Building a secure model of e-Medication management system for optimum pharmaceuticals safety

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***Abstract*—Managing the processes of prescribing, dispensing, administering and monitoring medicines are fundamental parts of ensuring good health outcome. Although improving medication management in Bangladesh is the crucial objective of the National drug policy-2016, there is no effective administration system for effective regulatory control. Our proposed e-Medication Management system (eMM) seeks to support policies and objectives by improving the access and quality of medicines information through the use of digital health service (eMM), enabling consumers and healthcare providers to make safe, informed decisions and achieve better health outcomes. We also investigate how the eMM system relates to the significant improvement in public health service.**

***Index Terms*—eMM, Security, National Drug policy, Public health, Bangladesh**

I. Introduction

Medication is an essential part of healthcare, and the appropriate treatment with drugs enables the cure and prevention of many disease [1]. However, the drug-related problems (DRP) are frequent and cause suffering for patients, and substantial costs for society [2], [3], [4]. Right medicines management can help to reduce the likelihood of medication errors and hence patients harm. Currently, there is no standard for medication management in Bangladesh, although antibiotic drug law 2016 is passed in the cabinet. Since uncontrolled antibiotic drug sales in our country cause a catastrophic increase in the medical and socio-economic burden of untreatable infectious disease, so it is very much essential to find out the reasons behind the resistance and take some necessary steps to solve the problems. E-medication management (eMM) is intended to prevent harm arising from ineffective medication information as a patient's transition across healthcare settings. The main objective of our research is to develop an effective medication management system to control antibiotic drug selling in Bangladesh, which will be transparent, accurate and ensure quality with efficacy. Besides, the eMM system will be implemented in such a way so that it can be easily accessed by general users from smart devices while ensuring all security perspectives.

II. Background

Self-medication is the use of medicine to treat the self-diagnosed disorder or symptoms, or continued use of a prescribed drug for chronic disease [5]. In Bangladesh, most patients diagnoses his illness and buys a specific medicine to treat it. Besides, self-medication with antimicrobial compounds is an extremely ubiquitous practice in developing countries like us for reasons of convenience, accessibility, perceived savings and other benefits, with poor adherence being a never-present consequence of self-medication. The arsenal of antibiotic medicine may be used up quickly while leaving the patient vulnerable to drug-resistant infections since there is a direct relationship between the amount of a given medicine used and the incidence of bacterial resistance. Resistance to commonly used antimicrobial drugs is significantly high in our country since antibiotics are not restricted. Increasing the rate of antibiotic resistance have left clinicians with limited drug options for the treatment of bacterial infectious diseases which is a significant public health concern worldwide. The antibiotic resistance in developing countries causes a catastrophic increase in the medical and socio-economic burden of untreatable in factious diseases.

Moreover, over-prescribing and inappropriate prescribing is very common due to the unethical practice of both health professionals and drug manufacturers. Besides, antibiotic self-medication is highly prevalent here due to easy availability and poor regulatory controls on the distribution of these drugs. Moreover, patients can get antibiotics quickly from pharmacies according to their demand without prescription. So, the misuse of antibiotics is increasing. In the long term effect, patients are exposed to severe health hazards, particularly liver and kidney damage, because of the indiscriminate taking of antibiotics. Experts state that unnecessary use of these drugs builds antibiotic resistance in human bodies, multiplying the extent of diseases that can even lead to death in extreme cases. Also, if the resistance continues to develop, bacterial infections could go beyond treatment in the future. Dr Iqbal Arslan, professor of Biochemistry at Bangabandhu Sheikh Mujib Med-

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TABLE I
SUMMARY OF THE OUTCOME OF ANTIBIOTIC DRUG MISUSE IN BANGLADESH

Pub.	Study type	Purpose	Result
[6]	Survey	Assess and evaluate the prescription pattern of antibiotic	Polyphamacy
[7]	Survey	The amount of antibiotic prescribed by physicians	Irrational medication
[8]	Survey	The prevalence of self-medication	Self-medication
[9]	Survey	Situation about antimicrobial resistance	Lack of proper regulation
[10]	Case study	Role of pharmacist	Need of pharmacist to counsel

ical University(BSMMU) said, "Irrational use of antibiotics poses a great danger, as it develops drug resistance faster than what a new generation drug takes to be developed". He also blamed it on the counter sales of antibiotics, suggesting the government frame a strict law to prevent sales of antibiotics and painkillers without prescriptions of registered doctors. In table I we summarize the outcome of antibiotic drug misuse from paper [6], [7], [8], [9], [10] in Bangladesh.

