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Digital health inclusion towards achieving universal health coverage for Bangladesh utilizing general practitioner model

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Objective: Bangladesh's health care system, particularly in rural areas, experiences enormous obstacles in providing complete preventive and primary healthcare services due to the lack of adequate healthcare facilities, resource constraints, and a non-functional referral system. To alleviate these problems, in this study, we introduce the digital general practitioner (GP) model for rural Bangladesh, digital platforms and present a statistical analysis of the data that was gathered from the pilot project.
Methods: A total of 12,746 people were provided regular health services during the pilot project, from all genders and age groups, and provided their socio-demographic and healthcare-related data. We analyzed healthcare-related data by carrying out both descriptive and inferential statistics.
Results: By utilizing this digital GP model, rural residents can receive routine health screenings at their homes, identify health risks early, receive consultation and health education, and be referred to GP and upper-level health facilities as needed. We found that hypertension was more prevalent (4.84% of the served population), and cancer was the least prevalent of all the NCDs in the studied population (0.05% of the served population). The population for stroke, hypertension, diabetes increased until the 50–59 age range as age increased, following which the population proportion declined as age increased. Additionally, 3.96% of young females were severely malnourished, comparably higher proportion than young males (2.34%).
Conclusion: NCDs such as hypertension, diabetes was prevalent among rural people. Necessary steps should be taken to raise preventive and primary healthcare awareness among rural people.
Public interest summary: The absence of proper healthcare facilities, resource constraints, and a non-functional referral system hamper Bangladesh's health care system's ability to provide comprehensive preventive and primary healthcare services in rural area. As a result, patients develop advanced ailments, including non-communicable diseases (NCDs), and must seek treatment at an expensive specialty hospital. To resolve this issue, we introduce a digital GP model for rural Bangladesh, then show digital platforms that use the concept, and lastly summarize significant findings from the piloted digital GP model. By utilizing this digital GP model, rural residents can receive routine health screenings at their homes, identify health risks early, receive consultation and health education, and be referred to GP and upper-level health facilities as need. From our data analysis, we discovered high burden of NCDs such as hypertension and diabetes in the piloted area. Necessary steps should be taken to raise preventive and primary healthcare awareness among rural people.

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Introduction

A general practitioner (GP) is a doctor who provides primary health care (PHC) services for several chronic illnesses, provides preventive and primary treatments within a catchment area, and refers patients to a hospital or specialist after risk assessment [1]. Many developed countries have implemented GP models that make their health care systems more effective and reduce the burden on hospitals for primary level health issues. In the early twentieth century, primary care was introduced in the UK, emphasizing the concept of referral [2]. The USA first introduced the assistant physician role to serve primary care in 1960 due to a shortage of doctors [3]. Norway has a strong primary care service and its people have been relying on general practitioners since 2001 as their regular doctors [3]. In Australia, general practitioners provide treatment for common illnesses, chronic diseases, and diabetes, and also provide vaccinations.

Additionally, developed countries began digitizing their health care systems in the 1990s and developed the Health Level Seven (HL7) standard, which ISO adopted as a reference for international standardization, by compiling several frameworks and related standards for the exchange, integration, sharing, and retrieval of electronic health records (EHRs) [4]. Previously, all documents were written by hand, and patients did not have access to them. However, with the advent of public EHR systems, various benefits for a public healthcare system have been recognized, including reduced and more efficient management of expenses, more effective management of vast volumes of patient data, and centralized medical patient records [5]. The digital healthcare system has been enhanced a lot after this revolutionary inclusion. For example, "Babylon Health" launched a "GP at hand" service that includes an instant symptom checker, face-to-face appointments, telephone appointments, video call appointments with a GP, and so on [6]. In 2017, England's National Health Service (NHS) tested a system in which smartphone-based applications were utilized to monitor chronic diseases such as chronic obstructive pulmonary disease (COPD) and gestational diabetes. These apps enabled clinicians to remotely access patient data via a smart device and prescribe them [7]. Gelogo et al. [4] proposed a system for ubiquitous health monitoring that consists of numerous sensors (embedded in a wearable belt) and android mobile application. When users wear the belt, it transmits vital physiological data to their phone, which the users are able to view. Additionally, the app includes an alert system in case of an emergency.

However, low- and middle-income countries (LMICs) like Bangladesh, where rate of population growth is high, are still facing several issues in digitizing and structuring their health care systems. Bangladesh has a population of 167,885,689 and is ranked number 8 among the most populated countries in the world [8]. Besides, areas comprising around 61.82% of Bangladesh are rural [9]. Some of the main challenges of Bangladesh's health sector are due to a lack of healthcare infrastructure at the rural level, as well as a scarcity of skilled general practitioners and health workers. According to a study from 2014, there are 18.2 physicians, 5.8 nurses, and 0.8 dentists per 10,000 people in urban areas, while the corresponding figures are 1.1, 0.8, and 0.08 respectively in rural areas [10]. In addition, due to a lack of education, rural people are not aware of their basic rights and do not address their health-related issues. Unfortunately, every day, rural people face challenges accessing health services, which can lead to avoidable health complications, including NCDs. Nujhat et al. reported that in 2018 prevalence of hypertension was 41.6% and diabetes was 4.3% among rural people [11]. Even if they face problems with these NCDs, due to lack of money, they often visit the local pharmacy and get medication from quack doctors, which is even more alarming for their health. However, sometimes they go to secondary and tertiary health clinics for some primary and preventive health care, costing them a fortune, which can be treated by merely seeing a GP doctor. Additionally, the World Bank reports that Bangladesh's Health Spending Per Capita (HSPC) is 123 dollars, the Government's Health Expense Per Capita is 22.9 dollars, and out-of-pocket expenses account for 72 percent [12]. Whereas Global Health Spending Per Capita (HSPC) is 1467$, Government Health Spending Per Capita (GHSP) is 865$, and out-of-pocket costs are 18% [12]. Due to this suffering, 16.4% people avoid treatment and 8.6 million people pushed into poverty due to out-of-pocket expenses [12]. Even though these lacking's, numerous telemedicine services have recently appeared in Bangladesh. In Bangladesh, for example, "Doc-Time" provides 24 h telemedicine services [13]. It is, nevertheless, unpopular in rural areas due to a lack of understanding and access to the internet. Similarly, despite the fact that "Digital Healthcare Solutions" provides medical consultation, micro health insurance, and health programs for diabetes, communicable diseases, and maternal and child care [14], its reach to rural populations is not thoroughly measured. Additionally, these organizations lack IoT devices that allow patients to monitor their vital signs [15].

To address all these issues, after the exploration of the health care system, digital health system, and the rural health service situation in Bangladesh, CMED Health [16] designed and implemented an integrated digital GP platform for rural areas to provide comprehensive preventive and primary healthcare service, which is named the "Rural General Practitioner" (RGP) model. People can get primary care on their doorstep through CMED's digital health kits and mobile applications, which are maintained by trained health workers. After proper risk assessment through the clinical decision support system (CDSS), health workers refer the patients to an integrated GP center or facilitate telemedicine services on their phone, where doctors provide further intervention and prescribe for the patient digitally. All the members of a household can have all the benefits of the digital GP model by spending 100 Bangladeshi Taka (US $1.20) monthly. The primary objectives of the study were the following: a) To introduce a digital GP model for Rural Bangladesh. b) To demonstrate digital platforms that incorporate the digital GP model. c) To outline key findings based on data collected from the piloted digital GP model.

The remainder of the paper is structured according to the following: Section 2 provides a comprehensive overview of the digital GP model for rural Bangladesh. In Section 3, we present our methodology for analyzing data that was gathered from the piloted digital GP model. We analyze all the data and outline the findings in Section 4. In Section 5, we discuss our findings, compare them with existing literature, outline our strengths and limitations, and finally conclude this paper with future work in Section 6.

