

*A Self-Management Mobile Information System Model for
People Living with HIV/AIDS*

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Abstract: *Mobile phones and other mobile devices are powerful tools for managing patients living with HIV/AIDS (PLWHA). With an already developed mobile phone-based self-management system application for supporting lifestyles of people living with HIV/AIDS in Makurdi, Benue State of Nigeria, a mathematical Self-Management Model was developed to ascertain the level of adherence to medication by PLWHA, their level of awareness on the virus and how to stay healthy and the number of health professionals needed during the course of managing their health. Matlab R2007b was used to simulate the results for a period of 12 months using the model equation 1. The differential equation was solved numerically using Runge-Kutta 4th and 5th order method and the simulated values generated were used to plot a graph indicated that the number of Uninformed Patients decreased drastically due to the use of the application over the 12 months period. Correspondingly, the number of patients living a healthy lifestyle (performing self-monitoring) also increased with time due to the use of the application and the number of health professionals needed decreased over time as the patients could effectively carry out self-monitoring with little or no intervention from the health professionals.*

Keywords: *Mobile Phones; Self-Management; HIV/AIDS; Mobile devices; Self-Management Model; Patients; Health Professionals.*

I. INTRODUCTION

A model formulation on mobile self-Management information system for people living with HIV/AIDS (PLWHA) was developed to evaluate the effectiveness of the long-term management of the treatment of HIV/AIDS with respect to adherence to medication, awareness on the preventive measures and mortality rate due to ignorance and non-adherence to proper medication. [3] one of the leading researchers in this area adds that self-management is also about enabling “*participants to make informed choices, to adapt new perspectives and generic skills that can be applied to new problems as they arise, to practice new health behaviours, and to maintain or regain emotional stability.*”

Patient Self-management tools are instruments of self-care, mobile care, and home care. They help patients deal with their own medical conditions, or those of loved ones, outside the walls of formal institutions. According to [4] Physicians/Health workers are present for only a fraction of the patient’s life and almost if not all outcomes/results were mediated through the patient’s own behaviour.

II. LITERATURE REVIEW

According to [5], Patient self-management or informal institutions are focused on making an expert control of health and health conditions easier or better.

The chronic care model by [1] assumed that the target point of care lies with the personal physicians supported by an integrated practice team. It has components which when combined together would yield improved outcomes. These components are: self-management, Decision support system, clinical information system which efficiently support all aspects of care of people with chronic illnesses – quality records, follow-up, recall etc., organisation of healthcare, community, national and informed activated patients.

Another model called the Self-regulatory process model by [2] was examined where several frameworks for assessing adaptation to chronic illness such as biomedical or stress-coping models. The model used the negative feedback loop such that it monitored the patient's regimen –relevant behavior. The self-regulation model can be compared with the recommended treatment regimen. When deviation or non-compliance is detected, an error signal is generated as a feedback to the patient. If the patient is motivated to comply, he will adjust his behaviours, which will be continuously monitored for the full self-regulation loop.

The Chronic Care Model according to [1] was used in the design and quality improvement activities of clinical services. It conceptualized how some factors impacted on the clinical outcome of chronic diseases management of which HIV/AIDS was not left out. It was also applied to a range of chronic conditions, target populations and health care settings.

The Model assumed that the target point of care lies with the personal Physicians, supported by an integrated practice team. According to [2], several frameworks for examining adaptation to chronic illness, such as biomedical or stress-coping models, the Self-Regulation Model was considered to be very comprehensive and flexible. As shown in Figure 1 below, a self-regulation model of HIV/AIDS patient compliance typically uses a negative feedback loop, which monitors the patient's regimen-relevant behavior. The self-regulation model is compared with the recommended treatment regimen. When deviation or non-compliance is detected, an error signal is generated as a feedback to the patient. If the patient is motivated to comply, he will adjust his behaviours, which will be continuously monitored for the full self-regulation loop.