III. LITERATURE REVIEW

Electronic medication systems are a crucial cornerstone of the digital healthcare system since prescribing and dispensing medication is a frequent activity that links various actors in the system (See [11]). Previous research has shown potential health and social benefits of e-prescriptions, such as improving quality of care and patient safety through error reduction(see [12]), and increasing patient convenience, particularly for repeat prescriptions(see [13], [14]). Our paper reviews the existing literature on e-prescriptions/e-medication, focusing on the country (Estonia, United Kingdom, Sweden, and Denmark) case studies, and systematizes the evidence around benefits and success factors.

In Estonia, 1.3 million inhabitants, is known for its cutting-edge approach to digitization. In line with many European countries, the Estonian health system is founded on solidarity, with a single public payer, the Estonian Health Insurance Fund (EHIF), providing mandatory health insurance for nearly all of the population. The Estonian e-medication system enables data exchange between patients, providers, pharmacies, and EHIF. To issue a prescription, the provider creates an entry in a patient's medication record system, based on which a patient can obtain their medicines from any pharmacy in the country based on their eID. Patients can also log in their account via an online portal and view the audit trail of data access and use. Since the digital service has grown rapidly: 84% of prescriptions in the country were issued electronically in 2011, 95% in 2013, and over 99% today. According to a survey "Citizens satisfaction with health and healthcare", 92% of users of digital prescription are satisfied with the service (see [15], [16]). In the United Kingdom, 64.1 million inhabitants, has a National Health Service (NHS) financed through general taxation and free at the point of care, which is separately managed for its constituent countries (England, Wales, Scotland, and Northern Ireland). Digital services in health and other areas of government form part of the UK government's digital by default vision to increase service levels and reduce costs in the long term (see [17]). In the UK, large differences for e-prescriptions exist between primary and secondary care(see [18], [19]). In primary care, e-prescriptions are becoming relatively well established. In secondary care, e-prescription systems are largely implemented in a decentralized manner based on initiatives of specific hospitals (see [20]). The UK aims to digitize hospitals and other aspects of the health system fully by 2020(see [21]). Sweden has a long history of the use of information technology in healthcare. It became one of the first countries to use e-prescriptions when, in 1983, a few doctors connected to local pharmacies to exchange prescriptions (see [22]). The national effort to improve connectivity in the health system began in 2000 when common standards for health data exchange were introduced(see [23]) and the organizational responsibility for e-prescriptions lies with the Swedish eHealth authority. Statistics show that the share of prescriptions transmitted electronically rose continually over the last decade: there were about 3 million e-prescriptions in 2002 and 25 million e-prescriptions (75% of prescriptions) in 2007(see [24]), while in 2014, about 90% of the prescriptions were sent electronically. Patients generally expressed high satisfaction with the system, with positive general attitudes for 85 % of the population, and positive views regarding the safety (79%) and benefits (78%) of e-prescriptions(see [14]).

To reduce misuse of drugs like developed countries, the government of Bangladesh has approved the draft of revised and integrated drug policy, to make sure pharmaceutical products meet international standards and substandard, fake and adulterated drugs are checked. The National Drug Policy 2016 will replace the existing one framed in 2005 (see [25]). According to the policy, no one can buy drugs without prescriptions from physicians, except 39 allopathic, 23 ayurvedic and 48 Unani medicines. This is very important as indiscriminate use of medicines, especially antibiotics, is harmful to public health. The policy also provides for the availability of effective, safe and standard drugs, rational and safe use of drugs, registration of drugs, registration for importing drugs as well as manufacturing drugs and its raw materials. There are proposals as well for the formation of a national drug regulatory authority, advertisement control, publicity of drugs and joint initiatives for research and development. The revised policy makes storage or display of drugs with the expiry dates changed or distorted a punishable offence. Legal steps would be taken against people for charging customers additional prices. Once the revised policy is implemented, there will be little scope for sub-standard and adulterated drug manufacturers(see [25]). But there is no e-medication framework (Table I) to support the policies and objectives to improve the current situation in Bangladesh. Now it's time

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demanding higher standards of care, better patient safety, more value for money spent, and an integrated continuum of care delivery.

IV. ELECTRONIC MEDICATION MANAGEMENT SYSTEM

Medication management (MM) is a formal process in which healthcare providers work together with patients to ensure accurate and comprehensive medication information communicated consistently across transitions of care. The goal of MM is to prevent potential patient medication errors and adverse drug events. So informal definition, Electronic Medication Management System (eMM) uses information technology to access and integrate electronically stored patient medication data to support: (i) the collection of the electronic Best Possible medication history (eBPMH), (ii) the development of an automatic best possible medication discharge plan (eBPMDP) and (iii) the comparison of eBPMH and new orders at transfers. Moreover, the eMM system can be tailored according to the policy and objectives of a specific country and organization (see [12]).

