Empirical Analysis of a Newly Developed mHealth Mobile Text Messaging System (MTMS) as a Tool for Healthcare Cost Reduction in Selected Rural Areas of Ghana

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ABSTRACT

Background: Innovative strategies such as mobile health (mHealth) are a serious requirement for the attainment of universal health coverage in Africa. An increasing amount of evidence proves that mHealth interventions may have the capacity to significantly reduce the cost of accessing medical care, especially in rural areas. A mobile text messaging system (MTMS) Framework was recently developed and successfully implemented in Ghana. Objective: The aim of this research was to conduct an empirical analysis of the cost-cutting effect of the newly developed MTMS framework. Method: Empirical data was collected from 32 hospitals and clinics in four districts (Mamprusi East District, Tamale Metropolis, Lawra District and Wa Metropolis) of two of the poorest regions of Ghana; the Northern and Upper West Regions. A purposeful interview was scheduled with caregivers, heads of institutions and patients to determine the cost of accessing healthcare at the health centers. Transportation, admission/readmission, emergency, complications and consultation were used for cost buildup. An average for each health center was determined and coded with MS Excel 2019. Further analysis was conducted using statistical tool SPSS v20. Results: The finding reveal that the newly developed mHealth framework can be used as a tool to cut cost of accessing healthcare by 18.88%, representing $24.04 savings per month. Also, transportation, inpatient traffic and emergency cases were observed to have reduced by 20% each. The findings further indicated that there was improvement in health outcomes, patient experience and clinical governance resulting from the cost cuts and efficiency of the system. Conclusion: The ability of Mobile Text Messaging System Framework to reduce the cost of accessing healthcare in rural areas by 18.88%, provides a great potential to significantly improve the quality of health service delivery in Ghana by scaling and integrating the model into the existing national health system. By harnessing the ubiquitous nature of mobile phone among different levels of citizens, MTMS offers the solution to affordable healthcare. This would strengthen the health systems leading eventually to the realization of the Universal Health Coverage (UHC) as proposed by the UN.

Keywords— mHealth, Mobile Text Messaging System, Framework, Healthcare Cost, Reduction, Rural Areas

1. INTRODUCTION

Healthcare systems in Ghana are confronted with underfunding and neglect, resulting in some severe challenges. Access to basic healthcare in remote regions in the country is hindered by factors such as limited infrastructure including health centers and roads, very few health professionals, high illiteracy level and poverty. These have contributed to the high cost of healthcare access in the rural areas. In the face of these challenges government interventions often appear snail-paced due to budget constraints, leading to increased child and maternal mortality, high morbidity and other deaths from non-communicable diseases as recorded in recent times. Since health is a driver of development and all its outcomes, a good intervention coupled with excellent policies can mitigate the suffering in rural communities and promote the needed development. An investigation involving 201 leading insurers in the medical field operating in 60 countries across the globe in 2017 and the results estimated an average global medical inflation at 7.2% in 2018, up from 6.8% in 2017 [1]. A corroborative research was conducted and the report suggests that the spiraling cost of healthcare is real and it derails the quest to a healthy world [2].

Mobile Health (mHealth), which is the provision of healthcare services using portable mobile devices was identified as the best modern tool to deliver quality medical services to the rural communities at reduced cost. In this introduction, a review of current literature directly related to the cost cutting effects of mHealth in rural areas was conducted. An e-clinical works survey in 2013 by [3] found out that 93% of physicians believe that mHealth apps have the potential to reduce medical cost for chronic diseases. As a follow up, Mayo Clinic implemented a Controlled Monitoring System for reducing preventable readmission for cardiac rehabilitation of patients which yielded 40% reduction in readmissions. The reduction translates into a considerable cut in medical cost and penalties. Accenture's mobile monitoring device project produced a 15% to 20% decline in hospital cost, a 23-billion-

dollar cost cut for patients with diabetes and heart diseases monitored over a period of one year. A similar application was used to check instant systems and the nearest urgent healthcare facility to facilitate quick access to quality care which led to healthcare cost reduction of up to $3000 per patient visit in USA. Also, mobile test and remote assistant app for ultra-scan on mobile devices was used to eliminate $600 cost compared to a full-scale normal scan [3].