Design and development of digital GP model for rural areas

System overview

The Digital GP Model is implemented by CMED Health and United Trust in Nayangar union, a small rural area in Jamalpur district, Bangladesh. The model was developed to provide comprehensive preventive and primary health care services to rural populations (with a focus on NCDs and maternal care) via doorstep service delivery, a structured and functioning referral system that adheres to WHO guidelines, and telemedicine—all facilitated by integrated digital solutions. The digital GP model works as follows: First, trained health visitors visit households and during this visit they provide basic primary health care services, including symptomatic health checks, screening, and counseling, as well as antenatal and postnatal care. Each served individual has their unique health account where their health data is stored. In addition, the health workers use mobile app to collect socio-demographic data and health-related data. The health workers app is integrated with an A.I.-driven clinical decision support system that notifies health workers, based on physical and biochemical measurements, whether or not to refer the patient to a doctor. If the patient consents to see a doctor based on the outcome of the primary health evaluation, they are referred to the Sushatho Digital Healthcare Platform (SDHP) or GP center. The comparison between SDHP and GP is that SDHP is a virtual

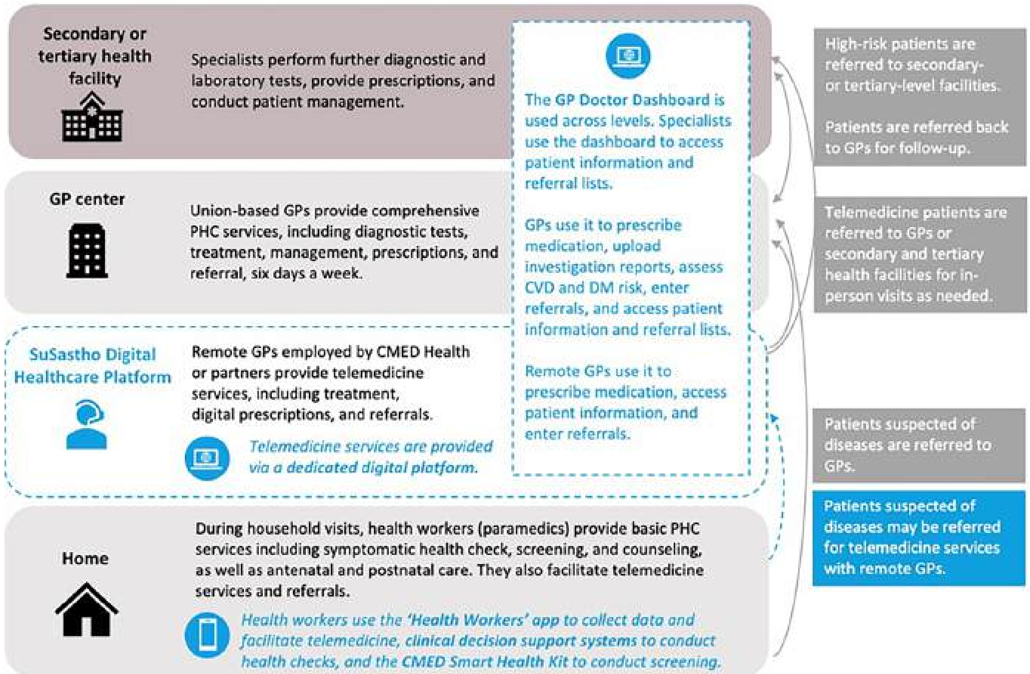

Fig. 1. A comprehensive graphical overview of the digital GP model for rural Bangladesh.

platform integrated with telemedicine services. On the other hand, GP is a physical center integrated with comprehensive primary healthcare services and diagnostic tests. After inspecting the patient, if necessary, doctors may choose to refer the patient to a secondary or tertiary healthcare facility where they can get treatment from a specialist. A comprehensive graphical overview of the digital GP model is presented in Fig. 1.

Digital platforms

This digital GP model is entirely integrated by 4 applications: 2 android applications and 2 web applications. All these applications were designed based on a Cloud based medical system framework shortly called CMED [17].

Health Worker Application: The health worker application is one of the primary applications of this GP model, as it collects the majority of sociodemographic and health data. When a health worker uses CMED smart health kits to collect health-related data such as SpO_2, Blood Pressure, and so on, this application allows the health worker to view all of the data and measurement results. Additionally, this application incorporates a system for offline synchronization. Due to the lack of a reliable internet connection in rural areas, all data collected by health workers is initially stored on the device's local system. After that, all the data are automatically uploaded to the cloud once the device establishes a reliable internet connection. Apart from that, another primary feature of this application is its data driven clinical decision support system (CDSS) that makes complex referral decisions based on a patient's health vital measurements and medical history. This can be used by health visitors and health officers to refer patients to doctors. Fig. 2 depicts several critical aspects of a health worker's application.

User Application: This user application includes several critical features, including the following: 1) Patients can constantly monitor and track their health records. 2) Additionally, they can educate themselves on primary and preventive healthcare by reading several articles. 3) They can use "Search" to locate hospitals, ATMs, blood banks, and pharmacies in their immediate vicinity. and so forth. A comprehensive overview of these features is depicted in Fig. 3.

Doctor's Dashboard: The GP doctor dashboard has several important features such as: 1) doctors can see the total served patient number till date, the total served patient number on a particular day, how many patients are waiting, and so on. 2) they can store patients' complaints, comorbidity, etc. and also see previous drug history, gynecological history, and can give diagnosis lab tests. 3) Besides, they can prescribe all the medicine, medicine dosage, and instructions for each drug, and also provide advice and suggestions. A comprehensive overview of these features is depicted in Fig. 4.

Admin's Dashboard: The admin's dashboard is created to control, monitor, and provide quality assurance of the digital GP model. When the admin logs in to the dashboard, at first glance, he can see all the organizations they are partnered with, how many unions (Union is Bangladesh's smallest rural administrative and local government unit [18].) they are serving, how many doctors they have, how many health officers they have, total number and percentage of households surveyed, total number and percentage of members served, total number of health cards the members bought, etc. Also, by scrolling down, they can see several visualization charts of socio-demographic data and health-related data. A simple overview of the admin dashboard can be observed in Fig. 5.

Methodology

Study design, setting, and population

CMED health piloted the digital GP model in the Nayanagar Union of Melandaha Upazila in the Jamalpur district, a rural area of Mymensingh division. This study was done with data that was collected from March 26th, 2021 to March 31st, 2022. During this one-year period, the digital GP model served 12,746 rural people from 5643 households with the help of 4 GP doctors, 3 registered health officers. Total targeted members for this study were 21049 people. Among them, 12746 people (response rate 60.55%) paid 100 Bangladesh Taka (US $1.20) monthly to receive the digital GP model services.

