THE NEED FOR HEALTH INFORMATICS (HI) IN ENHANCING BOTSWANA HEALTH SYSTEM SURVEILLANCE: A CASE STUDY OF BOTSWANA HEALTH POSTS

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ABSTRACT

Keywords: Botswana, Information Technology (ICT), Health, Informatics, Health Informatics.

Technology never ceases to amaze. Innovative health care technologies, treatments, medications and procedures are being developed quickly, and all health practitioners of various backgrounds are expected to integrate them into their daily practices, assimilating both old and new knowledge, applying it to their patients, retaining information about each individual patient including being able to communicate quickly with them. Achieving all this in the past has been difficult, due to lack of centralized systems to store, organize and retrieve such records. Nowadays, such systems do exist.

Health informatics is one field providing such systems. Health informatics (HI) earliest usage occurred in the 1950s by the National Bureau of Standards, and its usage has gathered pace all over the world with countries such as USA, UK, New Zealand, Australia and China enjoying its benefits. Botswana is trailing far behind with more than 61.9% not aware of it. Botswana's usage of HI is far less than 40% and only centralized in urban centers, and only on less than 10% of its diverse usage, painting a bleak future on the country's vision 2016!

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18

It's a calamitous situation for Botswana which needs immediate attention, as the study found. The study utilized mixed methods approach on a population size of 117 from 3 different areas of Botswana, covering a wide range of topics, including the medical record system, access to current information, clinical reminders, clinical decision support, electronic communication, patient education, and the benefits of health informatics to a health system. This research has shown that Botswana can greatly benefit to this growing sector.

1.0 Introduction

1.1 Botswana Health System

Since early 2000s Botswana has been trying to diversify its health sector. Botswana has partnered with various institutions and different personnel's all over the world in pursuit for better utilization of ICT in the health sector (Maitlamo, 2004; National health Policy, 2011). Concurring with the Botswana government (Ministry of Health) pursuit of integrating ICT in health, Tlogelang (Daily News, 2013) noted that "technology offers opportunities to improve both care delivery and health outcomes if administered thoughtfully."

Botswana has made strides in ensuring that all people living within its borders have adequate access to health care facilities and medications with almost all the health facilities in close proximity-within 5-8km (Ministry of Health, 2010; National Healthy Policy, 2011). Botswana's' health care system relies on the primary health care and operates on a decentralized mode with an extensive network of various health facilities around the country's 29 health districts. This include 3 referral Hospitals, 15 General hospitals, 17 primary Hospitals, 290 clinics, 357 health posts, 672 health facilities and 894 mobile stops; in which all the clinics, health posts & facilities and mobile stops forms the backbone of primary health care (Ministry of Health, 2010).

Figure 1.1: Botswana Health System structure
(Ministry of Health, 2010; national Health Policy, 2011).

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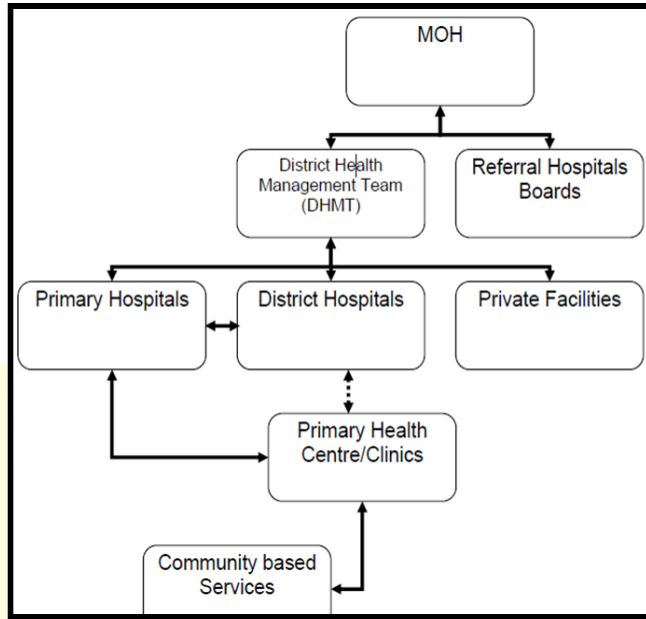http://www.ijmra.us

19

Figure 1.1a:

Botswana's' Health Delivery System (Ministry of Health, 2010; National Healthy Policy, 2011).