It has been determined that at the Brigham and Women's Hospital that taking care of patients in their homes via mHealth reduces healthcare cost and yet maintains the quality of care [4]. The results indicate that cost in healthcare delivery was 52% lower for patients treated at home for acute cases than those on hospital beds. Also, a report by Healthcare Cost and Utilization Project in 2015 stated that more than 35.7 million patients stayed at home resulting in an average cost cut of $11,259 per patient for the year under review. Another example is a one-year piloting of a remote monitoring program in Pennsylvania. It was found mHealth tools helped in cutting down annual medical cost for heart related patients by $8,000, while reducing hospitalizations by 30% [5]. Further, participants of the program announced a reduction in healthcare related expenses by an average of $8,375 per patient over the period. It helped them understand their health situations and how to better manage them. For further understanding of the subject, [6] undertook a non-readmission program for heart failure patients within 30 days and realized that readmission of a patient within this period after initial hospitalization costs $27,000 for each patient. As a result, the program was able to make savings of $216,000. Additionally, it was determined that there was 50% cut in hospitalization, 11% reduction in emergency cases, while 95% of those enrolled reported that the technology was secured and user friendly. A research published by the Stem School of Business, University of Carnegie Mellon and the Harbin Institute of Technology in China reveal that data collected on more than 1,000 Type 2 diabetic patients who used mHealth to track behavior, physician support, risk assessment as well as personalized and non-personalized text messages could actually bring down the number of hospital visits drastically. Since hospital visits are directly proportional to cost of medical access, it goes without saying that the project saw the reasonably downward trend of medical expenses for these patients [7]. The optimism of the capacity of mHealth to provide cost-savings was expressed by [8] as per results of a research conducted in 2018 across 19 countries, consisting of different economic might. This was achieved using Short Messaging System (SMS) as the mHealth function to gather patient data, send reminders and information, as well as provide support to clients in order to monitor adherence to medication and attendance rates. The findings indicate that the intervention helped reduce attendance rates while enhancing adherence to medication. As a result, mHealth is economically beneficial. Indeed, it provided cost savings because 69.2% of patients strictly adhered to their prescriptions and the same rate went for the reduction in hospital visits [8]. Even though this was not calculated in monetary terms, it is quite certain that the savings accomplished were significant.

With proliferation of mHealth interventions in America, there has been enormous savings due to fewer admissions and readmissions to the hospitals. This is because patients are more adoptive to wearables and apps based on one wellness program or another. Over 200 intervention apps were put in the market in 2019, making the current number to stand at 318, 000. The market size for sensors, wearables and mHealth apps continue to expand. Each day records an increase in over 200 health apps in the healthcare space, with umbers in health and wellness apps growing to 318,000, more than double the number from 2016. A demonstration of mHealth apps for preventive health services for ailments such as diabetes, asthma and rehabilitation of cardiac and pulmonary cases resulted in the cost savings to the tune of $7 billion in a year. According to the research body, IQVIA Institute for Human Data Science, this amount pertains to just a few hospitals. It is believed that if the program could be extended to cover every disease and many more institutions, the cost savings could rise to $46 billion per annum [9]. Even though [10, 11] have not provided data on the potential cost saving effect of mHealth apps, the literature behind the studies reveal a strong corroboration of other authors who have confirmed the nature of the phenomenon empirically. On the other hand, it is projected by [12] that 2019 alone will see 986 million online appointments for patients, which would yield dividend of close to $3.2 billion in cost reduction in the United States alone. Similar programs with positive outcomes in healthcare cost reduction include [13] with $8,375 per year per patient, savings of $2,650 over a six-month period for enrolling into a program called Medicaid. Another study by [14] determined that an organization, Dayton Regional Transit Authority achieved a cost savings of $2.3 million for its employees in 2016 after the launch of a Fitbit-based health program in 2014.

2. METHDS AND MATERIALS
The MTMS Framework was developed, implemented and validated, it was found to be effective and efficient in terms its capacity to reduce cost of healthcare. This section is dedicated to the analysis of its efficacy.

2.1 Comparative Analysis of Existing Healthcare Cost with the MTMS Intervention
To achieve this, the study area was divided into rural and urban areas and an interview conducted for 32 hospitals and clinics, both private and public to collect data on the main elements that contribute to the cost of healthcare access. These cost constructs include transportation, consultation, admission/readmission, emergencies and complications. Apart from existing records at the health centers, primary data was also gathered from care givers and patients. A summary of this data is represented on Table 1.