Data collection procedure

A group of well-trained health workers (both male and female)

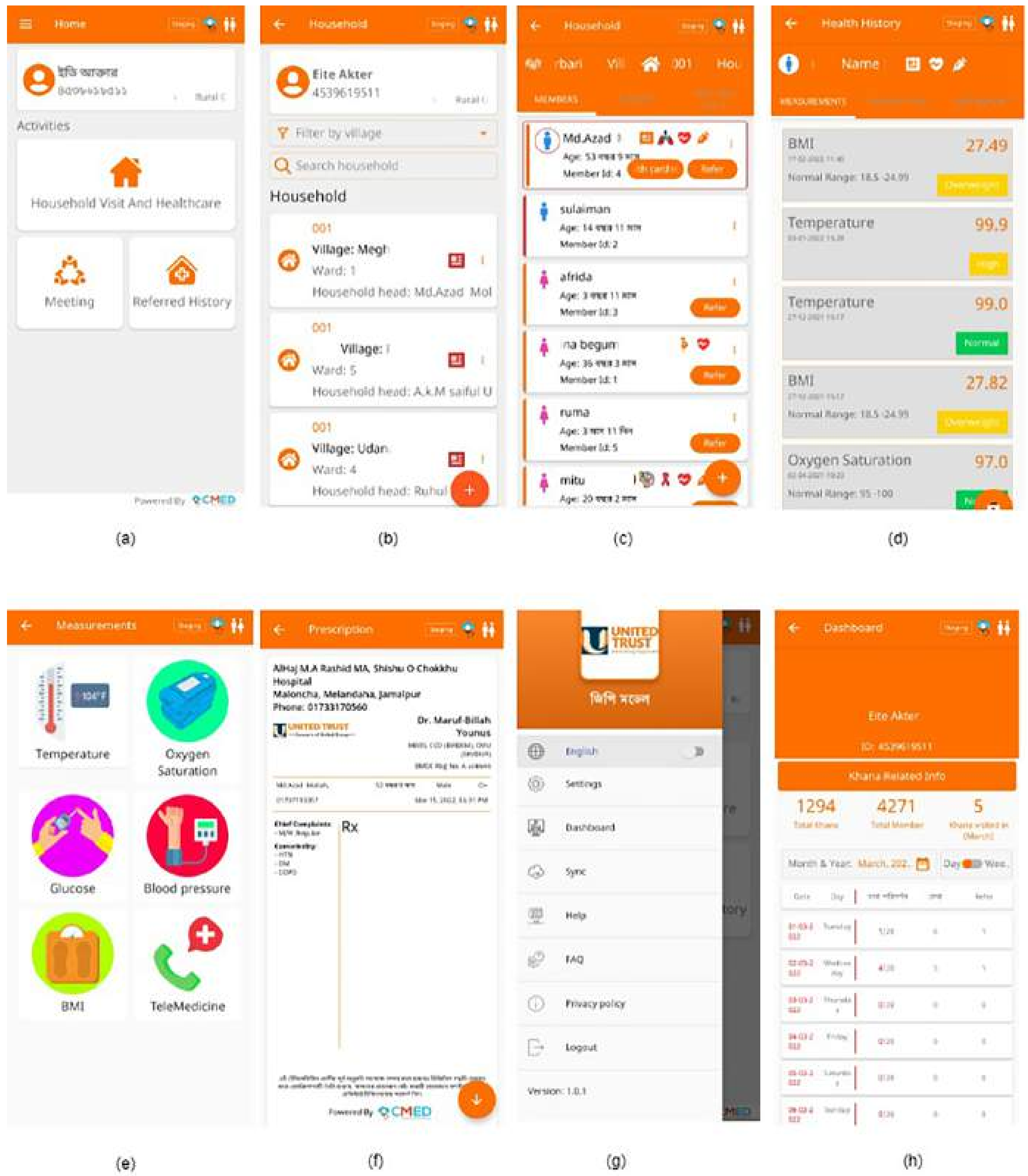

Fig. 2. Some of the main features from "Health Workers" application.

usually went to all the households and collected socio-demographic and health-related data through a mobile application called the "Health Workers App," as stated before. At this stage, health workers used IoT-enabled smart health devices to measure diabetes, blood pressure, pulse rate, weight, and SpO_2 (blood oxygen saturation) as shown in Fig. 6. Health workers also document height, temperature, and MUAC (Mid-Upper Arm Circumference) measurements (only for children), and input them into the mobile application manually. Participants were asked to take off their shoes and any headgear they were wearing before having their height measured. Afterwards, they were instructed to stand with their feet together, their heels on the floor, their knees straight, and their eyes level with their ears. A measuring tape was then used to measure height (cm). Following the removal of their shoes and light casual attire, participants were to stand still on a weighing scale on a firm and flat platform to measure their weight. In kilograms (kg), the portable weighing scale was used to measure the weight of the subject. After manually entering height and weight, BMI was automatically calculated by "Health Workers APP." Arm circumference was measured by a plastic tape placed horizontally around the arm. SpO_2 and pulse rate were measured by placing the index finger into the smart pulse oximeter for 30 s. Before taking oxygen saturation, and pulse rate, participants' fingers were warmed by some hand exercises, and while measuring, all participants were instructed to sit still on a chair and remove any nail polish. In order to assess blood pressure, health workers gave each participant five minutes to relax in a comfortable position with a straight back and uncrossed legs. Then, a health worker placed a smart blood pressure monitor on the participant's left arm and tightened the arm cuff. Concurrently, the health worker ensured that the participant's arm was put on a table such that it was parallel to their heart. Using a smart glucometer, blood sugar is measured. Initially, health professionals ensured the cleanliness of the smart glucometer. The participants were then asked to wash their hands with warm water and hand soap. After thoroughly drying the participant's hand, health care professionals punctured the participant's finger to get a little drop of blood for the smart glucometer. Ultimately, the smart glucometer examined the blood sample. All of the above-mentioned data were gathered with the consent of participants. Besides, all of the above-mentioned data were gathered maintaining adequate privacy. The ethical review board of United International University approved to conduct the study.

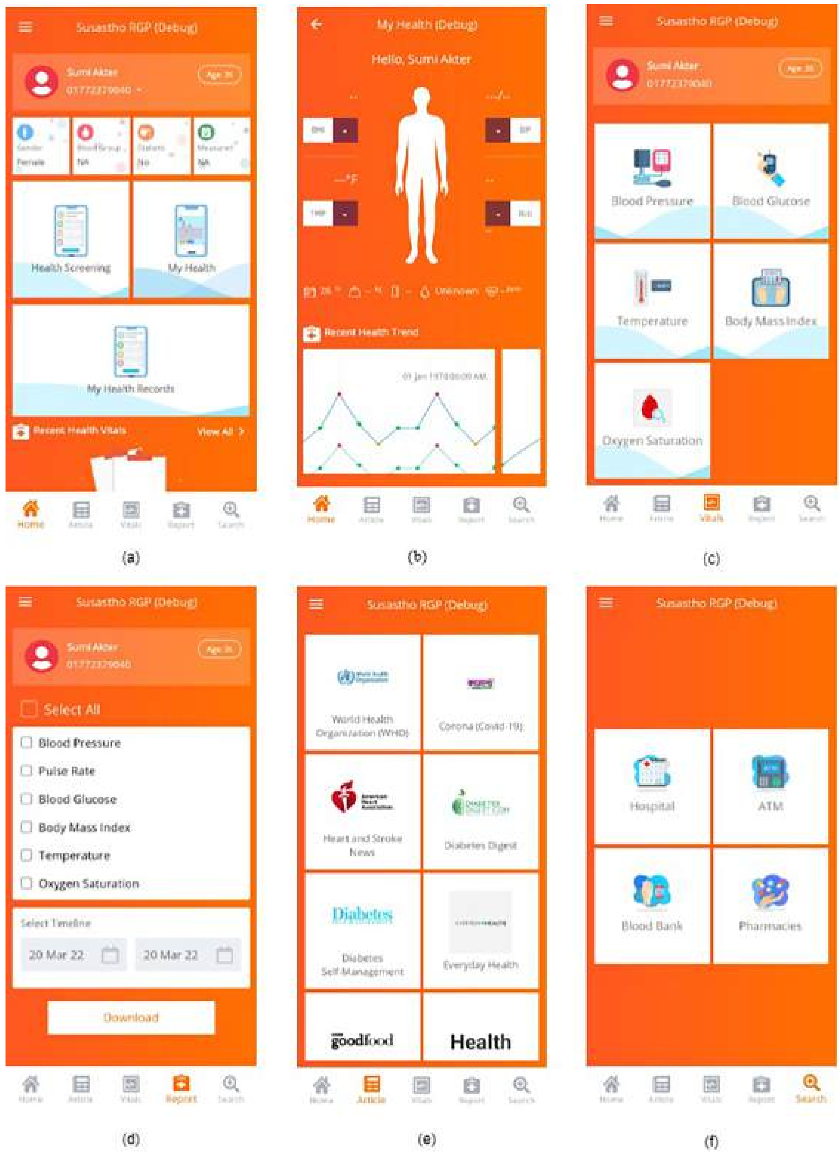

Fig. 3. Some of the main features from “User” application.