Currently, these facilities have ensured that life expectancy of Botswana remains increasing compared to 49years when Botswana took independence. The current life expectancy at birth is estimated at 54.4 years-48.8 for males: and 60 for females (National Healthy Policy, 2011). Moreover, statistics show that crude birth and crude death rates are at 29.7 and 11.2 per 1000 respectively. More money is continually being pumped onto the health sector, but deaths statistics still paints a grimy situation (National Healthy Policy plan, 2011). In this context, Health informatics, which is at its infancy, is left as another option to be fully integrated into the health system to help improve the situation.

1.2   Health   Informatics   Origins

Health Informatics can be traced back to the inception of computers when scientists, researchers and various individuals did some studies to find how information technology can be utilized to enhance health various aspects. Many individuals and or organizations contributed on the growth of this field, notably Gustav Wager (1949), United Sates National Bureau of standards (1950), mid 50s MYCIN, Medline (1965), Homer Warner (1968) and IMIA (1970) (Joseph, 2012). This field has come to be known with different names ranging from health informatics, health care informatics, nursing informatics, health information systems, clinical informatics, medical informatics, or biomedical informatics. This shows its diverse categories of health it affects. This discipline encompasses various disciplines in one; hence it is mostly defined as an intersection of computer and information technology, information science and medicine (health care) (Joseph, 2012; Shortliffe and Blois, 2006; AbouZahr, 2005). It is applied in various fields of health

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20

including but not limited to clinical care, dentistry, public health, physical therapy, nursing and bio-medical research (Shortliffe and Blois, 2006; Sttig et al, 2006).
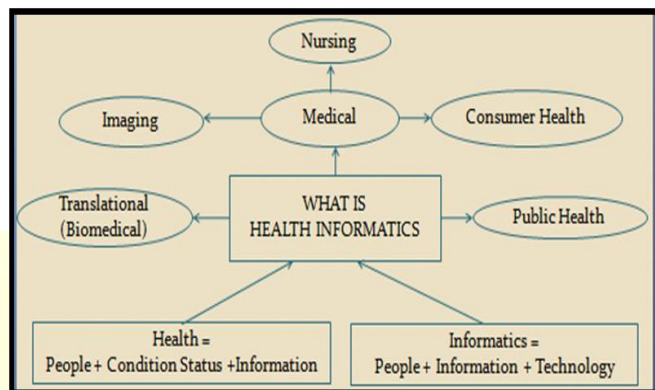

Figure 1.2a: Health Informatics (Adapted from Shortliffe, 2006 and Hersh, 2007)

1.3   Scope of Study

This study was carried out in 3 various health districts of Botswana, which included Ramokgwebana Clinic and Jackals 1 health Post (North East Health District) and Madiba health Post (Mahalapye Sub District) on a period of two months from December 2013 to January 2014. Due to the health facilities looking to be doing well in Botswana, the criteria used was to carry a study from the roots of Botswana health care system which is the primary care. Primary care occurs mostly in clinics and health posts and mobile clinics, and in this study Jackalas No 1 health post, Ramokgwebana Clinic and Madiba health post were utilized. These health care facilities are located in a very rural area (remote village), village and town respectively.

1.4   Purpose of Study

This research wishes to identify opportunities of health informatics and its challenges in Botswana as well as suggest various approaches to improve the medical data record keeping in the health system in Botswana.

2.0   Literature Review

Health Informatics benefits

There is a wide array of benefits which Botswana would enjoy as the result of employing health informatics and moving away from manual systems (National Healthy Policy, 2011; MSCT, 2007) as health informatics is beneficial (Lee at al, 2013; McGowan et al, 2012; Leo and LeRouge, 2010; Chaudhry et al, 2006; Kass-Bartelmes,2002; Friede et al, 1995). These benefits could be summarized as per the areas they are in, and this are but not limited to the following:

- **Reminder and Advertising systems:**   If health Informatics is comprehensively employed and deployed, Botswana would enjoy the benefits of having reminder systems for all patients and stakeholders involved in the health sector. Such systems would include usage of mobile applications and mobile phones. Currently Botswana has started sending short messages to patients in relation to their appointments (Daily News, 2013; Maitlamo, 2004), this could be rolled to include sending any health related adverts, alerts and any information deemed vital. She has also started consultancy and seeking assistance from ICT mature countries such as Britain, USA, China and India to help facilitate health informatics (Nkwe, 2012). This would in turn spearhead in

  - Better health care delivery
  - Health care outcomes
  - Help in decision making and implementation
  - Improve and provide better communication
  - improving the efficiency of health services administration

- **Electronic health/Medical records (EHR or EMR):** currently almost all records are done manual, and introduction of electronic health records would improve the discrepancies, and the anomalies which exist in the manual recording system. According to Lei et al (2013) and McGowan et al (2012), EHR/EMR bring a variety of sub benefits including the ones mentioned such as error-free records, traceable and readable records and accessible and future usable records.

