Feasibility of Electronic Health Kiosks to Assess Chronic Disease Status in Remote Areas of Developing Countries

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Abstract— **Developing countries lack the infrastructure for effective health care delivery, especially in remote areas. To prevent and manage the rising burden of chronic diseases in developing countries, health care services must reach even the most remote areas. The study presents the electronic health kiosk (EHK) as an effective and feasible solution to assess chronic disease status in remote areas of developing countries, having India as an example. Cross-sectional data was collected on a convenient sample of 429 subjects, 18 years and over, in urban, slum and tribal settings. Results show high prevalence of overweight subjects in urban settings (31.5%; n=70), a high prevalence of pre-hypertension overall (41.5%; n=178) and hypertension in tribal settings (26.1%; n=28), and high glucose prevalence in 27% (n=116) of subjects overall, and (17.8%; n=19). EHKs can be used to assess these health outcomes in areas that normally are not covered due to lack of infrastructure or health personnel. These health kiosks can be a medium to deliver evidence-based, contextual and tailored multimedia health education modules improving the overall quality of health care among these populations. They can also help to raise awareness about health issues and create meaningful information for public health decision-making.**

Keywords-health kiosk; public health informatics; global health; chronic disease.

I. INTRODUCTION

Chronic disease is a global burden responsible for over 50% of worldwide mortality [1]. It is estimated that, in 2020, chronic diseases will be the cause of 50 million deaths globally [2]. Their prevalence is increasing especially in developing countries, where diabetes alone is predicted to afflict about 298 million people in 2030 [3]. It has been estimated by the World Bank that controlling cardiovascular diseases would lead to improved life expectancy more effectively than trying to achieve WHO's Millennium Development Goals related to selected infectious diseases and maternal and child health [4].

Prevention, however, is still scarcely supported financially and politically through public health programs, even though the potential damage on population health and economies worldwide is evident. In addition to it, many developing countries lack the infrastructure for effective health care delivery, especially in remote areas. Lack of qualified personnel is also a challenge to provide meaningful service, as low wages, insufficient living, and working conditions, are obstacles that prevent the trained workforce to establish themselves in these areas of extreme need [5]. In India, for example, where a shortage of health care professionals normally exists, remote areas are even more underserved. Urban areas in average have 3 times the number of health care providers compared to rural areas [6]. Another example, Brazil has its health resources also concentrated in urban settings, leaving a young and inexperienced workforce to deliver care in more remote municipalities [7]. To contain the spread of chronic diseases in developing countries, it is paramount to find ways to bring quality health care even to the most remote regions.

The aim of this paper is to present the electronic health kiosk (EHK) as an effective and feasible solution to assess chronic disease status in remote areas of developing countries, having India as an example. The paper will be divided in 6 sections. Section I is the introduction. Section II will briefly explore the current state of health technologies and propose the EHK as a solution for delivering health care in remote areas. Section III will describe in detail the EHK used in this study. Section IV will present the methods and instruments used to conduct this research. Section V will identify the most relevant results. Section VI will be the conclusion and recommendations for future research.

II. CURRENT STATE OF HEALTH TECHNOLOGIES

Communication and information technologies have helped to change health care delivery to a model of management centered on the patient instead of the provider. Health care services are now able to reach beyond the traditional clinical settings, arriving to the point of care even in more isolated communities where these services are extremely needed.

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Educating patients through computer technology use has been recognized as an effective measure to develop patient skills and knowledge, and improving chances of appropriate behavior. The necessity of offering better services at lower costs makes the use of computer technology essential to support health education [8]. Health promotion, and chronic disease prevention and surveillance, can be achieved through telehealth technology, which acquires, disseminates and stores health-related information electronically [9]. This technology can be presented and accessed in different formats such as web-based applications, mobile phone and alert systems, and telephone and video conferencing with patients [10,11].

EHKs relieve the health care providers from the burden of providing preventive and continuous health education. Instead, they can then concentrate on the quality of their care, especially in circumstances that require immediate attention. EHKs can deliver interactive health information programs that are tailored to the specific needs of the community or the individual [12]. The ability to continuously tailor the EHK information based on patient's input could be the inexpensive bridge to addressing his need for adequate information, customized to his ever-changing health status.

