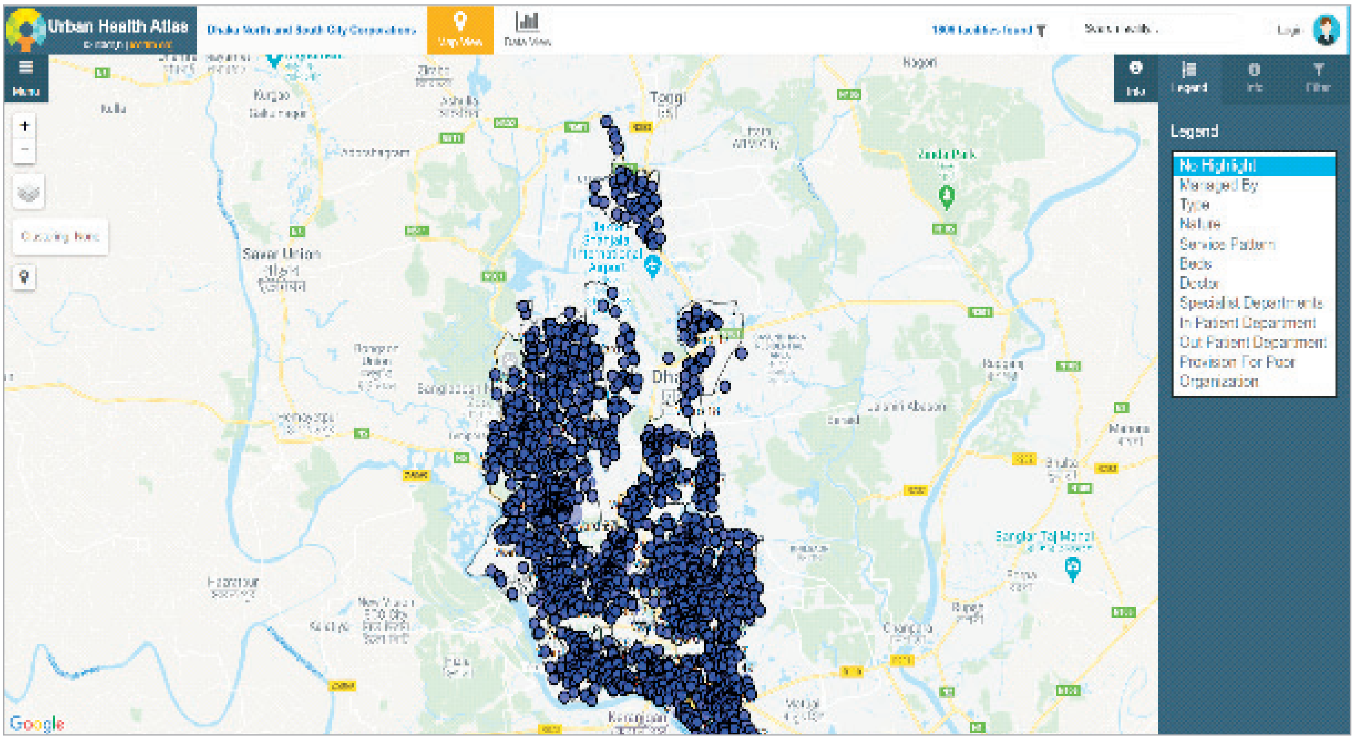

Figure 5a: Legends

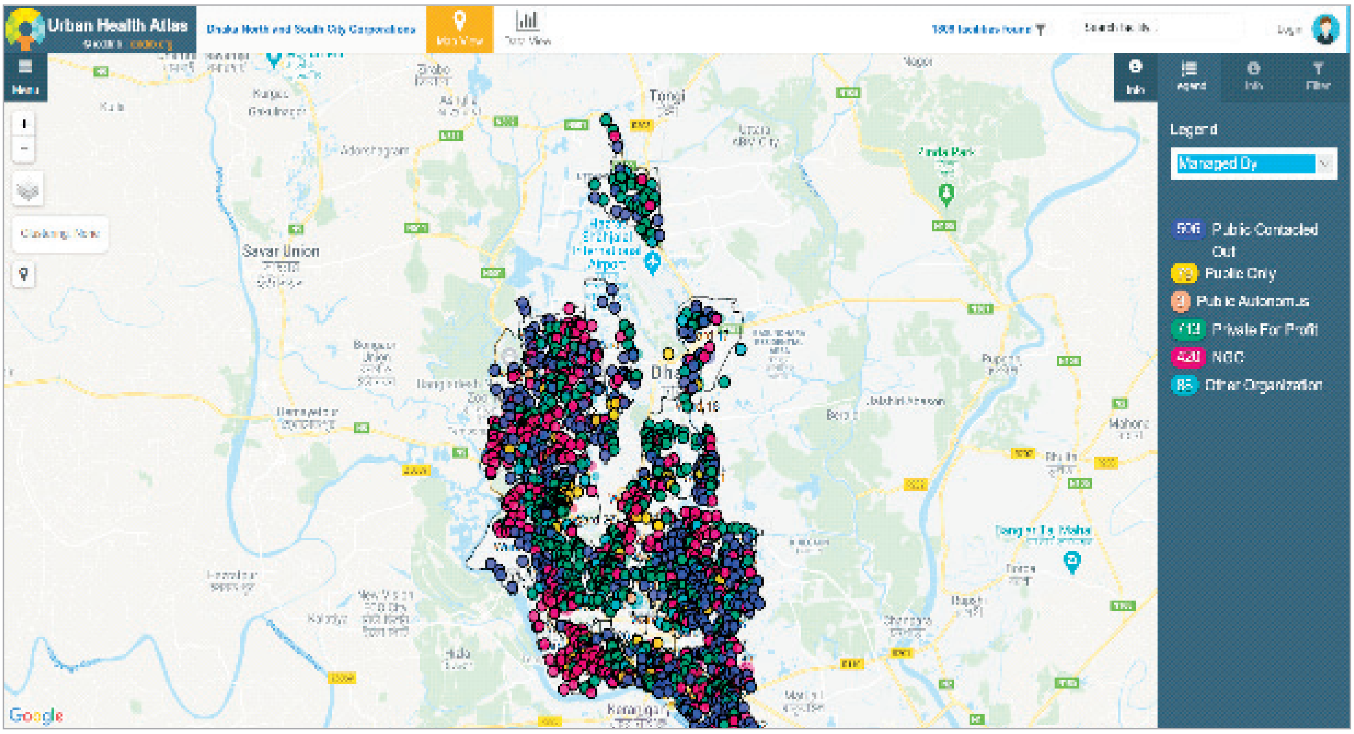

Figure 5b: Legends

3.3. FACILITY VISUALIZATIONS

3.3.1. Nearest facility

The 'menu' tab on the left side of the screen enables users to generate useful visualizations based on facility and other demographic data embedded in the tool. A particularly useful feature on the menu tab is the option labelled 'nearest facility'. The user indicates 'set his/her location' in the map and the desired distance, then clicks 'find all facilities within the given distance'. All the facilities within the area indicated will be shown on the map or also can be seen in a tabular format in data view.

The shortest path from the set location to each facility within the desired distance will be highlighted if a user hovers over that facility (Figure 6). This feature can save time by identifying the closest facility, and has the potential to reduce delays in seeking care.

3.3.2. Coverage area

Also, on the 'menu' tab is the option called 'coverage area' which allows the user to view the potential service area of a particular facility. By default, it is 1000 meters and the default coverage area opacity is 0.25, but these can be adjusted depending on the user's need. For example, if all public hospitals are selected using the filter and their coverage area is calculated, a map will be generated which identifies the overlap or gaps between facilities within a 1000-meter radius (Figure 7). Here, each circle represents an individual facility. The polygon around each circle has been generated using a 1000-meter distance from the facility. Similar coverage maps can be generated for specific services such as antenatal care, ultrasound. This feature is especially useful in identifying gaps in service coverage.