Table 1: Cost of Individual Components of Healthcare

District/Region	Element Description	Average Cost US$		
		Public Facility	Private Facility	Average
Wa Municipal (Wa)/Upper West Region (Urban Area)	Transportation	10.00	10.00	
	Consultation	5.00	10.00	
	Admission & Readmissions	30.00	40.00	
	Emergencies	35.00	45.00	
	Complications	50.00	52.00	
	Totals	**130.00**	**157.00**	**143.50**

Lawra District (Lawra)/Upper West Region (Rural Area)	Transportation	10.00	10.00	
	Consultation	5.00	7.00	
	Admission & Readmissions	30.00	40.00	
	Emergencies	20.00	30.00	
	Complications	25.00	28.00	
	Totals	**90.00**	**115.00**	**147.50**
Tamale Metropolitan (Tamale)/Northern Region (Urban Area)	Transportation	15.00	15.00	
	Consultation	7.00	10.00	
	Admission & Readmissions	30.00	40.00	
	Emergencies	35.00	45.00	
	Complications	70.00	80.00	
	Totals	**167.00**	**190.00**	**178.50**
Mamprusi East (Gambaga) / Former Northern Region (Rural Area)	Transportation	8.00	10.00	
	Consultation	5.00	8.00	
	Admission & Readmissions	12.00	15.00	
	Emergencies	25.00	30.00	
	Complications	30.00	35.00	
	Totals	**80.00**	**98.00**	**89.00**

Source: Field Survey (Nsor-Anabiah Solomon, 2019)

As indicated in Figure 1, which a graphical representation of Table1, transportation recorded $10 for both public and private facilities in the Wa Municipal or the urban area of the Upper West Region. However, for consultation, the public facility charged $ 5 while the private facility took $ 10. This second trend continued for the rest of the elements in this area. The same trend exist for Lawra, Tamale and Gambaga. The total cost for each district or metropolis was calculated for both the private and public health care centers and an average determined. Wa had $130.00, 157.00 for public and private with an average of $ 143.50. Lawra recorded $90.00 and $115.00 for the public and private hospitals respectively, giving an average of $147.50. Averages for Tamale and Gambaga are $ 178.50 and $ 89.00 respectively.
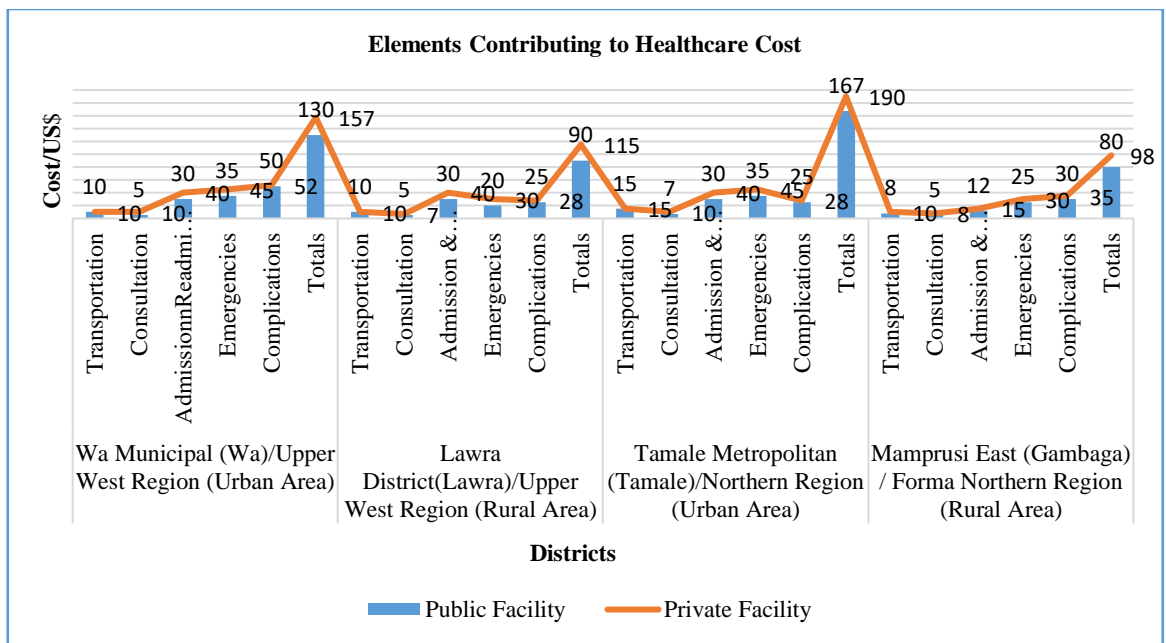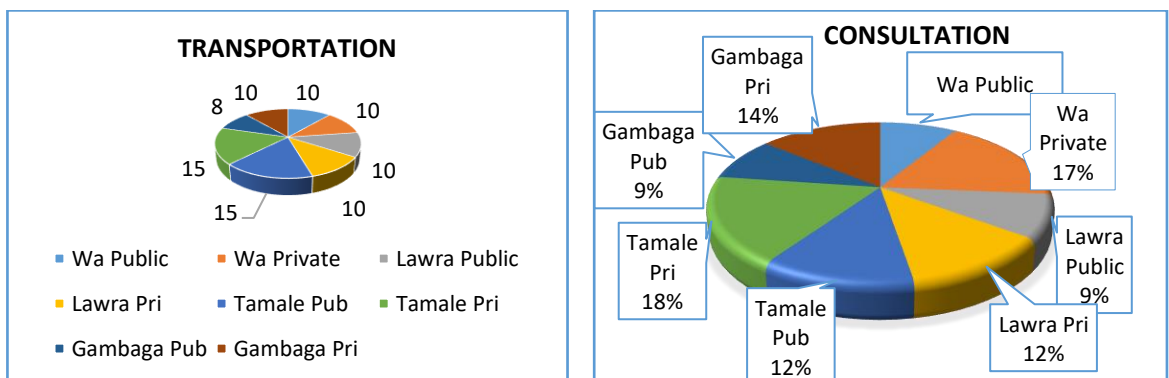