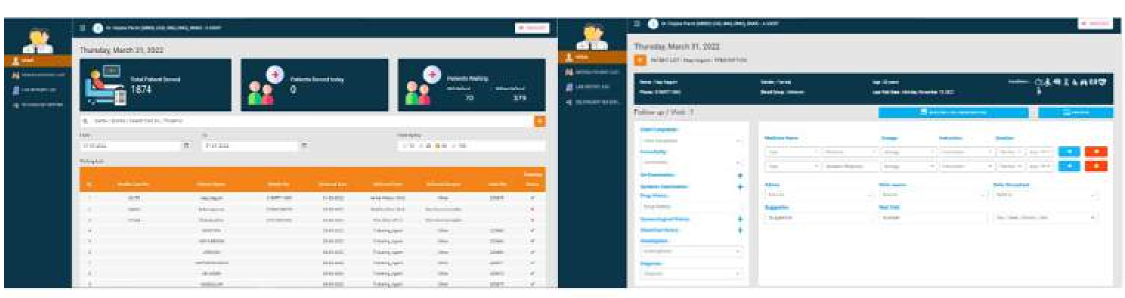

Fig. 4. Some of the main features from “Doctor” dashboard.

Quality assurance

To maintain the quality control of the study, CMED took several measures: (1) pre-piloted training of the team members, including admins, health officials, and health workers, to outline the procedures and potential difficulties associated with data collection and taking measurements; (2) strict monitoring at the field level to closely monitor the data collection through health officials; (3) comprehensive system monitoring via a separate admin dashboard; (4) to ensure safety, all four applications were tested by experts in software quality assurance before deploying in the field for data synchronization and integration; (5) Using long-lasting and intelligent measurement equipment for physical and biochemical measurements.

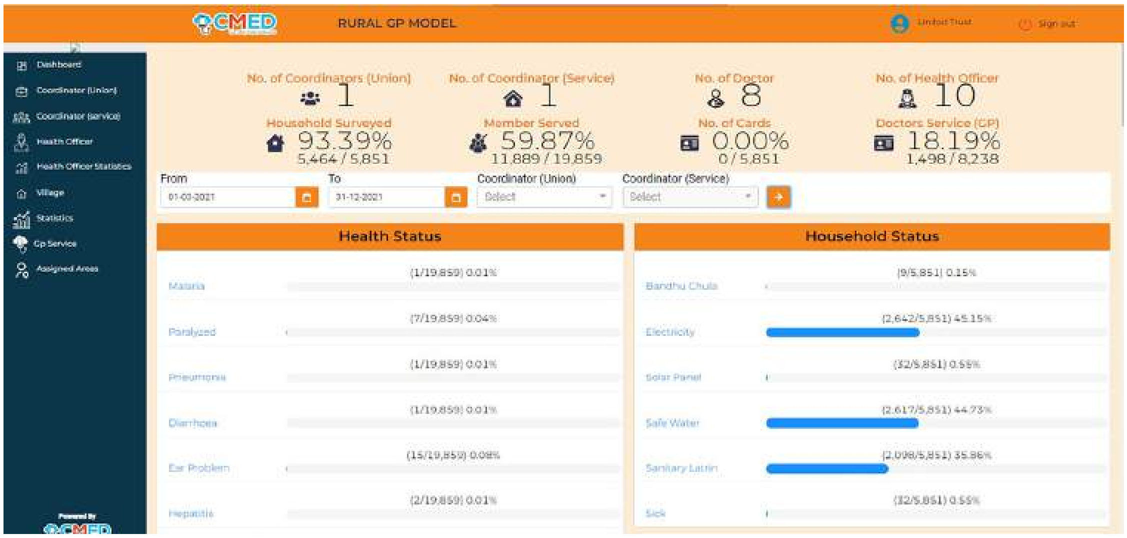

Fig. 5. A overview of "Admin" dashboard.

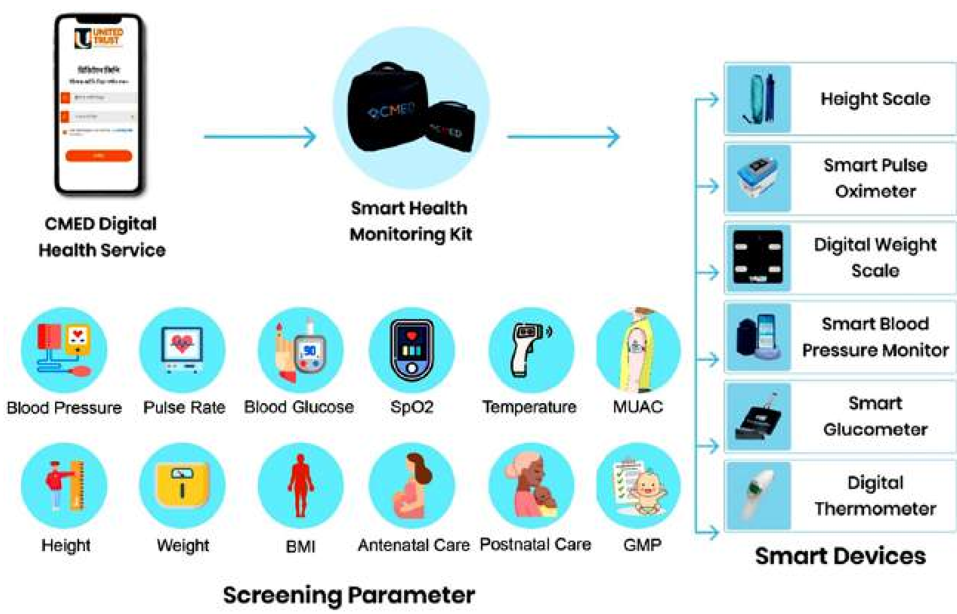

Fig 6. The digital GP model services and smart health devices.

Statistical analysis

The data that were collected through health workers app were kept in Amazon Web Service (AWS). Then we collected this data from AWS as a dump file and stored them in MySQL server. After that we applied MySQL (a structured query language) to extract necessary data. Following that, we examined the data for inconsistency, missing data, coding errors, and outliers [19]. Descriptive statistics were used to evaluate the distribution of the studied population. To evaluate the distributions of all measurements, all categorical variables were presented using frequency, percentages, and 95% CI (confidence interval), while continuous variables were presented using mean and standard deviation. In addition, the association of NCDs and its risk predictors were calculated using binomial logistic regression and presented in crude odds ratio along with 95% CI. Before using binary logistic regression, assumption check was done for normality, multicollinearity, and outliers. The bar graph and line graph were used to illustrate the major findings. All these analyses were done with the help of powerful Python libraries like pandas, matplotlib, NumPy, SciPy, stats model and seaborn.