3.3.3. Choropleth

Also found on the 'menu' tab is an option to generate choropleth maps those visualize the density of a given characteristic through the use of gradient shading. These maps are produced at the 'ward' level and express facility data as a function of ward-specific population size or area (square km). The desired ward property can be chosen by clicking 'enable' from the drop-down list, thereby producing a visualization that displays ward-wise population size, or the density of facility data as a function of ward area or population size, using a gradient color scheme. Deeper colors signify higher values of the ward property i.e. in Figure 8, deeper colors signify wards with higher population numbers. In a similar fashion, the user can view the density of facilities per ward, and if needed, refine this search further by choosing a specific attribute of the facility [ward, type, managed by, etc] by setting an appropriate filter and then enabling the 'choropleth' function. By checking the service ratio box one can a generate choropleth map showing the services available per 100,000 population.

Policy or health decision-makers can use this feature to understand and explore available services against the population or a specific area and make informed decisions to allocate resources or to fill the service gaps as per the need of the population.

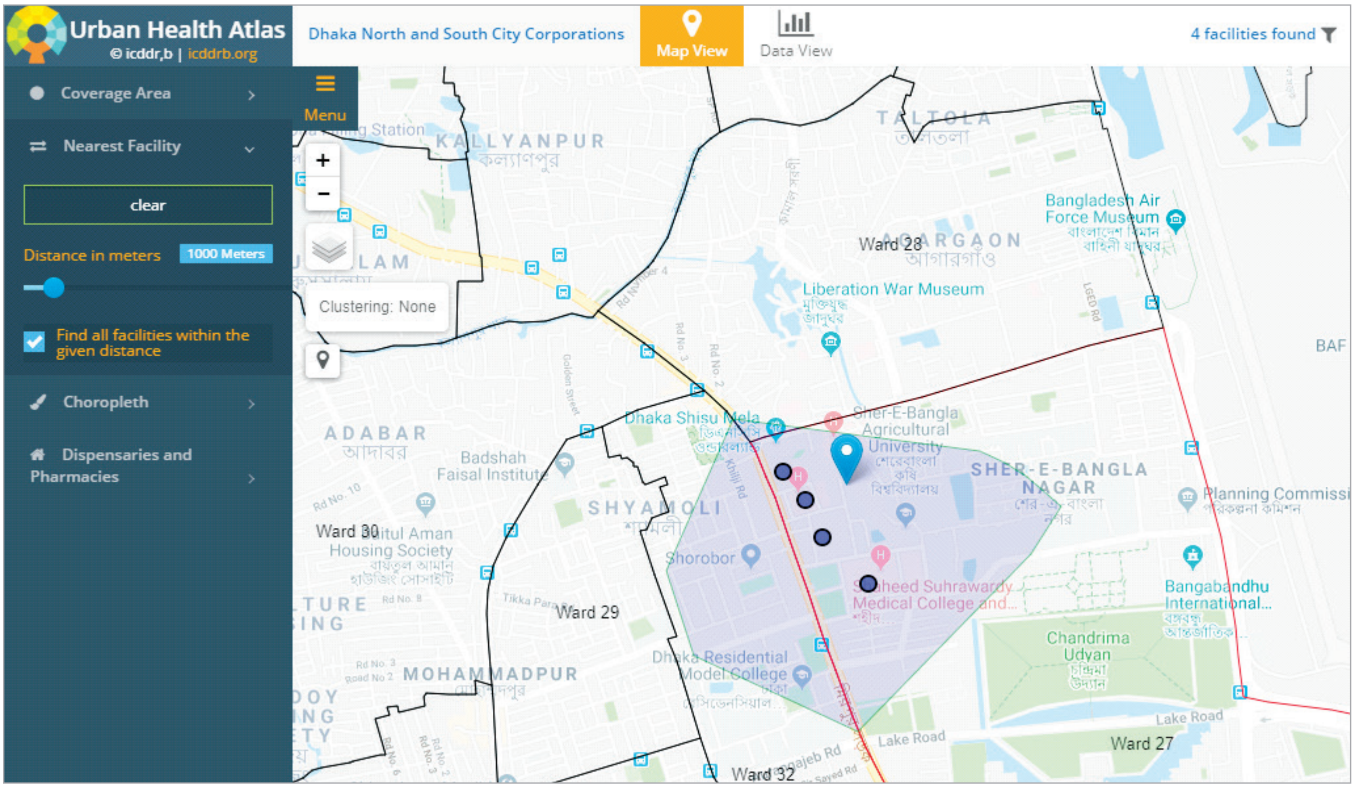

Figure 6: Nearest facility and shortest route

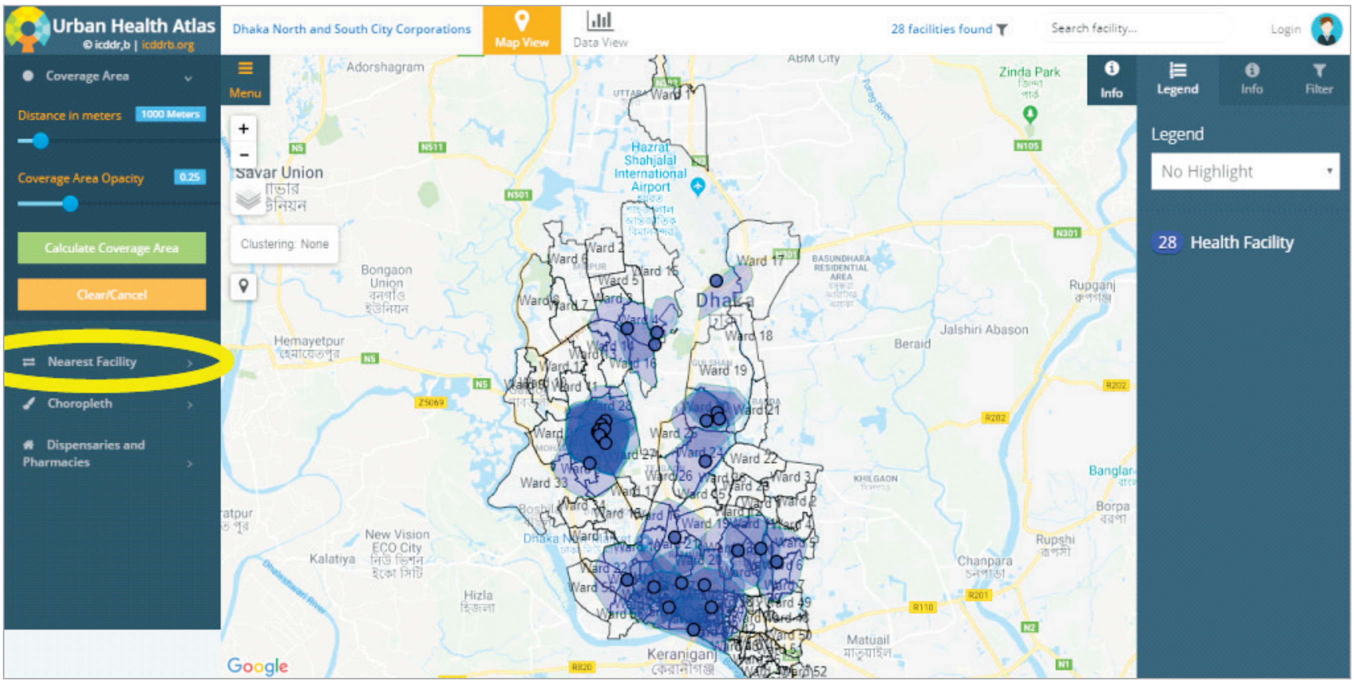

Figure 7: Coverage area and facility density

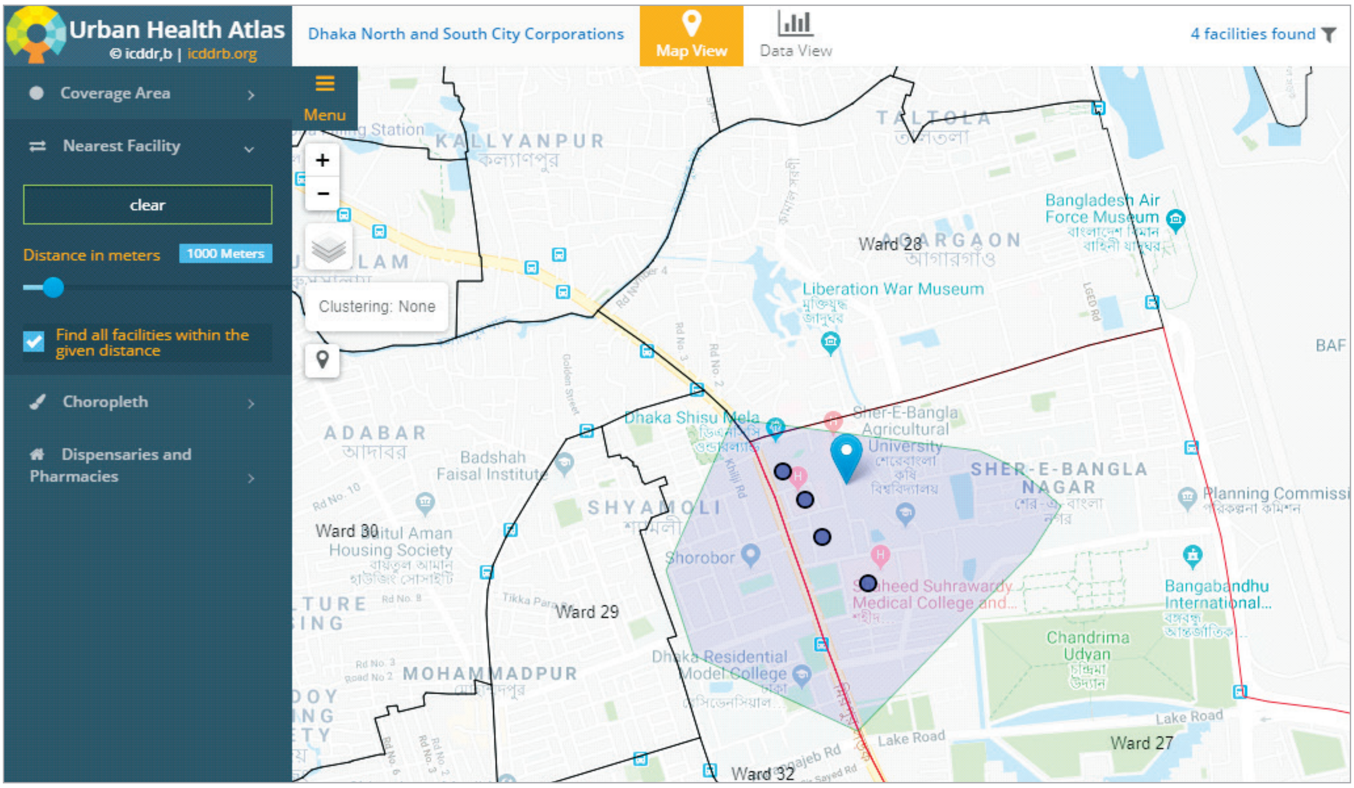

Figure 8: Choropleth map

CHAPTER 4

Discussion

Inequities in access, and disparities between demand and supply are concerns that modern-day healthcare planning must address. In the context of rapid unplanned urbanization in low- and middle-income countries like Bangladesh, the coordination of healthcare provision is even more difficult given the plurality of providers, heterogenous healthcare demands, and chronic information asymmetries [14]. Illustrating the complexity of this landscape are survey data revealing massive inequities in the distribution of formal healthcare delivery in Dhaka's urban informal settlements relative to the need [15], and in particular, a paucity of low-cost primary care services available during hours and days of the week convenient to the working poor [15].

