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Portable Health Clinic: An Advanced Tele-Healthcare System for Unreached Communities

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Abstract

The Portable Health Clinic (PHC) system endeavors to take healthcare facilities along with remote doctors' consultancy to the doorsteps of the unreached people using an advanced telemedicine system. Thus, the necessity of having physical healthcare peripheries specially in the developing countries can be mitigated. The PHC system promotes preventive healthcare by encouraging regular health checkups so that diseases can be prevented as well as their severity can be mitigated, leading to a reduction on healthcare expenses. Thus, the number of patients along with excessive workload on existing healthcare human resources can be minimized. The current project in rural Bangladesh alone has served more than 41,000 people so far by the PHC system and a simple analysis of this data shows some significant findings on regional health status. A simple expansion of this program, covering a wider service area, can produce a big data to reflect the whole country`s health profile.

Keywords:

Preventive Healthcare, Telemedicine, Triage

Introduction

Healthcare facility is a basic right for all human beings. Unfortunately, the shortage of qualified doctors and health workers, insufficient medical facilities and lack of healthcare awareness remain as some major obstacles for ensuring a standard level of healthcare service in the developing countries [1, 2]. Under this circumstance, telemedicine with preventive healthcare could be considered as a key to overcome this situation. Keeping this in mind, the Portable Health Clinic (PHC) system has been developed as an advanced telemedicine system for the rural communities in Bangladesh [3, 4]. This system, also called "Doctor in Box", enables bringing healthcare services to the doorsteps of the rural communities at a affordable price (Figure 1).

Nowadays, the prevalence of non-communicable diseases like Diabetes Mellitus and Hypertension has increased to a cautious extent. Being a developing country, Bangladesh is not an exception. From our studies, we have learned that not only the urban people, but the people in suburban and rural areas are equally affected by these diseases. These diseases and the consecutive complications can be effectively prevented by taking cautions beforehand. Prevention is more important in countries like Bangladesh because of the limited ability of people to spend on health bills and the absence of provision from government. Preventing such diseases to occur or diagnosing it at early stage can help people to save substantially on medical bills. For this, regular screening of health status is important which can be facilitated by the PHC. Thus, the PHC system has been developed in a preventive healthcare approach with a special focus on non-communicable diseases [5, 6]. One of the main obstacles for ensuring basic healthcare service in developing countries is the poor doctor-patient ratio. According to World Health Organization (WHO), where it requires at least 12 doctors for standard healthcare service to every 10,000 populations, Bangladesh have just 4 doctors. However, it is not that easy to increase the number of doctors in a short period of time. When it is not easy to improve this doctor-patient ratio by increasing the number of doctors alone, decreasing the number of patients is very important. The PHC system also aims to contribute in improving this doctor-patient ratio by introducing preventive healthcare to reduce patients by advance intervention to the problem.

Figure 1. Portable Health Clinic ("Doctor in Box")

The PHC system made it possible to provide primary healthcare services to the doorstep of the rural communities through a telemedicine system. However, to ensure better consultancy by the remote doctor, accurate and a wide range of diagnosis reports of the patient are required to be available to the remote doctor. Unfortunately, most of the developing countries do not have enough quality diagnosis laboratories in the rural areas with qualified pathologists for producing reliable reports. Therefore, this work introduces a new module to the PHC system called the "Tele-Pathology" system that enables rural laboratory technologists to gain assistance from a remote professional pathologist using an online tele-healthcare system and receive the verified report from the pathologist [7]. This involves a very simple technology using available devices like a camera and microscope, and it can be easily replicated.

While providing this primary healthcare service in rural Bangladesh, a huge need of eye care services was identified.

Considering this demand in rural Bangladesh, this work also added another new module with the PHC system called the "Tele-EyeCare" system for ensuring eye care services [7].

The main objective of this work is to improve the PHC system and expand the service scope so that it can respond to the wide range of demands of rural patients with quality consultancy aided by accurate diagnosis. Addition of Tele-Pathology and Tele-EyeCare modules will contribute significantly in this direction.