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22

- **Data repositories:** a well managed health environment would include having data repositories. Data repositories would be a central place were all data would be stored, thus having database servers which would centrally store the Botswana Health Data and accessed through servers from each station. This would provide an array of sub benefits including previously mentioned and the following:

  - provide both cost effective and effective data distribution channel
  - Provides better analysis of health and diseases across the country and counteract measures to employ.
  - Future usable data to track and analyze future trends of patients and diseases.

- **Data sharing:** the Botswana public health system is data dependent, hence the involvement of data repositories would help in data sharing between health experts and the relevant people who might need to use it. With the data, analysis of various health related scenarios can be done and shared among colleagues, and it would help to predict needs with measures put in place well in time to act on those needs, with quick sharing of critical information with colleagues and decision makers. Data sharing would occur again through an effective and cost effective channel (via online) and reach different destinations fast. Benefits include the following:

  - Easier to share data cheaply at a faster rate.
  - Improves health services administration with all health institutions and individuals able to manage and share data and information.
  - Concerned stakeholders can easily analyze existing health challenges with given data to address any weaknesses in the system inclusive of future forecasts using the current trends of data and information.
  - remote consultation and diagnoses, access medical information

- **Ontologies and coding**: Different patients' data and information can be compared and utilized wisely for decision making purposes which includes among being able to predict needs and act proactively (McGowan et al, 2012).

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23

3.0   Methodology

The purpose of this study as elaborated from above was to determine and recommend for health informatics full usage in the Botswana health system. Through this, the current status of the health system in relation to usage of health informatics was also determined. Identification of opportunities and benefits of health informatics and its challenges was also done. All this was achieved through utilization of the mixed method approach involving quantitative and qualitative research techniques. These techniques are questionnaire, semi-structured interviews and observation.

Utilization of the mixed methods approach was to gain conclusive statistical data through quantitative techniques, backed up with full insight of the problem domain which is achieved through qualitative analysis. According to Creswell (1998) quantitative research is a systematic scientific investigation of various quantitative properties which is conclusive in its purpose by quantifying and understanding prevalence of a problem by studying and applying projectable results to the population of interest compared to qualitative method. Myres (1997; 1999) and Creswell (1998) explains that qualitative research is exploratory and attempts to gain insights to the problem setting, understanding underlying reasons and motivations for further problem definition and development of approaches to the problem. For the study, questionnaires were employed together with observation.

For the selection of participants, both convenience and simple random sampling were employed. Convenience sampling was used to select 5 Ministry of Health workers at the headquarters tasked with the overall Botswana Health structure, 3 heads of facilities in question and health providers in those facilities (1 nurse in Ramokgwebana Clinic, 1 nurse in Jackals 1 health Post and 2 nurses in Madiba Health post). Simple random sampling selected 105 patients in the named health posts, proportional to the number of patients visits per health facility (62 Madiba Health post, 27 Ramokgwebana Clinic and 16 Jackals 1 health Post).

Both a combination of close-ended and open-ended questions were used for the questionnaire. The close-ended questions were limited to multiple choice and participants could elaborate more through open-ended questions. The questionnaire was sent to the three identified health facilities

under the scope. This questionnaire was addressed to the attendants at the health posts and also the patients who visited the health posts (only when health willing for them to answer).

The questionnaire was formulated in the indigenous language of Setswana and also in English to give respondents choice of language. The questionnaire required the respondent to assess the current status of the health system in relation to technology from data capturing during registration, data capturing when attending patients, and information dissemination between them and other third parties who may be involved including referral hospitals. I also had the opportunity to observe the daily proceedings of the said health facilities on different occasions and days. They were also asked to respond as to whether or not they believed the services were offered to acceptable level or they needed to be enhanced.

4.0   Results and Discussions

Upon the completion of the study, the following summated points were the results and each would be explained fully on this paper.

Result Discussion

Result Point 1: Botswana health care posts are overwhelmingly using the old manual systems.