The advantages of accessibility and a user-friendly interface can make kiosks a powerful tool for promoting health education in communities in both urban and rural settings. They are usually built as free-standing units, which facilitates their transportation and increases the possibility of providing access. They can be placed in health care settings or in any kind of public space [12, 13]. The EHK possesses a simplified interface and can be used by individuals from various backgrounds regardless of class or education level [12]. It also varies in many different levels, such as interactivity and feedback [12]. Kiosks can be an effective way to deliver high quality health care to remote areas in developing countries.

III. THE ELECTRONIC HEALTH KIOSK

The EHK used in this study is a multilingual standalone, internet and cell-phone based system. The kiosk has several calibrated metric physiological sensors that can capture a diversity of medical parameters, including blood pressure, blood sugar and weight. These measured parameters are communicated automatically to the software embedded in the touchscreen EHK. These sensors make EHK a useful and efficient approach to collect data electronically and help assess the actual state of the individual's health. The kiosk can be utilized on its own without any assistance as it is user-friendly, with minimal number of buttons and icons, and the program is very easy to operate and navigate through.

For each individual, the EHK system generates a unique ID to which all gathered data is assigned. Individuals can then create their own username and password, allowing them to log into the system and access their health information at any time and from anywhere. The self-report information gathered can include socio-demographics (such as age, gender, and educational status), health behavior variables (including body mass index, smoking, drug and alcohol consumption), and clinical variables (including current state of diabetes, hypertension and cholesterol, history of medications, and lifestyle) (Figure 1).

The quantitative and qualitative data measured and collected result in a unique health card that provides a snapshot of the individual's multiple risk factors. Further, health information is provided to help address and manage these various risk factors, tailored according to the data collected in the EHK for the specific ID.

IV. METHODS

The study was conducted in a community setting in the city of Rourkela, state of Orissa, in India. Between the months of March and May 2010, a convenient sample of individuals was enrolled from three diverse geographical locations including urban, rural and tribal areas, to explore the utilization of a portable electronic health information kiosk for the assessment of chronic disease health risks, and compare the differences among them. The targeted population included adults older than 18 years, both male and female. Participation in the study was voluntary, and willing subjects were provided with a one-page summary where the study was explained. The study was approved by the University of Maryland Baltimore County Institutional Review Board.

Subjects were asked to use the EHK described previously, which gathered subjective and objective data to understand the distribution of chronic diseases and associated risk in the diverse community settings.

The subjective data gathered included responses to a series of multiple choice questions. These questions assessed location of residence (urban/slum/tribal); age (years); gender (male/female); highest level of education attained (less than high school/some college/graduate and above/none); smoking and alcohol history (presently/in the past/ never); height (feet, inches); ever told by a doctor about high blood sugar (yes/no/I don't know) and if yes, are you currently being treated for your high blood sugar (yes/no/I don't know); ever told by a doctor about high blood pressure (yes/no/I don't know) and if yes, are you currently being treated for your high blood pressure (yes/no/I don't know).

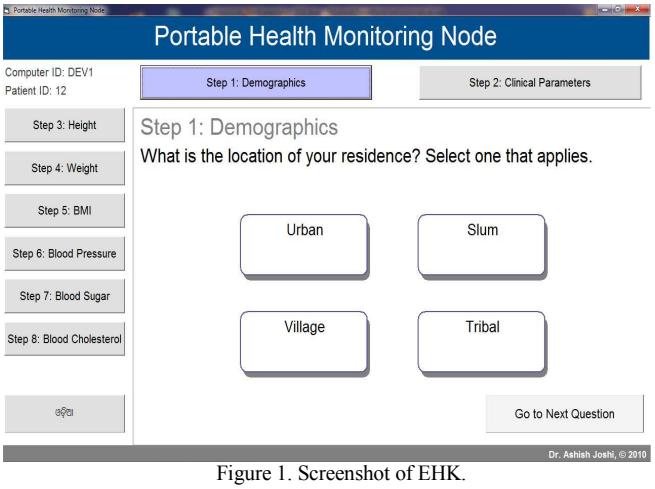

Figure 1. Screenshot of EHK.

Objective data was gathered using the multiple calibrated physiological sensors which measured weight (kilograms), blood sugar and blood pressure. The readings were automatically transmitted to the touchscreen EHK.