Methods

PHC System Structure & Operations

The PHC system consists of 4 components: 1) PHC box with various medical sensors, internet enabled tablet pc and printer, 2) health worker 3) online dataserver for sharing and preservation of health data and 4) remote doctor call center (Figure 2). The health worker brings this PHC box to the patient to measure the vital information and upload this data, along with the medical history of the patient to the online server using the system application (app). The remote doctor gains access to this data and makes a video call to the patient for further verification. Finally, the doctor produces an online prescription and preserves it in the server under the patient`s personal file. Then, the health worker prints the prescription from the server and passes to the patient with detail explanation instantly (Figure 3). The whole process to serve one patient takes about 15 minutes excluding doctor`s consultancy time.

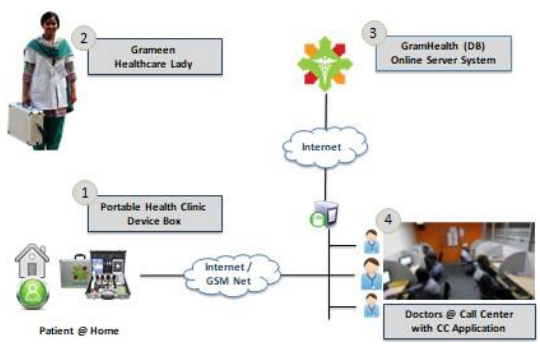


Figure 2. PHC System Structure

The PHC system introduces a triage process based on the concept of "B Logic" for the people of Bangladesh. It classifies the subjects under investigation in four categories, namely, (i) green or healthy (ii) yellow or caution (iii) orange or affected and (iv) red or emergent, based on the gradual higher risk status of health [8-11]. The subjects under orange and red are primarily diagnosed as in the risky zone who need doctor`s consultancy. However, the major part of the subjects who are diagnosed in the alarming zone (yellow) can be served by the trained health workers without medication and they can be prevented from shifting to the risky zone (orange and red) being under the guided lifestyle. This reduces the pressure on the doctors, enabling them to focus on the risky patients who deserve better attention.

Tele-Pathology System

The Tele-Pathology module of the PHC system enables the rural diagnostic centers operated by laboratory technologists (diploma) for producing quality pathological report with the support of the qualified remote pathologist (Figure 3). At present, this system is capable of a blood hematological (CBC) test, routine examination of urine, routine examination of stool and a skin scarping test. In this system, the rural laboratory technologist (1) collects the sample, prepares the physical report, produces the test slide, (2) takes a number of microscopic images of the slide with varying positions and then (3) uploads the images along with the physical report to the online server. The remote pathologist then (4) diagnoses the sample based on the microscopic slide images with the reference of physical report, finalizes the pathology report and preserves to the online server.

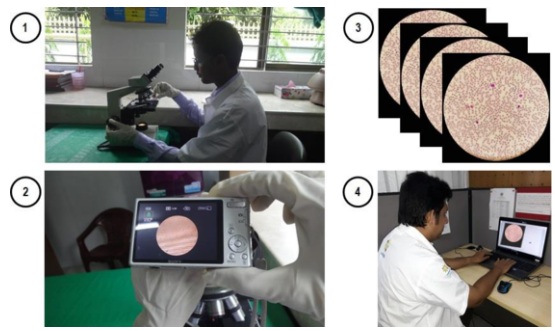


Figure 3. Tele-Pathology System

In case a pathological report is required by the call center doctor (physician), the doctor can gain access to the report from the online server for preparing a prescription. If needed, the laboratory technologist can also download this report to deliver to the patient.

Tele-EyeCare System

The Tele-EyeCare module of the PHC system ensures primary eye care services for the rural communities. This module has added a Digital Fundus Camera to the PHC box for retinal imaging (both Mydriatic & Non-Mydriatic) of the patients. This enables the health workers to have a better view of the retina and the peripheral for identifying the problem with certainty. Thus, the trained local health workers check and classify the patients as per severity of the problem. Low risk patients with simple complications are served by the health workers. However, in case of doubtful cases, the patients` vital information, initial primary checkup reports and ophthalmic images are shared with a remote ophthalmologist using the online server (Figure 4).