Results

Sociodemographic information of the study population

As stated before, there were 12,746 people in total, with 11,491 adults, and 1255 young people. From Table 1, it can be observed that overall, the female population was higher (total: 7651, in%: 60.03) than the male population (total: 5095, in%: 39.97). It is because health workers usually visited during the day when most of the male members usually go to work. However, the mean age of the males (41.12 ± 18.95 years) was higher than the females' mean age (37.95 ± 17.01 years). The average age of the study population was 39.22 ± 17.88 (Standard Deviation) years. Then we analyzed the comparison between male and female proportions among different age groups. The female population was higher in all age groups except the ">=70″ age groups, as shown in

Table 1
Sociodemographic status of the study population.

Characteristics Age (Mean ± S.D)	Overall $N = 12{,}746$ 39.22 ± 17.88	95% CI	MALE $N = 5095$ (39.97%) 41.12 ± 18.95	95% CI	FEMALE $N = 7651$ (60.03%) 37.95 ± 17.01	95% CI
Age Groups						
<18	1255 (9.85%)	9.33–10.36	599 (11.76%)	11.2–12.32	656 (8.57%)	8.09–9.06
18–29	2611 (20.48%)	19.78–21.19	724 (14.21%)	13.6–14.82	1887 (24.66%)	23.92–25.41
30–39	2783 (21.83%)	21.12–22.55	1029 (20.2%)	19.5–20.89	1754 (22.93%)	22.2–23.65
40–49	2081 (16.33%)	15.69–16.97	894 (17.55%)	16.89–18.21	1187 (15.51%)	14.89–16.14
50–59	1917 (15.04%)	14.42–15.66	789 (15.49%)	14.86–16.11	1128 (14.74%)	14.13–15.36
60–69	1349 (10.58%)	10.05–11.12	653 (12.82%)	12.24–13.4	696 (9.1%)	8.6–9.6
>=70	750 (5.88%)	5.48–6.29	407 (7.99%)	7.52–8.46	343 (4.48%)	4.12–4.84
Marital Status						
Married	10,791 (84.66%)	84.04–85.29	4327 (84.93%)	84.31–85.55	6464 (84.49%)	83.86–85.11
Unmarried	1328 (10.42%)	9.89–10.95	702 (13.78%)	13.18–14.38	626 (8.18%)	7.71–8.66
Divorced	23 (0.18%)	0.11–0.25	4 (0.08%)	–	19 (0.25%)	0.16–0.33
Widower	35 (0.27%)	0.18–0.37	35 (0.69%)	0.54–0.83	–	–
Others	59 (0.46%)	0.35–0.58	27 (0.53%)	0.4–0.66	32 (0.42%)	0.31–0.53
Widow	510 (4.0%)	3.66–4.34	–	–	510 (6.67%)	6.23–7.1
Education						
Illiterate	5488 (43.06%)	42.2 – 43.92	2026 (39.76%)	38.42 – 41.1	3462 (45.25%)	44.13 – 46.37
Primary	2707 (21.24%)	20.53 – 21.95	1183 (23.22%)	22.06 – 24.38	1524 (19.92%)	19.03 – 20.81
Secondary	1116 (8.76%)	8.27 – 9.25	428 (8.4%)	7.64 – 9.16	688 (8.99%)	8.35 – 9.63
College or higher	786 (6.17%)	5.75 – 6.59	408 (8.01%)	7.26 – 8.76	378 (4.94%)	4.45 – 5.43
Literacy	920 (7.22%)	6.77 – 7.67	258 (5.06%)	4.46 – 5.66	662 (8.65%)	8.02 – 9.28
Others	1729 (13.57%)	12.98 – 14.16	792 (15.54%)	14.55 –16.53	937 (12.25%)	11.52 – 12.98

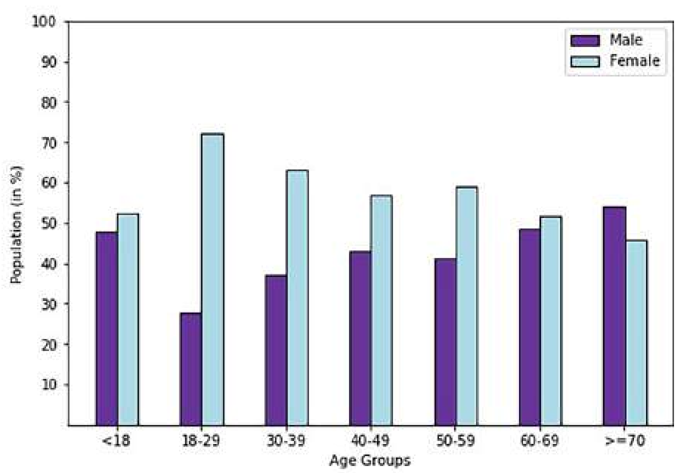

Fig. 7. A bar chart representation of gender proportions according to age groups.

Fig. 7. In ">=70″ age groups male proportion was higher. Most of the studied population was married (total: 10,791, in%: 84.66) and illiterate (total: 5488, in%: 43.06). In addition, among 5643 households, 5374 households had safe water, 4473 households had sanitary latrine.

Analysis of NCD risk factors

According to Fig. 8(a), hypertension was more prevalent than all other NCDs in the studied population. There were 617 people in the Nayanagar union who had hypertension, which was 4.84% of the overall population. Following that, diabetes was more prevalent. A total of 283 diabetes cases were observed, representing 2.22% of the total population. Cancer was the least prevalent among all NCDs. There were just 6 people (0.05%) with cancer and 11 people (0.09 percent) with kidney illness. The Fig. 8(b) depicts all of the NCDs classified by gender. It is seen from Fig. 8(b) that the male population numbers with strokes (male = 21, female = 14), COPD (male = = 41, female = 30) and CVD (male = 41, female = 32) were higher than the female population. On the other hand, kidney disease (male = 4, female = 7), diabetes (male = 126, female = 157), and hypertension (male = = 235, female = 382), were more dominant in the female population.

Additionally, Table 2 categorizes all NCDs by gender and age. Additionally, the most vulnerable age group was ">=40″, as all the NCDs were found to be more prevalent in this age group. For stroke,

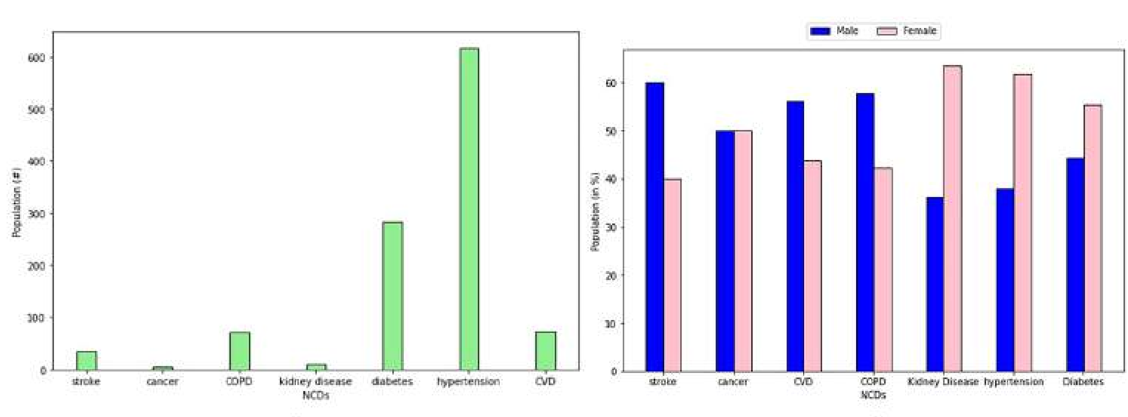

Fig. 8. (a) A bar chart representation of population number according to NCD's. (b) A bar chart representation all of the NCDs segregated into gender.