Figure 4.0a: Manual System everywhere (Parry, no date; WHO, 2010)

Respondents from the 3 health facilities identified under the scope, overwhelmingly noted that almost all the proceedings which occurred from patient registration, counseling and diagnosis and medication dispensing were all manual. These respondents included both patients and attendants to patients such as nurses or health personnel's and those who brought patients to the

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25

hospitals. The author also visited and observed the daily proceedings as they happened, and indeed all were manual (National Healthy Policy, 2011).

Result Summary

This sectional question wanted to find out how the daily proceedings are done in each health facility. The results combined for all those who answered this showed that all proceedings are manual. In total, 113 responded to this question. The question was divided into four categories of Patient registration, Patient Counseling and Diagnosis, Medication Dispensing and Patient Notification. This are the paramount categories in each an every health facility. Users were given choice under each category of either manual or digital system. Full explanations were made on each system with manual indicated as a system fully dependent on paper whilst digital was identified as a computerized system with either support of phones or any electronic information technology equipment or devices.

Patient Registration: This sectional question was aimed at finding out how patient information is gathered and how are they registered to indicate and capture patient visit. The choices given were manual system and Digital system inclusive of explanations on each. 100% of the respondents indicated that the manual system is used for patient registration. Most of those who answered this also affirmed that they were not exposed to or either haven't used any digital system, a finding result of result point 3. Respondents indicated that pen and paper were they devices of the day as information is gathered by word of mouth, noted down on paper and recorded in government visits book which is separated by dates.

Patient Counseling and Diagnosis: This sectional question was aimed at finding out how the patient data is captured during counseling and diagnosis. 100% of the respondents indicated that all proceedings under this question are done manually. They noted that when the attendant to a patient captures patient health details, from history to present details all is done manually with information written on patient record card. On certain instances only the patient present status is recorded with no past history noted as patients might not have it and the attendant relies heavily on the present health information.

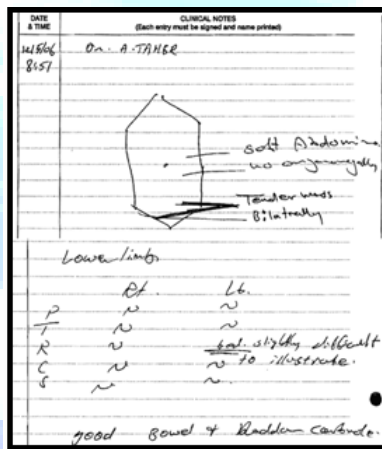**Figure 5.1b:** Health care personnel at work (Cloyd, 2012; Reinberg, 2011).

Figure 5.1c: Manual Diagnosis- Notes from the Consultation Room (Parry, no date)

Medication Dispensing: This was done to identify the ways in which medicines were dispensed to patients including how they are recorded. All respondents, 100% indicated that the process is manual. There is no scanning system or reading system to identify stock taken out only the attendants records everything manual.

Figures 5.1d: Health workers dispensing medication.(Pepfar, 2007)

Patient Notification: This question was to find out how patients with chronic diseases or medical follow ups are notified. From this question, 57.5% noted patient notification is manual whilst 39.8% noted digital technology is also employed. Respondents also noted that a combination of both is sometimes done as their patient records card are written with the dates and they can be notified through short messages in their mobile phones, thus concurring with Ministry of Health published initiatives of tracing and following patients (Daily News, 2013).

Result Point 2: There is a need to introduce and overhaul the manual systems in the Botswana Health posts.

The results found out that 100% of all respondents believed that the health system of Botswana from capturing patient's data and other proceedings found in result point 1 need to be improved to better standards. They noted that currently the government has introduced initiatives of having individual details accessible in all government departments, one of the e-government initiatives which is under the Ministry of Labor and Home affairs. They argued that if the same could be done under health, it would be easier to track records and provide quick assistance.

Result Point 3: Many people are not aware of health informatics.

Questions under this section were aimed at finding out the knowledge people have on health informatics. 61.9% of the respondents indicated that they didn't know anything in relation to health informatics. Many of the respondents who attempted sectional questions of result 1 and 2 did not answer this. This shows that majority of people around the country are not yet aware of the benefits of ICT in health (Botswana National ICT Policy, 2004; Ministry of Health, 2010). Many of those who would have been exposed to ICT in health at minimal would have been at referral hospitals of the country were ICT is still at its infancy (Nkwe, 2012).