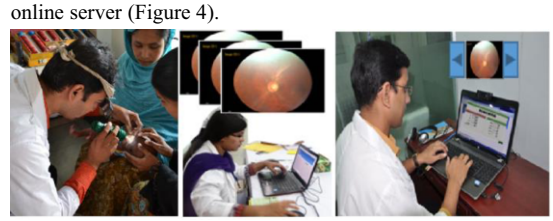


Figure 4. Tele-EyeCare Service System

The ophthalmologist then checks the initial primary checkup reports produced and shared by the local health worker, investigates the ophthalmic images, directly talks to the patients over video conference system, reconfirms their status and finally, provide online prescriptions. If needed, the ophthalmologist can ask for further investigation of the patient by the health worker and can also provide glasses prescription with the support of the health workers. Thus, this system enables to provide basic eye care to the ordinary patients by the health workers and special care for the critical patients by

professional ophthalmologist who really deserve special attention.

Village Service Delivery Model

In village service delivery model, preferably one female health worker works in a village as she can gain better access to the female patients due to privacy reasons. Usually, she uses a local village medicine shop (pharmacy) as her service point for daily service and general village patients come there for PHC service (Figure 5). However, she also visits door to door in case of elderly or disabled patients, pregnant women, emergency patients or special on-call service.

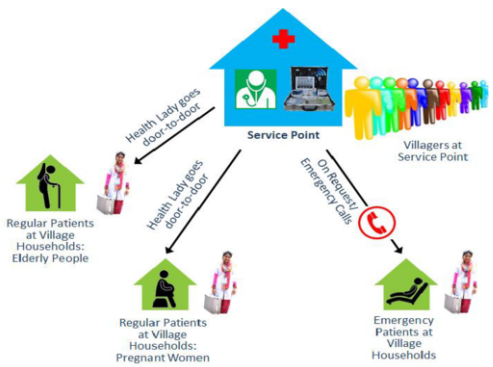


Figure 5. Village Service Delivery Model

Urban Service Delivery Model

Although, it was developed for the low income rural communities, it is found equality useful for the urban, rich, and aged community for home delivery service. The main clients are aged people who are suffering from non-communicable diseases like hypertension and diabetic that need regular checkups. Although, they are financially rich but as it is difficult for them to visit hospital regularly due to physical stress, trouble to arrive at doctor`s appointment at expected time, traffic congestion, etc. So the PHC home delivery service is offered to the pre-registered urban patients and the health workers visit the patients as per schedule.

Personal Health Record

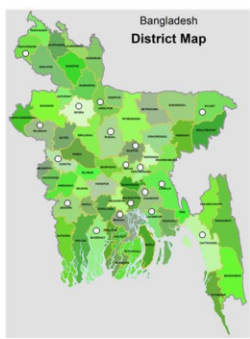
The PHC system preserves all medical data of the patients in the online server so that the doctor can refer previous data in need. All checkup data, pathological reports, medical histories and prescriptions are preserved sequentially. Also, all the patients are provided with their respective user id and password for their access to their personal, health record which is maintained with high security and privacy (Figure 6). They can change their profile information but only monitor the health records with graphical representations.

Figure 6. Personal Health Record & PHC Prescription

The prescriptions produced in the PHC system are unique in shape and format considering the targeted patients of the rural communities (Figure 7). It contains both the measured health data in the left side and doctor medication with advice on the right side. As most of the patients do not understand the significance of digits, it shows all health data with corresponding color sign. The same four colors of the triage system (green, yellow, orange and red) are used against each data point so that they can easily understand the severity of any particular item.

Results

The PHC healthcare services have been offered in 18 districts of Bangladesh at more than 70 service points all over the country (Figure 7). Until April 22, 2018, the number of patients served by the PHC system in Bangladesh alone was 41,949. Besides, the PHC activities are also continued in Cambodia, India, Thailand and Pakistan under the supervision and management of local partners.