V. SURVEY ON THE NECESSITY OF EMM SYSTEM

Generally, the success of e-administration depends on how users of the system accept it as a service. Implementation of an eMM will require changes in workflow. Since e-Medication Management system is an entirely new idea in the perspective of Bangladesh, it is essential to understand the services needed, degree of acceptance, prospect and challenges to implementing the system. To understand the necessity of e-medication system, we run a paper-based end-to-end survey that covers three basic entity of the system (i.e. doctors, patients and Medicine sellers). Our questionnaires were given only to the spontaneously interested candidates during the survey. The data collected was subjected to simple descriptive statistical analyses including frequency distribution and percentage, since the aim of the study was to find irrational antibiotic medication pattern and propose a framework to ensure appropriate antibiotic medication. From Patients survey, it is marked that 40% take antibiotic medicine by taking prescription from doctors and 60% take antibiotic medication without taking prescription from doctors due to suffering cough and fever most of the time. Besides, from doctors survey, it is evident that 55% prescribe antibiotic medicine in suspected cases and 45% prescribe medicine after confirming disease, which is a clear indication of irrational medication. Most of the doctors, patients, sellers opine that in order to avoid serious health hazard, patients should stop antibiotic drug self-medication, and they also blame that over the counter availability of the antibiotic drug is also a major reason of irrational medication (See figure 1). At the end of the survey, we observed that most of them (patients, doctors, medicine sellers) feel to use an antibiotic e-administration system that will ensure fair antibiotic medication practice (See figure 2, 3, 4).

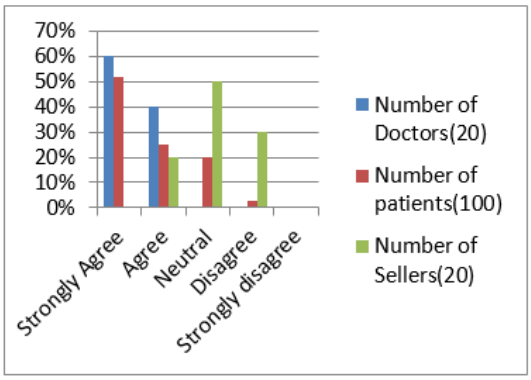

Fig. 1. Illustrating opinion on "Misuse of antibiotic for over counter availability of antibiotic".

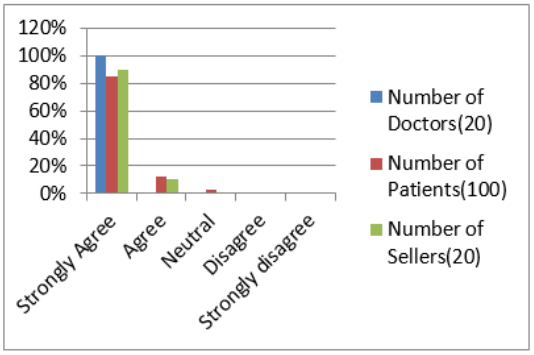

Fig. 2. Illustrating opinion on "Should we use e-medication system"?

VI. PROPOSED SYSTEM MODEL

The main objective of this paper is to design and develop a drug Administration framework that will help the ministry of health effectively in regulatory controls on the distribution and selling of antibiotics to reduce the frequency of antibiotic misuse. Since e-Medication management is a complex system, it must include all service and security component. So Prior to our design and implementation, we accomplished our requirements engineering processes by interacting with the doctors, patients, medicine sellers to gather the requirements for the system (See figure 5). We were able to identify some services which are represented architecturally in the following sections:

A. SERVICE REQUIREMENTS

The IT infrastructure for medication management should support all the clinical and administration services involved and should include the following:

- Comprehensive medication profile: The core component of a medication management infrastructure is a comprehensive medication profile that captures information about all medication transactions. More specifically, a comprehensive medication profile will contain: a history of all previous dispensing, a history of all non-dispensing events (such as "stop orders"), an active prescription drug profile; information on past drug interactions.

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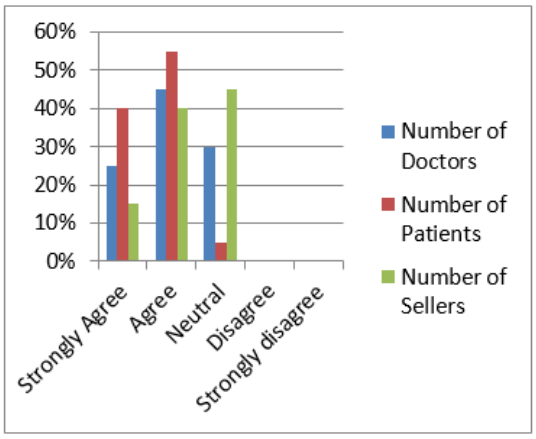

Fig. 3. Illustrating opinion on "None get medicine without e-prescription".