Table 2
NCD's segregated as gender and age.

NCDs		Age Groups <40	>=40
Stroke	Overall	1 0.01%	34 0.27%
	Male	1 0.02%	20 0.39%
	Female	0 0.0%	14 0.18%
Cancer	Overall	1 0.01%	5 0.04%
	Male	1 0.02%	2 0.04%
	Female	0 0.0%	3 0.04%
CVD	Overall	13 0.1%	60 0.47%
	Male	5 0.1%	36 0.71%
	Female	8 0.1%	24 0.31%
COPD	Overall	17 0.13%	54 0.42%
	Male	7 0.14%	34 0.67%
	Female	10 0.13%	20 0.26%
Kidney Disease	Overall	4 0.03%	7 0.05%
	Male	1 0.02%	3 0.06%
	Female	3 0.04%	4 0.05%
Hypertension	Overall	78 0.61%	539 4.23%
	Male	24 0.47%	211 4.14%
	Female	54 0.71%	328 4.29%
Diabetes	Overall	51 0.4%	232 1.82%
	Male	13 0.26%	113 2.22%
	Female	38 0.5%	119 1.56%

CVD = Cardiovascular disease; COPD = Chronic Obstructive Pulmonary Disease.

cancer, CVD, COPD, diabetes, hypertension, and kidney disease, the ">=40″ age group had a significantly higher prevalence of 34 (0.27%), 5 (0.04%), 60 (0.47%), 54 (0.42%), 232 (1.82%), 539 (4.23%), and 7 (0.05%), respectively. For stroke, hypertension, diabetes, overall population number increased with age until the 50–59 age range, after which overall population number decreased as age increased. However, for CVD, overall population number increased as age increased. Fig. 9 provides a more detailed look of these patterns.

In addition, Table 3 represents crude odds ratio association of different risk factors with different NCDs. Hypertension was associated with higher odds of stroke (OR: 59.24, $P < 0.01$, 95% C.I.: 27.64 −126.9). Also, diabetes had strong association with hypertension (OR: 21.24, $P<0.01$, 95% C.I.: 16.53 – 27.29). Moreover, CVD was associated with higher odds of hypertension (OR: 20.25, $P < 0.01$, 95% C.I.: 12.70 – 32.28).

Measurement analysis

There were seven distinct units of measurement, as listed in Table 4. Among them, blood pressure was taken from the highest number of people (11,328). The GP model's measurement severity status is designed for adult (age >= 18) and young (age < 18) people following the WHO PEN Protocol [20]. So, all the measurements were categorized for adult people (Table 5) and young people (Table 6) since most of the severity statuses were different among these two groups [21].

Adult People: The Table 5 depicts the distribution of the overall measured adult population (over the age of 17) by BP, BMI, Pulse Rate, TEMP, SpO_2, and Blood Sugar. As can be seen from this table, the majority of adult people in Nayanagar union were healthy, as the "normal" status number for all measurements is greater than the rest of the severity status numbers. However, in terms of Blood Sugar, among the adult population, 466 (4.06%) were suspected for diabetes, 29 (0.25%) as High (Borderline), 40 (0.35%) as Low (Hypoglycemia), and 62 (0.54%) as pre-diabetic. From "BMI" measurement, it can be observed that 164 (1.22%) adult people were obese and 1094 (9.52%) adult people were underweight. In addition, female adults (744, in%: 10.65) were underweight at a greater number than male adults (350, in%: 7.78). In terms of blood pressure, 3390 (29.5%) adult people were in prehypertension stage and 2147 (18.7%) adult people were suspected for hypertension.

Young People: The following Table 6 summarizes the distribution of the whole measured population (under the age of 18) by BP, BMI, TEMP, MUAC, Pulse Rate, SpO_2, and Blood Sugar. In terms of "Blood Sugar," two individuals had "High" blood sugar levels and one individual had "Low" blood sugar levels. Even though the female population was larger, 44 (7.35%) young males were obese, significantly more than their female counterparts (23, or 3.51%). However, females were underweight at a higher rate (75, or 11.43%) than males (53, or 8.85%). According to MUAC measurements, 40 young people (3.19%) were suffering from severe malnutrition. Females were more prevalent than males among them. 26 (3.96%) young females were severely malnourished, whereas 14 (2.34%) young males were severely malnourished. Having said that, the majority of the young population in Nayanagar union was in good health.

Discussion

The digital GP model for rural Bangladesh as a whole is comprised of

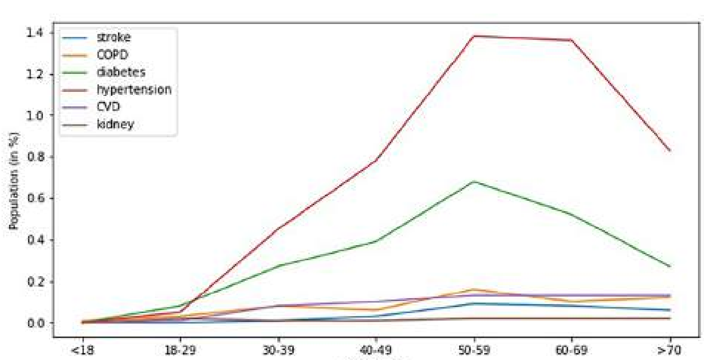

Fig. 9. A population (in%) line graph according to their age groups.

Table 3
NCD's associated with risk factors.

Disease	Total Cases (N)	Factor	Crude Odds Ratio (OR)	P-value	95% CI (for Odds Ratio)
Stroke	35	Age			
		>=40	37.28	<0.01	5.10–272.42
		<40			
		Hypertension			
		Present	59.24	<0.01	27.64–126.9
		Absent			
		Diabetes			
		Present	13.39	<0.01	6.03 – 29.74
		Absent			
		CVD			
		Present	16.93	<0.01	5.07 – 56.58
		Absent			
		COPD			
		Present	5.31	0.10	0.72 – 39.34
		Absent			
Hypertension	617	Age			
		>=40	10.45	<0.01	8.03 – 13.59
		<40			
		Diabetes			
		Present	21.24	<0.01	16.53 – 27.29
		Absent			
Diabetes	283	Age			
		>=40	5.96	<0.01	4.33 – 8.21
		< 40			
		Hypertension			
		Present	21.24	<0.01	16.53 – 27.29
		Absent			
CVD	73	Age			
		>=40	6.20	<0.01	3.26 – 11.78
		<40			
		Diabetes			
		Present	16.54	<0.01	9.67 – 28.29
		Absent			
		Hypertension			
		Present	20.25	<0.01	12.70 – 32.28
		Absent			
Kidney Disease	11	Hypertension			
		Present	16.51	<0.01	5.02–54.24
		Absent			
		Diabetes			
		Present	25.51	<0.01	7.43–87.65
		Absent			
		CVD			
		Present	67.85	<0.01	17.63–261.08
		Absent			

CVD = Cardiovascular disease; COPD = Chronic Obstructive Pulmonary Disease.

Table 4
Measurement value count.