Figure 1: Elements contributing directly to the Cost of Healthcare Access
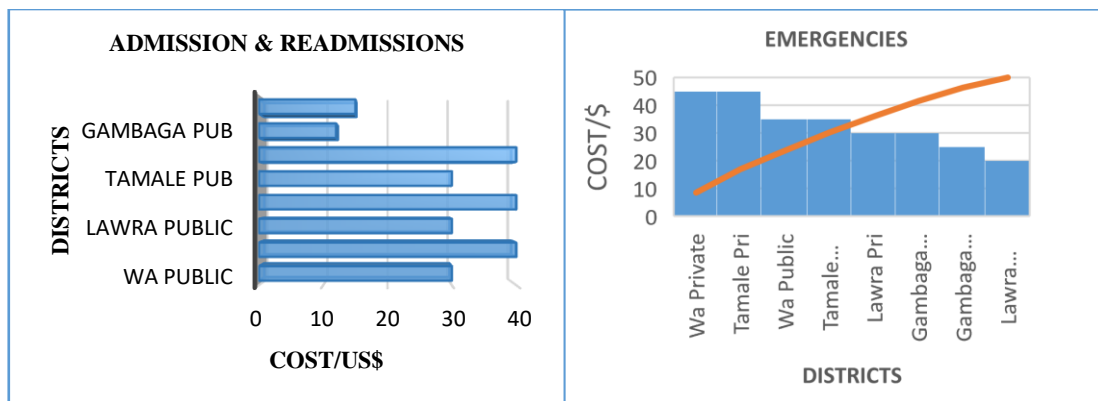
Figure 2: Amount Contributed by Elements to Healthcare Cost Build Up

Figure 2 consists of 2A, 2B, 2C and 2D represented by Transportation, Consultation, Admission & Readmission and Emergencies respectively show how much each element contributes to the total cost build up in the various districts. In 2A, the highest one would pay as transportation to and from any health facility is $15 per day, recorded in Tamale Metropolis for both public and private facility. The least is represented by $8 registered at Gambaga in the Mamprusi East District. During hospital visits, Tamale is known to charge the highest fees of $18 for consultation, while Lawra charges the lowest at the rate of $9 per visit as indicate in 2B. The fees for admission and readmissions are published in 2C and reveals that these fees are highest at Wa, Lawra and Tamale in the private institutions. This is at the rate of $40 for the three districts while the lowest was noticed at Gambaga. Finally, for emergencies which are indicated in 2D, Tamale and Wa recorded $40 each representing the highest and Lawra had the least of $20. In General, it can be observed that the elements are most expensive in the urban areas than the rural counterparts. Also, the private healthcare facilities charge higher the public ones.
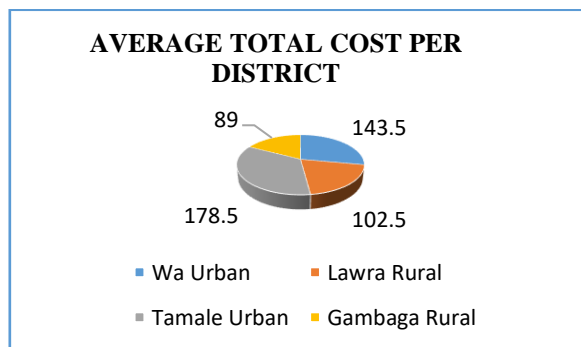

Figure 3: Average Total Cost of Healthcare Access per District

The total average cost of healthcare access in the various districts have been shown in Figure 3. To be able to attend a treatment facility in Tamale and either get treatment and go home or admitted for a night, one needs to spend $178.50. This is followed by Wa with $143.50, Lawra $102.50 and Gambaga with the least of $89.00.