Responding to these challenges, the UHA is a digital decision-support tool with much potential. Unlike other available national information systems [16], UHA brings comprehensive data on public, private and NGO health services into a single, integrated and easily accessible, electronic platform. Its strong data visualization capabilities offer decision-makers the potential to display city-wide coverage of healthcare facilities and services and their distribution at the lowest administrative level (wards) [9]. The application of GIS-based analytics and the use of different filters, search options, and linkage with population and road network data allows for further nuanced examination. Importantly, the tool doesn't require mastery in GIS technology, and is accessible to even non-technical users.

The visualization features of UHA can also empower local policy makers in decision-making regarding the optimal allocation, or reorganization of healthcare services by helping identify health facility deserts or areas of oversupply [17]. For example, health planners in one municipality in Bangladesh have used geospatial data collected and connected to UHA as a means of streamlining NGO services to reduce duplication and gaps in service provision without any additional investment [18]. Useful visualizations of facility distribution and coverage gaps are produced by merging facility information, with population census data, road networks and administrative information.

The potential of GIS in health care management is increasingly being realized in recent years. GIS-based approaches can inform effective decision-making as most health-related events can be described spatially. According to Hilton, spatial information can help in planning for health care services including mapping health needs and existing services [19]. Accordingly, countries are being encouraged to collect geo-coded master facility lists [11], and to develop data visualization platforms for their display and use.

In Zambia, for example, the Ministry of Health (MOH) has promoted the use of GIS as a decision support system for non-technical health administrators [20]. Functionalities that closely resemble UHA include the 'nearest neighborhood search' and 'routing' options that enable users to search and get directions to the nearest health facility [20]. The 'Country Health Situation Room' initiative in seven Sub-Saharan countries integrates service delivery, human and other information into a single user-friendly display. This initiative has encouraged a culture of data use and visualization among decision makers to track progress in healthcare indicators [21]. In the USA, a web-based visualization tool called the 'Community Health Map' was developed to help local health officials visualize county health performance [22]. At the State level, the 'State Health Mapper' captures health services, facilities, providers and licensure information to inform in-state health workforce planning [23]. In a similar fashion, UHA might be applied to managed licensure and regulation of the large and diverse private sector [4, 24] - indeed persistent concerns about sub-standard quality of care, overpricing and medical negligence due to lack of regulation and oversight [4,24] in countries like Bangladesh, are issues that UHA might help manage.

Referral is another weak aspect of the urban health system in Bangladesh and other similar settings. The plethora of urban providers with no clear-cut jurisdiction, authority or coordination is reflected in the absence of an effective referral mechanism [4]. The potential of UHA to refer patients to the nearest and most appropriate facility, or to build a rationale referral system is also worth exploring. Its use in facilitating timely emergency care seeking through 'nearest facility' and 'shortest route' functions, is particularly interesting. Illustrating this potential, UHA data have been used to illustrate the time and cost savings offered by more effective and appropriate referral for maternal and critical care services [25], and to identify inequities in timely access to emergency services among residents of poor urban settlements [26].

Finally, although developed to aid health planners in evidence-based decision making, the UHA tool can also be a helpful tool for individual healthcare consumers seeking particular services or providers that are proximate, affordable and of good quality. The UHA provides important information on facility characteristics (services offered, operating hours, qualified human resources, bed numbers, cost etc.) that increases awareness about available options. Consumers can compare these options, and make informed healthcare choices.

CHAPTER 5

Conclusion

One of the key functions of healthcare planning is to balance population needs for healthcare, with the supply of proximate, appropriate, and quality services [27]. In the context of rapid urbanization, this is an essential yet difficult task. The heterogeneity of population healthcare needs from emergency care, chronic disease management to immunization, the diverse range of providers both public and private, as well as substantial information asymmetries and gaps, highlight the urgent need for healthcare decision support tools for planners, providers and patients alike. UHA offers a multipurpose digital solution with the potential for strengthening health care planning and patient decision-making in urban areas, and offers an interesting model for other countries experiencing similar challenges. However, its effectiveness and sustainability depend on whether underlying databases are kept up to date, uptake and use are institutionalized into routine roles and responsibilities, and if integration into existing health information systems occurs. Such investments are substantial but necessary given the rapid digitization of urban life, and the imperative of increasing the equity and efficiency of urban health systems.

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