Measurement Name	No. of People
BP (Blood Pressure)	11,328
Pulse Rate	11,178
BMI (Body Mass Index)	7065
Blood Sugar	6444
SpO_2 (Oxygen Saturation)	3453
TEMP (Temperature)	3398
MUAC (Mid-Upper Arm Circumference)	192

four digital platforms and GP centers. Two of these four digital platforms ("Health workers application" and "User application") are Android applications, while the other two are web applications ("Doctor dashboard" and "Admin dashboard"). Besides, patients can visit with doctors via telemedicine or in person at a GP center. Additionally, the GP center provides diagnostic services such as "blood tests" and "urine tests." Our neighbor country, India began the National Digital Health Mission (NDHM) in 2020 with the goal of providing a digital health id, a digital patient health record system, an electronic medical record web application, a digi doctor platform, and a health facility registry [22]. They will accomplish this by providing all citizens with a single, secure health ID, electronic prescriptions, digital referrals and consultations, clinical decision support, and the interchange of health information between public and private health care facilities, among other things. While CMED's digital primary care model incorporates the majority of these services, it is still unable to transmit health information between public and private health care facilities. However, we believe that the digital GP model for rural areas will have this capability if scaled up with government assistance. In addition, we were unable to locate any research that discusses the digital GP model in Pakistan. However, we discovered a study [23] that highlighted some telemedicine programs such as "eDoctor" and "Sehat Kahini," as well as electronic health systems such as "Dengue activity tracking system" and mobile health immunization record systems such as "Teeku."

From our result analysis we found that, hypertension was more prevalent, and cancer was the least prevalent of all other NCDs in the studied population. In this study, hypertension was prevalent among 4.84% of the studied population, which is very smaller than 25.9%, that was found by this study [24]. We argue that, it is because we only took data from one union and their life style could be healthier than the study mentioned above. However, according to this study [25], the prevalence of hypertension ranged from 1.10% to 75.0% in the investigated population, which supports the findings of our study. In this study, the male population numbers with stroke (male = 21, female = 14), COPD (male = = 41, female = 30) and CVD (male = 41, female = 32) were higher than the female population, which is supported by these studies [26,27], and [28]. Besides, people with hypertension were more likely to have stroke which is also shown in this study [28]. On the other hand, for kidney disease (male = 4, female = 7), diabetes (male = 126, female = 157), and hypertension (male = 235, female = 382), the female population was more extensive than the male population. Similar results for kidney and hypertension were also found in these studies [29,24], However, for diabetics, the male population was more prevalent than the female population, as found by these studies [30,31],. Also, we found that NCDs were more prevalent among the ">= 40″ years age group. It is hard to compare with other studies since different studies represented the age range differently, and most of the studies were only for the adult population. With the exception of CVD, the population for stroke, hypertension, diabetes increased until the 50–59 age range, following which the population proportion declined as age increased. From "BMI" measurement, it can be observed that 164 (1.22%) adult people were obese, and 1094 (9.52%) adult people were underweight. In addition, female adults (744, in%: 10.65) were underweight at a greater number than male adults (350, in%: 7.78). Similar results also observed for young people. Even though young female population was larger, 44 (7.35%) young males were obese, significantly more than their female counterparts (23, or 3.51%). However, females were underweight at a higher rate (75, or 11.43%) than males (53, or 8.85%). According to MUAC measurements, 40 young people (3.19%) were suffering from severe malnutrition. Females were more prevalent than males among them. 26 (3.96%) young females were severely malnourished, whereas 14 (2.34%) young males were severely malnourished. We argue that this discrimination is due to rural people's tendency to give more food to the male members than the female members [32].

Our study has several strengths. To the best of our knowledge this is the first digital GP model introduced for rural Bangladesh. In addition, we analyzed health related data from Nayanagar union and outlined some key findings. Having said that, our study has several limitations. To begin with, we analyzed only one union, Nayanagar. As a result, our study's findings cannot be inferred to the entire rural population in Bangladesh. Finally, because the data is skewed toward females, it may underestimate the true prevalence of non-communicable diseases and health vital measurements in the study group.

Table 5
Distribution of overall measured population over the age of 18 years based on BP, BMI, Pulse Rate, SpO2, TEMP and Blood Sugar.

Total Population (age >=18)	Overall 11,491	95% CI	Male 4496 (39.13%)	95% CI	Female 6995 (60.87%)	95% CI
BP	11,105 (96.64%)	96.31–96.97	4258 (94.71%)	94.05–95.36	6847 (97.88%)	97.55–98.22
Low	1191 (10.36%)	9.81–10.92	358 (7.96%)	7.17–8.75	833 (11.91%)	11.15–12.67
Normal	4377 (38.09%)	37.2–38.98	1502 (33.41%)	32.03–34.79	2875 (41.1%)	39.95–42.25
Prehypertension	3390 (29.5%)	28.67–30.34	1534 (34.12%)	32.73–35.51	1856 (26.53%)	25.5–27.57
Mild High	1399 (12.17%)	11.58–12.77	562 (12.5%)	11.53–13.47	837 (11.97%)	11.21–12.73
Moderate High	569 (4.95%)	4.56–5.35	227 (5.05%)	4.41–5.69	342 (4.89%)	4.38—5.39
High	5 (0.04%)	–	2 (0.04%)	–	3 (0.04%)	–
Severe High	174 (1.51%)	1.29–1.74	73 (1.62%)	1.25–1.99	101 (1.44%)	1.16–1.72
Pulse Rate	10,959 (95.37%)	94.99–95.75	4253 (94.6%)	93.93–95.26	6706 (95.87%)	95.4–96.33
Low	291 (2.53%)	2.25–2.82	203 (4.52%)	3.91–5.12	88 (1.26%)	1.0–1.52
Normal	9677 (84.21%)	83.55–84.88	3804 (84.61%)	83.55–85.66	5873 (83.96%)	83.1–84.82
High	991 (8.62%)	8.11–9.14	246 (5.47%)	4.81–6.14	745 (10.65%)	9.93–11.37
BMI	6477 (56.37%)	55.46–57.27	1982 (44.08%)	42.63–45.53	4495 (64.26%)	63.14–65.38
Underweight	1094 (9.52%)	8.98–10.06	350 (7.78%)	7.0–8.57	744 (10.64%)	9.91–11.36
Normal	4384 (38.15%)	37.26–39.04	1378 (30.65%)	29.3–32.0	3006 (42.97%)	41.81–44.13
Overweight	834 (7.26%)	6.78—7.73	230 (5.12%)	4.47–5.76	604 (8.63%)	7.98–9.29
Obesity	140 (1.22%)	1.02–1.42	21 (0.47%)	0.27–0.67	119 (1.7%)	1.4–2.0
Highly Obesity	19 (0.17%)	0.09–0.24	2 (0.04%)	–	17 (0.24%)	0.13–0.36
Morbid Obesity	6 (0.05%)	–	1 (0.02%)	–	5 (0.07%)	–
TEMP	2701 (23.51%)	22.73–24.28	922 (20.51%)	19.33–21.69	1779 (25.43%)	24.41–26.45
Very low	272 (2.37%)	2.09–2.65	72 (1.6%)	1.23–1.97	200 (2.86%)	2.47–3.25
Low	1200 (10.44%)	9.88–11.0	431 (9.59%)	8.73—10.45	769 (10.99%)	10.26–11.73
Normal	1200 (10.44%)	9.88–11.0	401 (8.92%)	8.09–9.75	799 (11.42%)	10.68–12.17
High	29 (0.25%)	0.16–0.34	18 (0.4%)	0.22–0.58	11 (0.16%)	0.06–0.25
Very high	–	–	–	–	–	–
SpO_2	2832 (24.65%)	23.86–25.43	1060 (23.58%)	22.34–24.82	1772 (25.33%)	24.31–26.35
Very low	54 (0.47%)	0.34–0.59	26 (0.58%)	0.36–0.8	28 (0.4%)	0.25–0.55
Low	144 (1.25%)	1.05–1.46	81 (1.8%)	1.41–2.19	63 (0.9%)	0.68–1.12
Normal	2634 (22.92%)	22.15—23.69	953 (21.2%)	20.0–22.39	1681 (24.03%)	23.03–25.03
Blood Sugar	6421 (55.88%)	54.97–56.79	2100 (46.71%)	45.25–48.17	4321 (61.77%)	60.63–62.91
Low (Hypoglycemia)	40 (0.35%)	0.24 – 0.46	11 (0.24%)	0.1 – 0.38	29 (0.41%)	0.26 – 0.57
Normal	5660 (49.26%)	48.34–50.17	1826 (40.61%)	39.18–42.05	3834 (54.81%)	53.64–55.98
Pre- Diabetic	62 (0.54%)	0.41–0.67	28 (0.62%)	0.39–0.85	34 (0.49%)	0.32–0.65
Diabetic (need confirmation)	466 (4.06%)	3.69–4.42	153 (3.4%)	2.87–3.93	313 (4.47%)	3.99–4.96
High (Borderline)	29 (0.25%)	0.16–0.34	17 (0.38%)	0.2–0.56	12 (0.17%)	0.07–0.27
High	164 (1.43%)	1.21–1.64	65 (1.45%)	1.1–1.79	99 (1.42%)	1.14–1.69