Descriptive analysis was performed using univariate statistics with results for the continuous variables being reported as means and standard deviations while results for the categorical variables were reported as frequency statistics as appropriate. Analysis of variance was performed to determine if there were any significant differences in the continuous variables across the different geographic settings including urban, slum and rural. Similarly chi-square analysis was performed to determine if there were significant differences in the proportion of the categorical variables and the geographic settings in which individuals were living. All analysis was performed using SAS V 9.1 and the results have been reported as p-values.

V. RESULTS

Cross-sectional data was collected on a convenient sample of 429 subjects, 18 years and over, in urban, slum and tribal settings. Fifty-two percent (n=222) of the subjects were from urban settings, followed by 23% (n=100) living in slum, and 25% (n=107) living in tribal settings. The average age was 41.98, and the majority of the population was male (61.3%; n=263). Subjects enrolled from slum settings, however, were predominantly females (69%; n=69). Although the majority of the subjects reported some college to post-graduate level of education (54.6%; n =234), most subjects in the slum and tribal settings had no formal education (40% and 36.4%, respectively) or at most high school level (44% and 37.4%, respectively). In the tribal setting, 36.4% (n=39) of subjects were current smokers, and 29.9% (n=32) consume alcohol.

Results showed a high prevalence of overweight subjects in urban settings (31.5%; n=70) (Table 2). Albeit in smaller numbers, overweight subjects were also identified in the tribal (12.1%; n=13) and slum settings (10%; n=10). A high prevalence of pre-hypertension among subjects was also detected (41.5%; n=178). It is important to note that in tribal settings, 26.1% (n=28) of the subjects were diagnosed with stage 1 or stage 2 hypertension. Abnormal blood sugar levels were detected in 27% (n=116) of subjects overall, while in the tribal setting 17.8% (n=19) had high glucose. Results also have shown that 79.4% of subjects (n=85) in tribal setting reported that they don't know if they were ever told to have diabetes by a doctor (Figure 2).

TABLE I. SAMPLE CHARACTERISTICS

Variables	*Total N=429*	*Urban N=222*	*Slum N=100*	*Tribal N=107*
Age	41.98	45.72	41.13	35.02
Female	38.7%	21.2%	69.0%	46.7%
Education level				
High School	27.0%	14.4%	44%	37.4%
Some college /Graduate	47.6%	72.1%	16%	26.2%
Post graduate/Professional	7.0%	13.5%	-	-
None	18.4%	-	40%	36.4%
Smoking History				
Presently	18.6%	13.5%	11.0%	36.4%
In the past	13.3%	18.9%	9.0%	5.6%
Never	68.1%	67.6%	80.0%	57.9%
Alcohol History				
Presently	20.5%	16.7%	19.0%	29.9%
In the past	13.1%	14.9%	11.0%	11.2%
Never	66.4%	68.5%	70.0%	58.9%

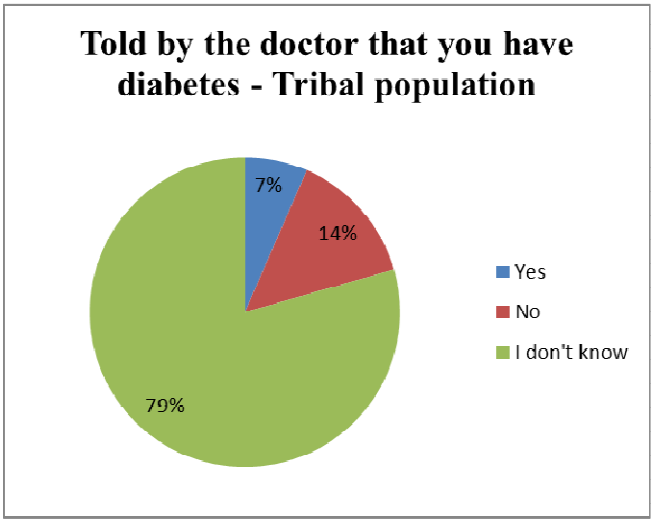

Figure 2. Percentage of answers for information on diabetes status by a health professional in tribal population.

These findings reflect an urgent need to utilize novel accessible and cost-effective technologies that can gather evidence-based data at the grassroots level so that timely interventions can be done to minimize the rising burden of chronic diseases in the rural and remote areas of developing countries.

VI. CONLUSION AND FUTURE WORK

The study results have shown that the prevalence of chronic diseases in tribal and slum communities is considerably high.