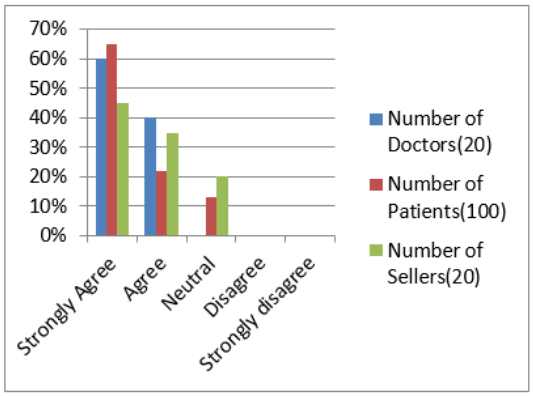

Fig. 4. Illustrating opinion on "e-Medication system can improve public health".

- Electronic prescribing: Electronic prescribing systems to reduce medication errors, support appropriate, prescribing practices, and streamline medication management interactions between physicians and pharmacists. Most electronic prescribing systems function in the following way: The physician sends a prescription to an approved repository, allowing a pharmacy to retrieve the prescription with the patient's authorization. Pharmacies retrieve the electronic prescription from the approved repository using a unique identifier. If the physician cannot send the prescription electronically to the pharmacy selected by the patient, the physician prints out a hard copy of the prescription for the patient(A.B.R. Kumar, etal, 2012).
- knowledge management and translation: to provide appropriate, 24-hour clinical and drug information's.
- Provider and patient portals: to give patients and their health care providers ready access to patient information and to ensure greater involvement of patients in their own health care. Provider portals make it possible for health care providers to get access to information and resources specific to their practice. For example, electronic health journals and news, Practice guideline, secure email etc.
- Pharmacy network: Advanced medication management systems depend on secure, broadband networks integrated with other health infrastructure at the local, regional, and provincial levels. A pharmacy network must comply with standards for connectivity and compatibility (such as the National claims Standard Initiative) to support pharmacy claims processing and adjudication by public and private health insurance companies.
- Standards: to ensure that the entire system is integrated and coordinated;
- Pharmacy management system: to support dispensing, inventory management, claims processing and adjudication, and compensation;
- Medical test report management system: to support uploading the lab test report in the specific patients account so that doctors can view these report according to their demand.
- Physician practice management system: to manage the administrative functions of a physician office, such as appointment scheduling and physician billing.

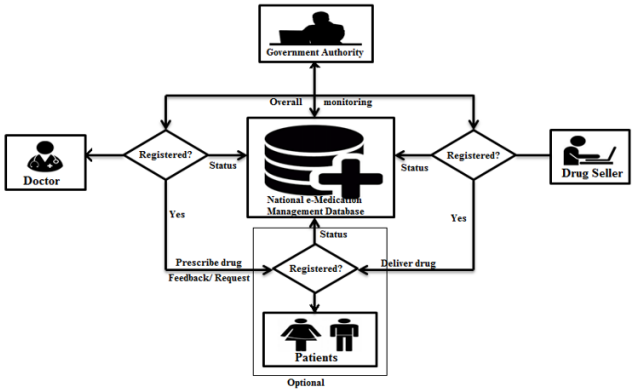

Fig. 5. Simplified presentation of e-Medication system Model.

B. SYSTEM REQUIREMENTS

In order to make completely successful and long lasting system, it must fulfill the following requirements. It includes:

- System reliability: System reliability is an essential aspect of implementing eMM. There must be a back-up plan if eMM fails or goes down.
- Usability: Higher rates of compliance will be achieved with an intuitive, easy- to- use system. Users are more likely to revert to paper-based processes or find workarounds if eMM is difficult to use.
- Sustainability: To ensure sustainability, it is important to continually consider and communicate: eMM achievements and remaining goals, the importance of eMM from a patient safety perspective, Buy- in and support from clinicians and other end users of the system.
- Cost: For any implementation to be a success it is important to identify project and long term maintenance costs. Therefore it is critical to: Ensure commitment and support of senior management through an executive sponsor dedicated to this project, Ensure that sufficient financial

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resources are available to implement eMM, Provide a dedicated team of healthcare professionals and Health IT staff for project implementation, Determine the impact on time of using new eMM processes by physicians, nurses and pharmacists, Ensure there is sufficient staff with enough time to conduct eMM on an ongoing basis.