BP = Blood Pressure; BMI = Body Mass Index; TEMP = Temperature; SpO2 = Blood Oxygen Saturation.

Conclusion & future work

Overall, the digital GP model for rural Bangladesh presents digital health accounts, health records, healthcare at doorsteps, telemedicine at doorsteps, data driven operational decision making, digital prescription and promote health awareness among rural people. We believe, by adapting this digital GP model, rural people may be able to escape higher-level health facilities for primary healthcare services and reduce out-of-pocket expenditure. By scaling up this digital GP model across the Bangladesh may achieve sustainable development goals (SDG), and universal health coverage. Moreover, from our data analysis, we see that NCDs such as hypertension, diabetes were prevalent among rural people. Necessary steps should be taken to raise awareness among rural people. In the future, we aim to show impact of digital GP model by collecting data from rural areas across Bangladesh. Also, future researchers can analyze NCD behavioral risk factors by accessing socio-demographic data [33] and can find risk factors and predictors of BP, diabetes, etc. [24]. In addition, the existing GP model can be improved by implementing an A.I. based symptom checker. Also, CMED health is working towards making this digital GP model more sustainable, cost effective. This digital GP model is only implemented in one union and now CMED health is trying to scale it so that all the rural people of Bangladesh can get healthcare benefits from this model.

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None.

Competing interests

None.

Ethical approval

The ethical review board of United International University approved to conduct the study. All of the above-mentioned data were gathered with the consent of participants.

CRediT authorship contribution statement

Moinul H. Chowdhury: Formal analysis, Writing – original draft, Writing – review & editing. **Rony Chowdhury Ripan:** Conceptualization, Investigation, Methodology, Writing – review & editing. **A.K.M. Nazmul Islam:** Conceptualization, Investigation, Methodology, Formal analysis, Writing – review & editing. **Rubaiyat Alim Hridhee:** Conceptualization, Investigation, Methodology, Formal analysis, Writing – review & editing. **Farhana Sarker:** Conceptualization, Investigation, Methodology, Writing – review & editing. **Sheikh Mohammed Shariful Islam:** Investigation, Writing – review & editing, Supervision. **Khondaker A. Mamun:** Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors have no conflict of interest.

Table 6
Distribution of overall measured population under age 18 based on BP, BMI, Pulse Rate, MUAC, SpO2, TEMP and Blood Sugar.

Total Population (age < 18)	Overall 1255	95% CI	Male 599 (47.73%)	95% CI	Female 656 (52.27%)	95% CI
BP	223 (17.77%)	15.65–19.88	80 (13.36%)	10.63–16.08	143 (21.8%)	18.64–24.96
Low	110 (8.76%)	7.2–10.33	30 (5.01%)	3.26–6.76	80 (12.2%)	9.69–14.7
Normal	85 (6.77%)	5.38–8.16	36 (6.01%)	4.11–7.91	49 (7.47%)	5.46–9.48
High	28 (2.23%)	1.41–3.05	14 (2.34%)	1.13–3.55	14 (2.13%)	1.03–3.24
Pulse Rate	219 (17.45%)	15.35–19.55	79 (13.19%)	10.48–15.9	140 (21.34%)	18.21–24.48
Low	6 (0.48%)	–	3 (0.5%)	–	3 (0.46%)	–
Normal	195 (15.54%)	13.53–17.54	68 (11.35%)	8.81–13.89	127 (19.36%)	16.34–22.38
High	18 (1.43%)	0.78–2.09	8 (1.34%)	–	10 (1.52%)	–
BMI	588 (46.85%)	44.09–49.61	258 (43.07%)	39.11–47.04	330 (50.3%)	46.48–54.13
Underweight	128 (10.2%)	8.52–11.87	53 (8.85%)	6.57–11.12	75 (11.43%)	9.0–13.87
Normal	354 (28.21%)	25.72–30.7	149 (24.87%)	21.41–28.34	205 (31.25%)	27.7–34.8
Overweight	39 (3.11%)	2.15–4.07	12 (2.0%)	0.88–3.13	27 (4.12%)	2.6–5.64
Obesity	67 (5.34%)	4.09–6.58	44 (7.35%)	5.26–9.43	23 (3.51%)	2.1–4.91
TEMP	697 (55.54%)	52.79–58.29	327 (54.59%)	50.6–58.58	370 (56.4%)	52.61–60.2
Very low	42 (3.35%)	2.35–4.34	14 (2.34%)	1.13–3.55	28 (4.27%)	2.72–5.82
Low	248 (19.76%)	17.56–21.96	106 (17.7%)	14.64–20.75	142 (21.65%)	18.49–24.8
Normal	391 (31.16%)	28.59–33.72	196 (32.72%)	28.96–36.48	195 (29.73%)	26.23–33.22
High	15 (1.2%)	0.59–1.8	11 (1.84%)	0.76–2.91	4 (0.61%)	–
Very high	1 (0.08%)	–	–	–	1 (0.15%)	–
SpO_2	621 (49.48%)	46.72–52.25	306 (51.09%)	47.08–55.09	315 (48.02%)	44.2–51.84
Very low	36 (2.87%)	1.95–3.79	16 (2.67%)	1.38–3.96	20 (3.05%)	1.73–4.36
Low	23 (1.83%)	1.09–2.57	11 (1.84%)	0.76–2.91	12 (1.83%)	0.8–2.85
Normal	562 (44.78%)	42.03–47.53	279 (46.58%)	42.58–50.57	283 (43.14%)	39.35–46.93
Blood Sugar	23 (1.83%)	1.09–2.57	6 (1.0%)	–	17 (2.59%)	1.38–3.81
Low	1 (0.08%)	–	1 (0.17%)	–	–	–
Normal	20 (1.59%)	0.9–2.29	4 (0.67%)	–	16 (2.44%)	1.26–3.62
High	2 (0.16%)	–	1 (0.17%)	–	1 (0.15%)	–
MUAC	192 (15.3%)	13.31–17.29	99 (16.53%)	13.55–19.5	93 (14.18%)	11.51–16.85
Normal	151 (12.03%)	10.23 – 13.83	84 (14.02%)	11.24–16.8	67 (10.21%)	7.89–12.53
Moderate	1 (0.08%)	–	1 (0.17%)	–	–	–
Severe	40 (3.19%)	2.22–4.16	14 (2.34%)	1.13–3.55	26 (3.96%)	2.47–5.46

BP = Blood Pressure; BMI = Body Mass Index; TEMP = Temperature; SpO_2 = Blood Oxygen Saturation; MUAC = Mid-Upper Arm Circumference.

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