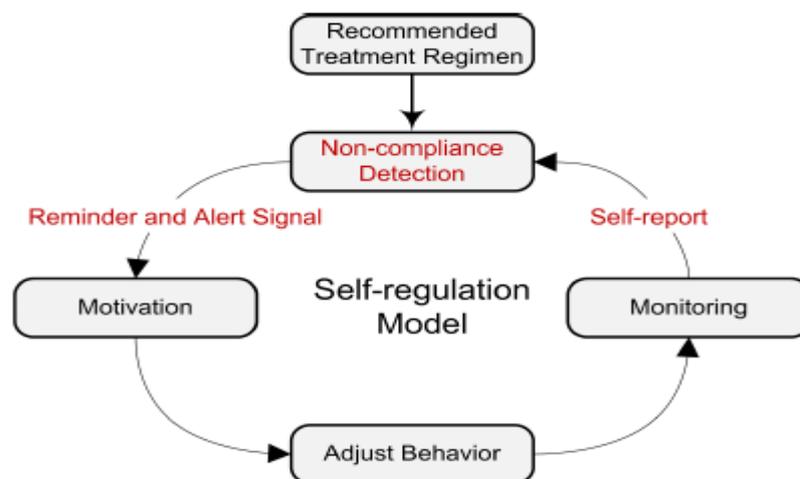


Figure 1: The Self-Regulation model for HIV/AIDS Patients [2]

III. MODEL FORMULATION

At the top of this model was an uninformed patient who had little or no knowledge about his/her condition. The use of the system enabled the patient to ask questions/search available literature which were answered by a professional in the field. This made the patient become more informed on how to manage his/her condition better. An educated patient was motivated and

subsequently adjusted his behaviour which led to continuous monitoring and subsequently a healthy life. Figures 2 and 3 are the schematic flow diagram and the model flow diagram of the Mobile Self-Management Model respectively.