- Patient Safety: As with other electronic tools, the introduction of eMM has the potential to reduce errors and/or introduce new errors into the eMM process. To fully benefit from the potential of eMM to decrease errors: Ensure that healthcare professionals are educated in and aware of their role in all aspects of eMM processes, Encourage healthcare professionals and patients to report near misses and errors that arise, in order to refine eMM processes to ensure system reliability and maximize the benefits of eMM, Ensure a well-defined evaluation plan is in place to track compliance with and outcomes of implementing eMM.
- Risk Assessment: Although eMM has many benefits, implementation may introduce risks and potential for error that must be considered and mitigated. Risks potentially introduced by eMM implementation include: Over-reliance on electronic medication lists and avoidance of, or performing lower quality, patient interviews. Technology-induced errors may be inadvertently introduced and inadvertently increasing workload by requiring electronic entry of medications.
- Training: Training of users is critical and clinicians will require more than one training session or training combined with follow-up support. Indeed, in studies of eMM implementations, training and education of end users of eMM was found to be one the most important factors in facilitating adoption by physicians and pharmacists

VII. ARCHITECTURE OF THE SYSTEM

Since the e-Medication system is an emergency service portal, it needs to be characterized by timely and accurate access to information at all time. We design an architecture that will always allow easy access, search, retrieval and update of information from the access device. In our system, we use client-server multi-tier based architecture for hardware (physical) and 3-tier client/server architecture for software (logical) deployment.

A. HARDWARE ARCHITECTURE

Our system architecture comprises of a complete range of robust performance client and server platforms with integrated enterprise application as shown in figure 6. In the proposed hardware architecture, we didn't utilize cloud computing infrastructure due to security reason [26], [27]. The hardware architecture is highly secure and utilizes multiple layers of firewall protection to create several regions of trust. The robust servers with load balancing system provide, real-time access to the point of care database originating from systems across the enterprise system to facilitate timely and accurate care delivery and practice management. From the client-side, information can be accessed through PC, smartphone and other internet-enabled devices. User Load on the application server tier is balanced by using multiple application servers and load balancer. A firewall is integrated to filter all traffic moving in and out of the system. When a user proxy database is created, metadata for the proxy tables are imported automatically from the remote location that contains the actual tables. This metadata is then used to create proxy tables within the proxy database to make more secured database back-up.

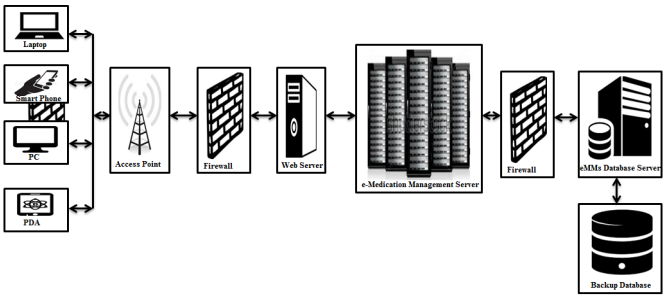

Fig. 6. Hardware architecture for e-Medication Management (eMM) system.

B. SOFTWARE ARCHITECTURE

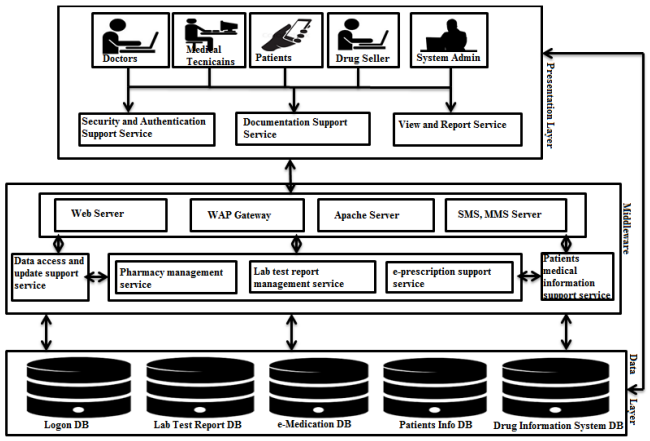

Fig. 7. Logical architecture of e-medication management system.

Figure 7 gives an overall logical (software) view of the architecture of the eMM system that shows the locations of each of the supports service in the system. Our system is a 3-tiered client-server which consists of the client interface, middleware and database repository where the database is separated from the client through the middleware. The middleware concept helps to solve scalability, load balancing, transactional processing and interoperability issues by providing a means that allows different hardware and software from different manufactures to share common Patient medical records. The client has its parts the Security and Authentication Support Service (SASS), Documentation Support Service (DSS) and the View and Report Service (VRS). These support services do not store or process any form of data. They only provide an interface for the middle layer and the data layer.

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C. HOW IT WORKS?