Result Point 4: There is need to sensitize and teach majority of people about health informatics, its benefits and challenges.

This sectional question wanted to find out if education in relation to health informatics is being disseminated to people. From the respondents, 100% indicated that there is need for them to be taught about health informatics. Botswana is currently running initiatives to educate the public on ICT; this could probable be part of the initiative beginning from schools.

Result Points 5 and 6: Money is the key issue blocking the overhaul of the Botswana Health care system and it is not yet late to implement health informatics in the Botswana Health posts. This question were identified as to find out what could be the possible problems downgrading the advancement of Botswana Health System into fully assimilating ICT and if its early or late to implement this. Many of the respondents could answer this question, but the author went on further research on this and identified that Money is one issue constraining the growth of health informatics and it is not yet late to implement it. Health is one of the areas in Botswana which get a fatter budget but still ICT has come expensive in this developing nation, hence its adoption its centralized mostly on the referral hospitals, and whenever is there is at minimal. Thus still there is need to overhaul the whole system to meet international standards.

5.0   Foreseen Challenges

They are a number of challenges which the country could face in fully embracing Health Informatics and they include but not limited to the following:

- **Financial constraints:** the government of Botswana funds almost all the health budget and dependent on the budgets of the country (National Healthy Policy, 2011; Nkwe, 2012), health informatics will stretch the government pockets to the limit on the first phase of implementing and deploying it but be helpful as a cost saving mechanism in the long run. Currently Ministry of Health has stretched budgets due to various commitments, thus budget and resources are often cited as factors hampering many of the Ministry of Health objectives (MOH website, 2013).

- **Security:** Information Technology environment needs an utmost security to be able to protect all the records and systems which would be utilized by the health informatics systems, so that it is only intended to be viewed by those who are suppose to view it, hence its deployment might also bring other challenges such as security, as Botswana is not yet advanced in the area of network, database and cyber security.

- **Transition:** Transitions from the current predominantly manual system to digital system might also become a challenge as people are used to the status-quo. More knowledge would need to be disseminated and all the stakeholders educated as people receive and react to change differently.

- Lack of basic connectivity needs such as electricity and availability of Information technology equipments such as telephones and internet could also hamper its deployment (Maitlamo, 2004).

6.0 Conclusion & Recommendations

6.1 Conclusion

Based on the discussions above, it can be concluded that:

1. Botswana health care posts are overwhelmingly using the old manual systems.
2. There is need to introduce and overhaul the manual systems in the Botswana Health posts.
3. Many people are not aware of Health Informatics.
4. There is need to sensitize and teach majority of people about health informatics, its benefits and challenges.
5. Money is the key issue blocking the overhaul of the Botswana Health care system.
6. It is not yet late to implement health informatics in the Botswana Health posts.

6.2 Recommendation

The following are recommendations:

1. It is recommended that Health Informatics be fully integrated in the Health System of Botswana with focus on critical areas of patient registration, consultation and monitoring and Electronic Medical Records. This would also help reducing costs due to focus on stage by stage rollout.

2. Educating the public on Health Informatics is also recommended as a measure of having the public knowledgeable of its benefits.

3. Lastly, it is recommended that both the government and private sector jointly work together in realizing Health Informatics integration in the Botswana health system.

8.0 References

- AbouZahr, C. and Boerma, T. (2005). Health information systems: The foundations of public health. Bulletin of the World Health Organization, vol.83, pp.578–583.

- Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., Morton, S.C. and Shekelle, P.G. (2006). Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med, vol.144, pp.742–752.

- Chiasson, M.W., Reddy, M., Kaplan, B. and Davidson, E. (2007). Expanding multi-disciplinary approaches to healthcare information technologies: what does information systems offer medical informatics? International Journal of Medical Informatics, vol. 76, pp.S89–S97.

- Cloyd, C. (2012). Botswana_Gaborone_Community Public Health. Available at http://study-abroad-blog-gaborone-cph.ciee.org/2012/10/clinic-visit.html (Accessed 19 February 2014).

- Friede, A., Blum, H., and McDonald, M.C. (1995). Public health informatics: How Information-age technology can strengthen public health. Annual Review of Public Health, vol.16, pp.239–252.

- Harvard AIDS Initiative. (2011). News and Publications: Spotlight newsletter. Available at http://www.aids.harvard.edu/news/spotlight/archives/v8i3_kate_powis.html (Accessed 23 February 2014).