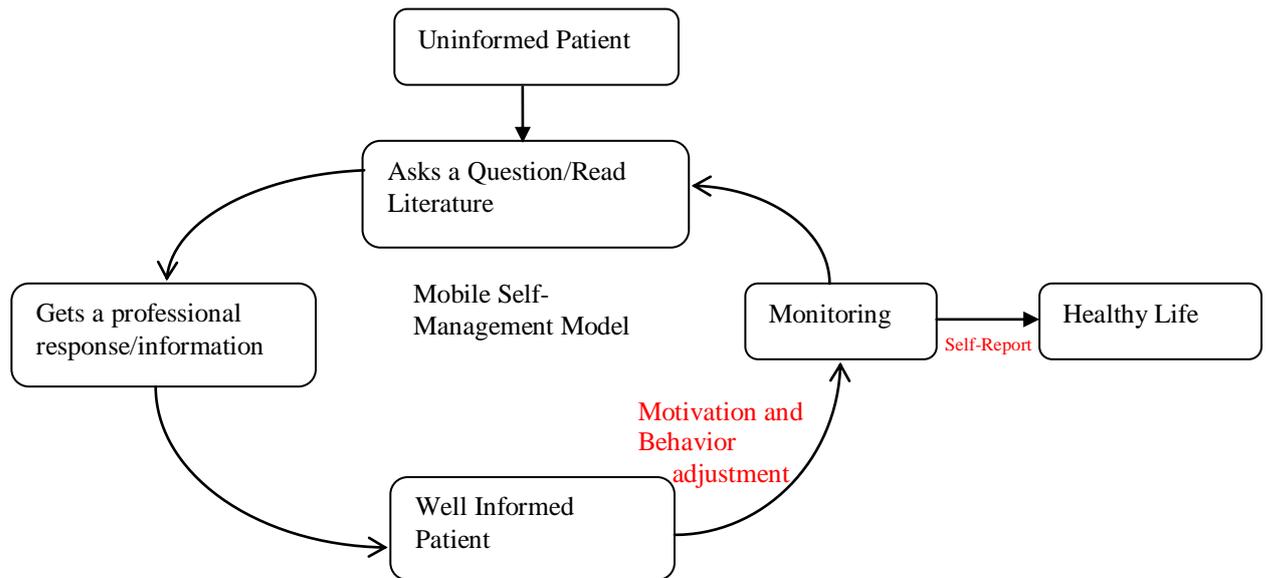


Figure 2: The Schematic Flow Diagram of the Self-Management Model

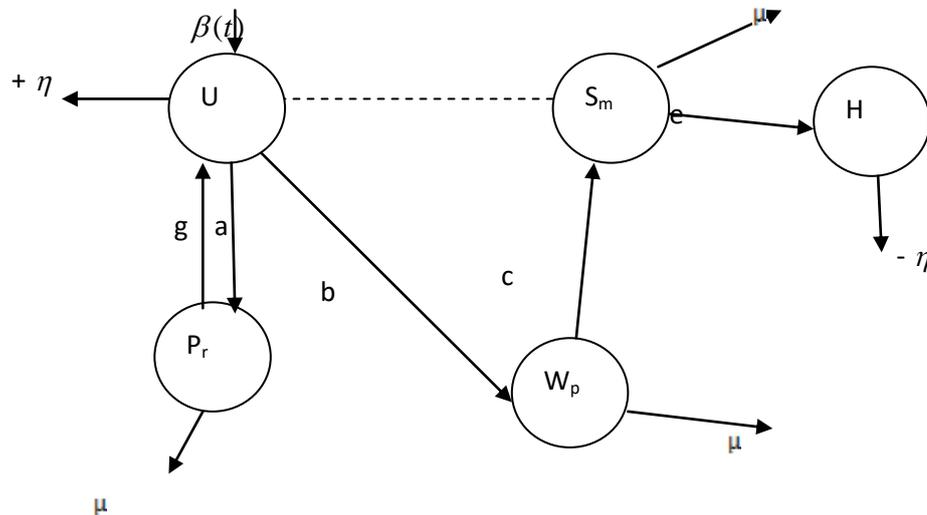


Figure 3: The Schematic Flow Diagram of the Self-Management Model

$$\left. \begin{aligned}
 \frac{du}{dt} &= \beta(t) - (a + \mu + \eta)u \\
 \frac{dPr}{dt} &= au - (a + \mu + g)Pr \\
 \frac{dWp}{dt} &= bU - (\mu + c)Wp \\
 \frac{dSm}{dt} &= cWp - (\mu + e)Sm \\
 \frac{dH}{dt} &= eSm - (\mu - \eta)H
 \end{aligned} \right\} \quad (1) \text{ Model Equation}$$

Model Variables

U – Uninformed patient

Pr – Professionals (Health workers)

S_m – Self monitoring

W_p – Well-informed patients

H – Healthy living

Parameters of the Model

μ - natural mortality

η - mortality as a result of ignorance

a – rate at which questions are asked

b – rate at which patients become informed

c – rate at which patients carry out Self Monitoring

e – number of patients living a healthy life

g – rate at which questions are answered

$\beta(t)$ - Migration rate of the patients (uninformed patients) due to immigration/emigration

IV. RESULTS

Matlab R2007b was used to simulate the results for a period of 12 months using the Model (Equation 1) with initial conditions y_0 corresponding to:

$$U(0) = 10, P_r(0) = 2; W_p(0) = 5, S_m(0) = 3; H(0) = 3.$$

$$a = 0.1; b = 0.1; c = 0.2; d = 0.2; e = 0.3; m = 0.05; \beta = 0.4; g = 0.05; \eta = 0.09;$$

The differential equation was solved numerically using Runge-Kutta 4th and 5th order method and values were generated as shown in Table 1 below. The data values were used to plot the graph in Figure 4 below. The results indicated that the number of Uninformed Patients decreased drastically due to the use of the application over the 12 months period. Correspondingly, the number of patients living a healthy lifestyle (performing self-monitoring) also increased with time due to the use of the application.

Table I: Simulated Data Values of Model Variables for 12 Months Period

T	U(t)	$P_r(t)$	W(t)	$S_m(t)$	$H_{(t)}$
0	10.0000	2.0000	5.0000	3.0000	3.0000
1.0000	8.2219	2.4573	4.6937	2.9319	3.7224
2.0000	6.8232	2.6891	4.3160	2.8250	4.3840
3.0000	5.7229	2.7665	3.9124	2.6832	4.9767
4.0000	4.8574	2.7416	3.5119	2.5151	5.4948
5.0000	4.1766	2.6518	3.1323	2.3307	5.9359
6.0000	3.6411	2.5236	2.7834	2.1394	6.3003
7.0000	3.2198	2.3757	2.4697	1.9488	6.5908
8.0000	2.8884	2.2207	2.1924	1.7648	6.8123
9.0000	2.6277	2.0673	1.9506	1.5915	6.9706
10.0000	2.4227	1.9208	1.7418	1.4316	7.0724
11.0000	2.2613	1.7843	1.5631	1.2864	7.1246
12.0000	2.1345	1.6597	1.4114	1.1564	7.1340