The system is based on forcing the user except the patient to register the real identity to ensure transparency in medical practice. This system has Databases, managed by the system authority as well as Database Manager. The whole system (see figure 8) comprises of two types of users: 1) Who use the system 2) Database Management Authority. Through this process, the eMM system will help fair medical practice.

D. SOFTWARE ARCHITECTURE

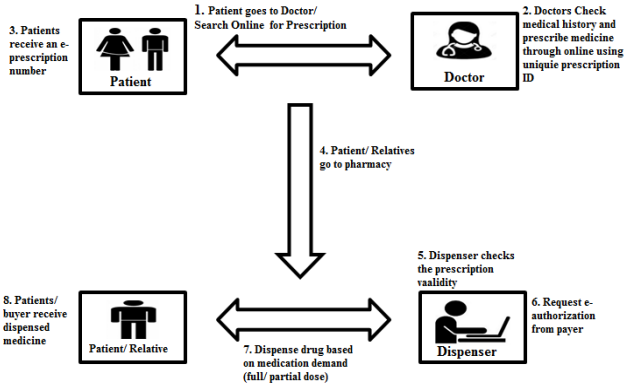

Fig. 8. Diagram of prescription flow and drug dispensing cycle.

1) USER OF THE SYSTEM: In our system, there are three types of user. They are medical practitioners (i.e. doctor, Medical technicians), patient and seller. In our system, the Patients registration process is optional keeping in mind about emergency medical service, but the doctor and medicine seller must be registered user to interact with the whole process of prescription service. Our system will force users to use real identifications. There will be a verification technique in our system to check whether the user account holder uses the proper identity or not. If the user account contains proper identity, the user will be proceeded to use the system. If not, the user account will be pended to use and detected as a malicious user. Then the system will automatically notify them to use proper identity to prevent from being suspended. After completing the registration process, successfully doctor can view medical history (i.e. disease history, previous prescriptions, etc.) and prescribe medicine to the patient through our drug administration system. When a prescriber (doctor, specialist, dentist etc.) generates an e-Prescription two things happen - an electronic copy of the prescription is secured via encryption and submitted to the Prescription Exchange Service (PES); and a unique number is generated and printed on the paper prescription. An electronic copy of When the patient takes the paper prescription to the participating pharmacy, pharmacists or authorized sellers will distribute the drug to the respective patient. In addition, the system will automatically send SMS to the prescription holder, if the medicine is taken by another person and track necessary information of the buyer. If the pharmacy does not use the eMM system, the prescription is dispensed as per the standard dispensing process. That is, the prescription information is manually transcribed into the pharmacy's dispensing system and the medicine dispensed. Moreover, the system will contain a facility of partial dose purchasing facility. Besides, it will also contain a feedback facility so that doctors and patients can communicate with each other to know whether the disease is cured or not. This system can be accessed using both computer and smartphone for ease of use.

2) DATABASE REPORTING AUTHORITY: In order to ensure fair practice, the system will be under proper authority. The authority will periodically check the user's activity. If a user of the system wants to complain about any illegal activity, then he/she will enter into our proposed system and paste that id of the illegal practitioner in the mentioned box. Then he has to write a description of why he complains against the ID. Then he has to click the report button. Finally, the reported complains will be saved in the system Database. Here one thing should be mentioned that only registered and valid ID holder can report their complaints in our system model.

3) ANTIBIOTIC DRUG REGISTRA-TION AND CATEGO-RIZATION: Authorizations to manufacture, import, distribute or sell antibiotic drugs in Bangladesh are only being granted for registered antibiotic drugs which are included in the National health database. In our system, there will be an updated list of an antibiotic drug authorized by the ministry of health Bangladesh. Though our system only registered antibiotic drug can be prescribed and sold. For special reasons and after receiving the opinion of the health ministry, the Minister may authorize the distribution of un-registered antibiotic drugs not yet included in the database. Our system contains the facility to update the antibiotic drug list.

E. SECURITY DESIGN

In the e-Medication Management (eMM) system scenario, each asset has huge importance as long as the system must provide services with high reliability and guarantee the confidentiality of the data. We have secured the eMM system by applying security mechanism I) Availability II) Authentication and Access control III) Confidentiality IV) Non-repudiation at different layers.