2.2 Validation of Healthcare Cost Elements

Table 2: Reliability Index

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.698	.682	5

Table 2 reflects the validation of the five elements contributing to the cost of healthcare access in the districts used in this research. In order to validate the data collected, the SPSS was used revealing a Cronbach's Alpha of 0.0698. This is greater than the minimum alpha index of 0.50 required to validate and make data reliable, this means that the elements use in this case are fit for purpose.

Table 3: Mean and Standard Deviation of Data

	Mean	Std. Deviation	N
Transportation	1.38	.609	32
Consultation	1.22	.420	32
Admission and Readmissions	1.28	.523	32
Emergencies	1.31	.471	32
Complications	1.44	.564	32

The means and standard deviations for the five constructs included in the study have been shown in Table 3. The minimum mean is 1.22 for consultation and the maximum being 1.44 recorded for complications. The standard deviations are also between 0.420 and 0.609 for sample of 32 prescribed by N. A careful inspection shows that both the means and deviations are closely related make them statistically acceptable. Apart from the overall reliability, the individual constructs were also tested and the results presented in Table 4. The results show that apart from consultation which has an alpha reliability index bigger than the overall index, the rest have values less than 0.698 but greater than the 0.50. This makes the individual reliable and therefore validated for the research.

Table 4: Individual Reliability Index

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Transportation	5.25	1.677	.654	.598	.546
Consultation	5.41	2.636	.197	.130	.734
Admission and Readmissions	5.34	1.910	.621	.496	.574
Emergencies	5.31	2.351	.352	.221	.687
Complications	5.19	2.028	.457	.376	.648

Table 5: Cost Benefit Analysis of MTMS

District	Transportation US$	Consultation US$	Admission/ Readm US$	Emergencies US$	Complications US$	Total US$
N/R Tamale	15.00	8.50	35.00	40.00	75.00	173.50
N/R Gambaga	9.50	6.50	13.50	27.50	32.50	89.50
UW/R Wa	10.00	7.50	35.00	40.00	51.00	143.50
UW/R Lawra	10.00	6.00	35.00	25.00	26.50	102.50
Mean	**11.13**	**7.20**	**29.63**	**33.13**	**46.25**	**127.33**
Less 20%	8.90	**	23.70	26.50	37.00	
Savings (20%)	2.23	**	5.93	6.63	9.25	**24.04**

The mean values of the five healthcare cost components for the four districts have been determined and totaled to get US$ 127.33 as indicated by the fifth row and last column of Table 5. The savings generated by 20% of the various components have also been calculated and the total (US$ 24.04) found, as shown in Table 5. The cost of consultation did not have any savings since it was rejected by the MTMS model. In other words it was not statistically significant and hence does not contribute to the cost savings mechanism of the system. Hence, patients are required to pay the same amount as under the old system.

Under the existing system, cost of healthcare is US$ 127.33 per day per patient
Under MTMS there is cost cut of US$ 24.04, attributable to four variables, transport, admission, emergencies and complications.
*Efficacy of MTMS = 24.04/127.33*100 = 18.88%*
Considering all the assumptions being constant, the newly developed MTMS Model can be used as a tool to sustainably reduce the cost of accessing healthcare in the rural regions of Ghana by 18.88%.

3. CONCLUSION
This empirical cost analysis of a newly developed mHealth intervention for cost reduction in accessing medical services in rural areas in Ghana has been well established. The average estimated cost cut of 18.88% in medical expenses per patient per month is significant enough to trigger a scale up for the system as well as integrating it into the national health system. The earnings generated by the intervention is useful for policy-makers and managers of health institutions in order to develop comprehensive health programs for the nation. The overall findings in this study for cost cuts in healthcare access are well-grounded from the fiscal sustainability view point. The framework has also awaken awareness in patients as take more interest in their own health needs and also understand the paradigm shift from doctor-centered to patient-centered health delivery. There were underlying challenges to this study which include lack of adequate funds leading to a small sample. Lack of interest, poverty, illiteracy, bad roads and the absence of adequate infrastructure might have affected the findings.

4. RECOMMENDATION
In view of the enormous benefits to be delivered from the MTMS framework when scaled and fully integrated into the national health system, it is recommended by the researchers that government should make a swift and decisive political move to adopt the system. Provide enough funding for further studies and enacting specific laws solely for the development and scale of mHealth interventions in the country.

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