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TABLE II. BODY MASS INDEX, HYPERTENSION AND BLOOD SUGAR CHARACTERISTICS OF INDIVIDUALS IN DIVERSE SETTINGS

Variables	*Total N=429*	*Urban N=222*	*Slum N=100*	*Tribal N=107*	*Statistics*
Body Mass Index					**Chi Square =50.175; p<0.001**
Underweight (<18.5)	17.2%	8.1%	21.0%	32.7%	
Normal (18.5-24.99)	56.6%	56.3%	62.0%	52.3%	
Overweight (25.0-29.99)	21.7%	31.5%	10.0%	12.1%	
Obese (30 or greater)	4.5%	4.1%	7.0%	2.9%	
Blood Pressure					**Chi Square =16.365; p=0.012**
Normal (<120 and <80)	28.9%	20.7%	36.0%	39.3%	
Pre Hypertensive (120-139 or 80-89)	41.5%	45.5%	40.0%	34.6%	
Stage 1 Hypertension (140-159 or 90-99)	18.2%	21.2%	13.0%	16.8%	
Stage 2 Hypertension (>160 or >100)	11.4%	12.6%	11.0%	9.3%	
Blood Sugar					**Chi Square =8.157; p=0.017**
Normal (<140)	73.0%	67.6%	75.0%	82.2%	
Abnormal ((≥140)	27.0%	32.4%	25.0%	17.8%	

Results suggest that 1 in 3 subjects in urban settings are overweight, similar to what has been presented in a recent study where rates as high as 40% were measured in some urban areas [14]. Another important finding of the study was the high prevalence individuals in the tribal population with of pre-hypertensive status (34.6%; n=37) and hypertensive status (26.1%; n=28). High glucose levels were also detected in 17.8% (n=19) of subjects in the tribal setting. A very recent study in India, has presented similar prevalence with variations according to different Indian states [15].

The state of Orissa, India, where Rourkela is located, has a population of over 40 million people. According to the 2001 census, 85% lived in rural regions and 22% were tribal populations [16]. Of the Indian tribal population, however, 25% doesn't have access to health services [17]. This is a serious limitation for public health surveillance in India, as risk factors and harmful health conditions are not being assessed in a regular basis. Studies have been consistently detecting a high number of individuals with undiagnosed chronic diseases, such as diabetes and hypertension, among populations in different areas of the country [15,18].

EHK can be a feasible technology to assess burden of risk of chronic diseases at the grassroots level and even in resource poor environments. These assessments can provide us true representation of the risk burden and the evidence based data to make informed decisions and timely interventions for improving the overall well-being of the individuals, the communities and the environment they live in. However, due consideration should be given to design and develop accessible and tailored technologies that take into account health literacy of the individuals and utilize targeted mode of delivery of health promotion messages for better adoption of these technologies. Further research is warranted to determine the role of utilizing EHK as a medium to bridge the gap among individuals with different risk factors in various settings.

Limitations of the study include the use of a convenient sample, although similitudes in measured characteristics with recent studies may attest to the representativeness of the data [14, 15, 18]. Results showed less percentage of females participating in the urban setting as compared to the slum or tribal settings. This difference might be due to more number of females being employed in the urban setting as compared to the others. In addition, cultural variations in the diverse settings might also account for these differences in participation. Another limitation was the lack of cost-effectiveness assessments for the use of EHK in these settings and the long-term impact on population outcomes. These assessments are currently being evaluated in the ongoing studies.

The EHK can be the multifaceted solution to the difficult obstacles faced by public health in developing countries. There are current plans to implement EHK by engaging community health extension workers in the diverse Indian settings including urban, rural, slum and tribal. Further, the development of a randomized controlled clinical trial is in course. The aim is to test the EHK efficacy as an interactive, personalized, culturally adaptive, contextually relevant, accessible and cost-effective platform. Another goal will be to help improve health outcomes among populations in resource-poor environments.

EHK can be used to assess chronic disease status in areas that normally are not covered by a developing country public health system due to lack of infrastructure or health personnel. EHK can be a medium to deliver evidence-based, contextual and tailored multimedia health education modules, and could improve the overall quality of health care among these populations as further research is needed to determine this.

For governments and institutions to act, enacting policies that can improve health outcomes in disadvantaged areas, first they need the data and the evidence to support it. EHK can be an instrument to raise awareness about health issues

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and create meaningful information for public health decision-making.

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