- Availability: Since this system is an emergency service portal, it must be available to the users at all time from everywhere. System availability is ensured by a robust set of servers. Besides load balancer technology is integrated to ensure availability of service as per user request. In addition, a firewall is implemented to filter out un-usual traffic in and out from the system.
- Authentication and Access Control: In order to provide authentication and access control, we divide this scenario into two cases.
  - General user case: Our System will force the users to use real identifications. There is proper verification technique using National ID, Birth registration number, driver license number, passport number for the general user, BMDC number for doctors and drug

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TABLE II
SUMMARY OF ROLE BASED ACCESS CONTROL MECHANISM FOR USERS OF THE SYSTEM

Entity	Read Permission (Patients Personal information + Medical history + Registered drug list+ Dose Information)	Write permission (Patients Personal Information + Medical history + Registered drug list+ Dose Information)
Patient	Yes (All)	Yes (Patients Personal Information)+ No (Medical history + Registered drug list+ Dose Information)
Doctor	Yes (All)	Yes (New Medical History+ Dose information)+ No (Patients Personal Information+Registered drug list)
Medical Technician	Yes (Patients Personal Information+ Registered drug list+ medical history)+ No(Dose Information)	Yes (Medical Lab Report)+ No (Patients Personal information +Medical history +Registered drug list+ Dose Information)
Drug seller	Yes (Dose Information+ Registered drug list+ Personal Information)+ No (Medical History)	Yes (Dose Information)+ No (Patients personal Information+Medical history +Registered drug list)
System administrator	Yes (All)	Yes (Patients personal information)+No(Medical history+ Registered drug list)

license number for medicine sellers to check whether the user account holder use the proper identity or not. If the user account contains proper identity, the user will be proceeded to use the system. If not, the user account will be pended to use and detected as a malicious user. Then the system will automatically notify them to use proper identity to prevent from being suspended. Thus fake account holder will be filtered and reduce misuse of our system. If a patient and doctors activity related to medical service seems unusual in their account then they can complain against them(doctor and patient vice versa) in our system Besides access control is another security approach science our system database contains sensitive data of users. In our system, we use a role-based access control mechanism for users as shown in table II

– Emergency User case: In case of emergency use, if a user has no account he/she can take medical service using his any unique ID(Ex: national ID, Birth certificate number, Passport number, driver license, student ID etc.). In this case, the doctor will generate a prescription ID for the patient to prescribe medicine and print a prescription with a unique ID. Using this prescription ID, the patient/ relative of the patient can take medicine from registered medicine store. In order to handle misuse of the emergency service, the system will contain the facility to check the frequency of taking medicine by the patient from the different doctor in the same day using the same ID. Using emergency medical service, a patient can take medicine from doctors not more than n (n=2 or 3 or 4) times for the same purpose. If he/she requires medicine further, he/she must have to register as a valid user of our system through the proper registration process and must require special authorization from doctors.

- Confidentiality: The major documents that are to be exchanged among totally different medical entities are patient's medical reports. These documents ought to be changed firmly. In our system, all reports of the patient are encrypted before uploading to the patient's medical directory. To improve security, a cryptologic rule will be used. Therefore, a trade-off between security and system performance has to be thought-about fastidiously. Therefore AES encoding rule can be employed that is optimum (Key size=128, 192256 bit, Block Size=128 bit, speed=Fast (use computer memory unit substitution, row shifting, column compounding key auditioning), Rounds=10, 12 or 16, crack able=Not possible)(A.B.R. Kumar, 2012). In our planned system, we tend to use AES Rijndael-128 algorithm (key size=128) to cypher and rewrite a file. To implement file encoding and cryptography method we've got used PHP Avestan Framework one.11.0.
- Non-repudiation: Most of the cases suspected medical employees are unidentified because of the non-transparency of the system. Medical employees offer health service through the eMM system, and a central access log is maintained to trace every medical entity. Therefore suspected medical employees are going to be known at the time of the event or straight off when the event through this access log.

F. SYSTEM IMPLEMENTATION AND UNIT TESTING

The proposed model has been developed at the Computer Lab of NSTU and tested in a lab environment by dividing students into three categories of actors(i.e. Doctors, patients and medicine sellers). Teachers and Students have played the role of patient, doctor and seller. We assume our testing environment has the facility of patient treatment, diagnostic test and pharmacy. The testing of this model has been applied to 40 users (students, teachers). The web-based module with database server has been placed at the NSTU data centre. Testers of the system have played the role of central admin to verify register users because currently there is no instant access on national, BMDC and pharmacist databases for verification of patients, doctors and medicine sellers. Figure: 9 shows the main page (web module) of the e-health system where the central admin is logging to the system to perform his task. Each medical entity can log in and can perform their task through this page.