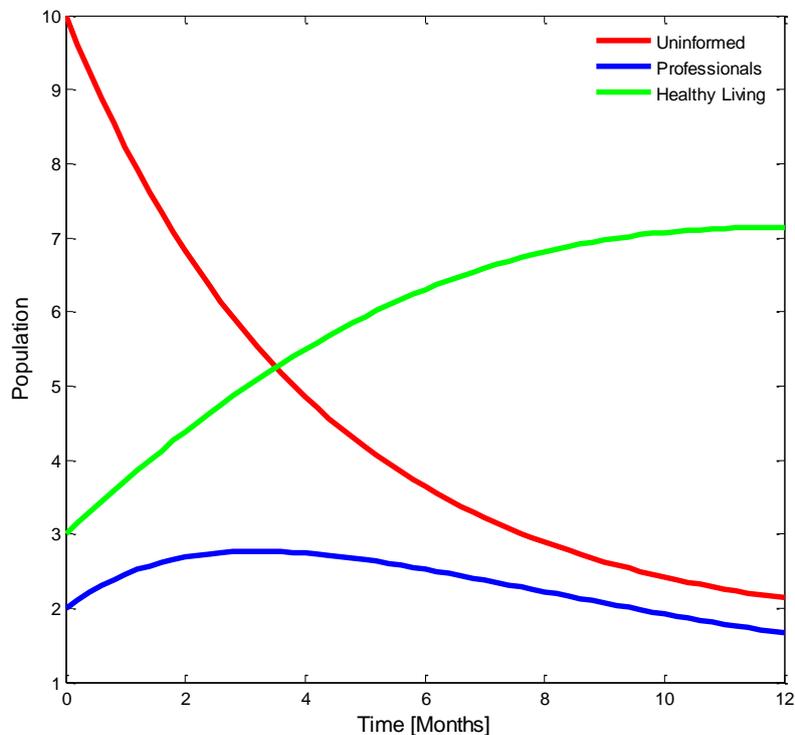


Figure 4: Graph of Simulated Data Values of Patients against Time

From the graph in Figure 4, it can be deduced that the Self-Management Mobile Information system model for PLWHA yielded three significant results which are:

- (i) The level of uninformed PLWHA decreased significantly on the red line graph above from 10 to 2 in the 12 months period in the course of the application usage. The level of awareness on HIV/AIDS increased among the patients as they became more and more knowledgeable on how to live a healthy lifestyle and adhere strictly to their medication.
- (ii) The number of health professionals (physicians such as Doctors and Nurses) attending to the patients (PLWHA) increased in the first 3 months (first quarter of the year) and declined respectively in the succeeding months (i.e. other quarters of the year) as can be seen on the blue line graph. This is because more patients were needed to be attended to and as they became more informed on how to manage their health status, the number of health professionals needed reduced over time.
- (iii) The number of patients living a healthy lifestyle increased drastically as seen on the green line graph. This was because they were able to carry out self-monitoring and adhered strictly to their medications with little or no assistance from the health professionals.

V. CONCLUSION

The introduction of mobile phones and other mobile devices into the self-management of health related issues pose significant advantages on the patients. This paper has developed a mathematical model and simulated it using Matlab to know how self-management using mobile phones can be carried out by people living with HIV/AIDS. There were three areas of emphasis which were the number of health professionals attending to the HIV/AIDS patients reduced significantly as they could carry out self-monitoring on their own, the level of awareness of the patients on HIV/AIDS increased and very few of them became uninformed about the virus and the number of patients living a healthy lifestyle increased drastically cause they strictly adhered to their medication.

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Beatrice Akumba, received the B.Sc and M.Sc degrees in Computer Science from Benue State University Makurdi, Nigeria and University of Nigeria Nsukka, Enugu State, Nigeria in 2006 and 2015, respectively. She is currently a Lecturer in the Department of Mathematics/Computer Science and also a PhD student of Federal University of Agriculture Makurdi, Benue State, Nigeria.