- Improving the quality of care in Botswana's health system. Available at http://www.cdc.gov/botusa/Success-Stories/1111-HealthSystemQuality.pdf (Accessed 22 February 2014)

- Joseph, J. (2012). *Biomedical Computing: Digitizing Life in the United States*, Baltimore: Johns Hopkins University Press.

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31

- Kass-Bartelmes, B.L., Ortiz, E. Rutherford, M.K. (2002). Using informatics for better and safer health care. Rockville (MD): Agency for Healthcare Research and Quality. Research in Action Issue 6. AHRQ.

- Lee, J., McCullough, J.S .and Town, R.J. (2013).The impact of health information technology on hospital productivity. RAND Journal of Economics. RAND Journal of Economics Vol. 44, No. 3, pp.545–568

- Lei. J., Sockolow,P., Guan,P., Meng,Q. and Zhang, J.(2013). A comparison of electronic health records at two major Peking University Hospitals in China to United States meaningful use objectives. BMC Medical Informatics and Decision Making, vol.13, no.96.

- Leo, G.D. and LeRouge, C. (2010).Information Systems and Healthcare XXXV: Health Informatics Forums for Health Information Systems Scholars. Communications of the Association for Information Systems. Vol.27, no.7, pp. 99-112

- Maitlamo. (2004). Botswana National ICT Policy. Available at http://www.bits.org.bw/downloads/MAITLAMO_NATIONAL_ICT_POLICY.pdf (Accessed 19 February 2014).

- McGowan, J.J., Cusack, C.M. and Bloomrosen, M. (2012).The future of health IT innovation and informatics: a report from AMIA's 2010 policy meeting. J Am Med Inform Assoc.

- Ministry of Health. (2010). Master health facility list. Health statistics unit: Ministry of health, Botswana. Available at http://www.moh.gov.bw/templates/moh/File/2013/SEPTEMBER%202013/2010%20MASTER%20HEALTH%20FACILITY%20LIST.pdf (Accessed 21 February 2014).

- Ministry of Science, Communication and Technology-MSCT (2007). National Information and Communication Technology Policy. Republic of Botswana. Botswana. Available at http://www.ub.bw/ip/documents/2007_National%20Information%20and%20Communications%20Technology%20Policy.pdf (Accessed 18 February 2014).

- National Health Policy. (2011). Final Draft: National Health Policy Towards a Healthier Botswana. Ministry of Health. Botswana.

- Nkwe, N. (2012). E-Government: Challenges and Opportunities in Botswana, International Journal of Humanities and Social Science, vol.2, no.17, Available at:

http://www.ijhssnet.com/journals/Vol_2_No_17_September_2012/5.pdf (Accessed 19 February 2014).

- Pepfar.gov (2007).The President's Emergency Plan for AIDS Relief Newsletter. Available at http://www.pepfar.gov/documents/organization/91294.pdf (Accessed 20 February 2014).

- Reinberg, S. (2011). Many with HIV Not Getting Meds: CDC. Available at http://www.philly.com/philly/health/news/HealthDay659332_20111129_Many_With_HIV_ Not_Getting_Meds__CDC.html#YtgYUc2rCIgZ0WOA.99 (Accessed 20 February 2014).

- Shortliffe, E.H. and M.S. Blois (2006) 'The Computer Meets Medicine and Biology: Emergence of a Discipline, in Shortliffe, E.H. (ed.) Biomedical Informatics: Computer Applications in Health Care and Biomedicine, 3rd edn, New York: Springer-Verlag.

- Sittig DF, Ash JS, Ledley RS (2006). 'The story behind the development of the first whole-body computerized tomography scanner as told by Robert S. Ledley'. Journal of the American Medical Informatics Association, vol.13, no.5, pp.465–469.

- World Health Organization. (2010). Framework for the implementation of the Ouagadougou Declaration on primary health care and health systems in Africa. Available at http://www.afro.who.int/en/clusters-a-programmes/hss/health-policy-a-service-delivery/features/2751-framework-for-the-implementation-of-the-ouagadougou-declaration.html

- World Health Organization (2007). Strengthening Health Systems to Improve Health Outcomes: WHO's Framework for Action. Geneva: World Health Organization.

- Zhou, L., Soran, C.S., Jenter, C.A., Volk, L.A., Orav, E.J., Bates, D.W. and Simon, S.R.(2009).The relationship between electronic health record use and quality of care over time. J Am Med Inform Assoc, vol.16, pp.457–464.