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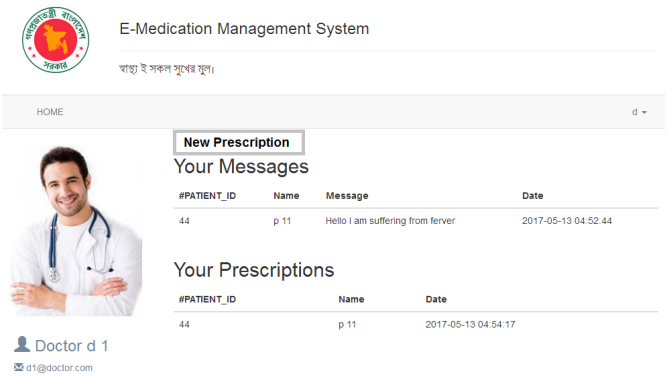

Fig. 9. eMMS system demo page view.

VIII. BENEFITS OF E-MEDICATION MANAGEMENT SYSTEM

Better medication management means that the health system and health professionals are organized to ensure that the most appropriate medications are prescribed and consistently taken by the patient with desired results and fewer adverse reactions (Emergis Inc., 2006). The implementation of eMM system in Bangladesh improves the accuracy of the medication related functions, transparent with the legibility issues related to a tradition medication flow. By using an eMM system users get benefits inclued:

- Benefits to Doctors: When eMM system is fully implemented in the office environment, Doctors find that efficiency increases. eMMs applications have the potential to check drug information databases for appropriate prescribing guidelines, the patient's complete medication profile for drug interactions, and the patient's electronic medical record for disease contraindications. These features save the doctors valuable time and effort and further reduce the number of errors or adverse events.
- Benefits to Patients: The benefit most evident to patients is increased convenience. Prescription orders sent via electronically to pharmacies make it possible for patients to arrive at the pharmacy and have their prescription orders waiting for them. Patients can easily communicate with doctors for further suggestions and feedback. Moreover, it will highly reduce irrational medication problems and consequent result is improved public health.
- Benefits to medicine sellers: eMM system has the potential to significantly improve pharmacy dispensing operations. Prescriptions that are electronically transmitted are more legible and can improve work flow. More effective handling of refill authorization and routine issues via electronic means will also improve the efficiency of pharmacy operations.

IX. CHALLENGES TO IMPLEMENT AN E-MM SYSTEM

In order to implement this eMM system in national level, we have to overcome some limitations. These are:

- Financial Cost and Return on Investment (ROI) - The costs related with purchasing, implementing, supporting and maintaining such a system may be beyond the means of most small clinical practices in specially in rural area, and which we noted it to be one of the greatest implementation barriers.
- Change of management – Healthcare providers and associated staff are adapted their current management system, in which case change of management becomes extremely important. Also the management needs to be trained to adapt with new system.
- Integrity of data input - Accidental data entry errors such as selecting the wrong patient or clicking on the wrong choice in a menu of dosages may occur. In this case Software vendors can reduce errors by continually reviewing user feedback and follow best practices in user interface design.
- System downtime - Periods of system downtime may arise, either due to network-related issues, hardware failure, or loss of electricity. In addition, the inability to use electronic prescribing when the system is not accessible is of great concern, and must be addressed with the discussion of fall-back procedures and mechanisms when such situations arise.
- Patient Access Lost - In the event of a development beyond the control of the patient, such as a software malfunction in the health care provider's office, the patient can no longer ask the care provider for a paper script to take to a pharmacy in order to obtain needed medicines. This leaves the patient at the mercy of technicians or other unrecoverable workers.

X. COMPARISON OF EMM SYSTEM WITH TRADITIONAL PAPER BASED SYSTEM

The following comparison (Table III) will show how eMM system significantly improve public health service in Bangladesh keeping consistency with National drug policy 2016.

XI. CONCLUSION

Our proposed electronic medication management (eMM) system can help to achieve higher standards of care with better patient safety. We have developed a centralized eMM system with all medical entities(Doctors, Patients, and Medicine Sellers) to give faster service to the patients by replacing paper-based medical records through eMM where the privacy of all entities have been ensured by role-based access. Malpractice by doctors, over-counter drug availability, and irrational medications can be controlled entirely through our system. Also, through this project implementation, a substantial nexus among patients, physicians, and drug sellers will be established, and promote the fair exercise of digital medical practice.

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TABLE III
COMPARISON OF EMM SYSTEM WITH TRADITIONAL PAPER BASED MEDICATION SYSTEM

Parameters	eMM System	Traditional paper based system
Reduce prescribing and dispensing errors?	Yes	No
Improved standardization of documentation?	Yes	No
Improved accessibility of documentation?	Yes	No
Avoid more adverse drug interactions and reactions?	Yes	No
Potentially improved compliance through the implementation of soft stops?	Yes	No
Improved efficiency of many medication-related processes?	Yes	No
Reduce the incidence of drug diversion?	Yes	No

Bangladesh), medicine sellers, students who participated in the survey of this research work.

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