As on April 22, 2018					
Year	Total Checkup	Health Status			
2010	377	103	15	248	10
2012	6,412	1,056	4,035	1,084	237
2013	13,277	1,595	6,781	4,301	546
2014	5,288	1,004	2,278	1,659	326
2015	5,547	1,330	1,429	2,016	772
2016	7,007	1,875	1,614	2,255	1,069
2017	2,853	366	800	868	361
2018	1,188	95	410	325	121
Total	41,949	7,424	17,362	12,756	3,442
		24,786 (61%)		16,198 (39%)	

Figure 7. PHC Service Statistic in Bangladesh

The diagnosed major diseases found in PHC healthcare services are hypertension (1,944), diabetes (1,365), anemia (647), and ophthalmic problem (138).

The Tele-Pathology service started in 4 rural diagnostic centers under 4 districts (Barisal, Bogura, Manikganj and Thakurgaon) of Bangladesh. So far, this system has served patients with a total of 1,610 Hematological (CBC) reports and 918 Routine Examination of Urine using remote pathologists.

The Tele-EyeCare mobile service has recently started in 1 rural center called “Vision Center” in the Nator district of Bangladesh on a test basis. So far, it has already served 2,410 checkups for 2,046 patients using remote ophthalmologists. Soon this service will be extended to other parts of the country.

Discussion

Out of a total 41,949 PHC healthcare patients, 61% (24,786) was green and yellow patients who were served by the health workers alone. The rest of the patients 39% (16,198) were served by doctors who needed medication. So, the PHC system can reduce the work load of a professional doctor by 61% that can be managed by local health workers. Thus, the best use of the valued resource of a doctor can be ensured and only the people who really need expert`s consultancy can avail it.

Due to its easy operation, a huge number of health data can be collected by the PHC system and this big data can be used for countrywide disease pattern analysis. For example, this research has found some significant differences of health parameters in different areas. In one area, we have found a

significantly small number of anemic cases among the adult women compared to the rest of the country. In another area, we have identified very high urine protein compared to the rest. Thus, the detail analysis of this data may show some significant findings including environmental issues.

Similar to the shortage of physicians, there is a huge shortage of ophthalmologists and it is just 0.063 ophthalmologist for every 10,000 populations in Bangladesh. The Tele-EyeCare module of the PHC system can highly contribute to ensure the best use of this valued resources for dealing with complicated cases and manage ordinary cases by health workers. For the further advancement of the Tele-EyeCare system, a new development has been started using Artificial Intelligence (AI). It will use ophthalmic image recognition technology with the aid of neural network and deep learning for automatic diseases identification. This will facilitate both the village health workers and ophthalmologists for better and prompt services.

Conclusions

At present, the PHC tele-healthcare system offers a unique opportunity for ensuring better healthcare service covering primary healthcare, eye care and pathological services to the unreached rural communities. However, this modular system will gradually be expanded in other healthcare service areas to cover common healthcare issues based on the local demand. Now, we are working on an Obs & Gyne module and Dental Care module to be added soon to the PHC system.

The concept of the PHC system came from the local demand of Bangladesh. However, since most of the developing countries are facing the same problem and having similar situations, an easily replicable PHC system can be in good use there. So far, this system has been replicated in India, Pakistan, Cambodia and Liberia with some localizations. However, there is still plenty of opportunities for further improvement of the system and expansion of the service to the other parts of the world.

Since the aging communities are increasing in the developed countries, they are also facing a similar crisis of doctor shortage in their rural areas. Therefore, there will arise a huge demand of PHC services in the developed countries as well [12]. To address this demand, the PHC system can be further improved with the aid of technologies. One of these attempts is to include Bluetooth enabled medical sensors so that the measured vital data from the sensors will be automatically transferred to the online server to avoid typing error from manual data entry [13]. Also, there is a requirement to develop the PHC box as an integrated unit so that it will be low cost, handy and light weight for easy operation by a rural health worker.

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