

Work in Progress:
Asangansi & Shaguy

*Complex Dynamics in the Socio-Technical Infrastructure:
The Case of the Nigerian Health Management Information System*

COMPLEX DYNAMICS IN THE SOCIO-TECHNICAL INFRASTRUCTURE: THE CASE OF THE NIGERIAN HEALTH MANAGEMENT INFORMATION SYSTEM

Ime Asangansi
imeasangansi@gmail.com

*Health Information System Programme, Nigeria
and
Department of Informatics, University of Oslo, Norway*

Jerome Shaguy

Health Information System Programme, Nigeria

Abstract: This paper discusses the results of an ongoing research which contributes to the current discourse of how the application of information and communications technologies can foster socio-economic development. Specifically, it discusses the socio-technical dynamics associated with the implementation of a computer-based health management information system as well as factors that contributed to a successful implementation. The Nigerian health system continues to negotiate a dramatic turn with the implementation of a computer-based public health information system, based on the principles of primary health care. Important findings in this study have included: the realization of the role of political buy-in as crucial for successful implementation; the HMIS is an installed base in constant evolution; democratization and political decentralization contribute to the success of the primary health care-based information; and the implementation of a free and open-source solution reduces total cost of ownership.

Keywords: Nigeria, health management information system, socio-technical, primary health care, dynamics, complexity, DHIS.

COMPLEX DYNAMICS IN THE SOCIO-TECHNICAL INFRASTRUCTURE: THE CASE OF THE NIGERIAN HEALTH MANAGEMENT INFORMATION SYSTEM

INTRODUCTION

Health is an issue of central concern to all countries and societies as it is a crucial cornerstone for socio-economic progress. The fundamental struggle to provide good health care to all in the society is epitomized by the Alma Ata declaration of 1978 which states that health “is a fundamental human right” and its attainment is a “most important world-wide social goal whose realization requires the action of many other social and economic sectors in addition to the health sector”. This code, to which Nigeria is signatory, prescribes that “primary health care is the key” and that “governments have the responsibility” [1]. Unfortunately, this goal of universal primary health care, as stated in the Alma Ata declaration has not been achieved. One of the impediments to this is thought to be the lack of an information system to guide decision making and planning [2]. This is an issue that has continued to plague most developing countries [ibid] including Nigeria. But this is gradually changing. Currently, the Nigerian health system negotiates a dramatic turn, with the implementation of a computer-based public health system that is based on a district health information system embedded with data handling best practices. This district health management information system is based on a free and open source health information system developed by an international team, configured and maintained by a local team with considerable expertise. But, how did this implementation come to happen? This paper discusses the dynamics involved in the establishment of the health information system and how this is tightly linked with policy and socio-political factors. The lesson to be learnt herein is that a number of external factors influence the dynamics of the health information system, a major one being health policy – the installed base. The paper also mentions important areas that health management information system policy needs to address.

1. BACKGROUND

1.1. Nigeria - The Context

With a population of over 148 million people [3], Nigeria is a heavily populated country that accounts for about half of West Africa’s population [4]. However, 71% of the population lives below the international poverty line [5] and the average per capita income is US\$930 (ranking 161st in the world)[6]. In April 2007, Nigeria held its third consecutive national elections, further consolidating the military-to-democratic transition that began in 1999. Health indices have remained poor and healthcare provision remains a major concern for the democratic government and its partners. The poor condition of health and health care in Nigeria is one of the factors responsible for an average life expectancy of only 47 years [7]. The country is committed to the long-term United Nations (UN)–sponsored Millennium Development Goals (MDGs) [8]. Under the program, which covers the years from 2000 to 2015, Nigeria is committed to achieving a wide range of ambitious objectives involving poverty reduction, education, gender equality, health, the environment, and international development cooperation. In an update released in 2004, the UN found that Nigeria was making progress toward achieving several goals but was far from achieving others. Specifically, Nigeria had advanced efforts to provide universal primary education, protect the

environment, and develop a global development partnership. However, the country lagged behind on the goals of eliminating extreme poverty and hunger, reducing child and maternal mortality, and combating diseases such as human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) and malaria. Thus, the "development of human capital through provision of health services" represents a central thrust of the present democratic government's 7-point agenda [9].

1.2. Policy and Implementation

Nigeria inherited a weak colonial health system from England at independence in 1960 [10]. Subsequently, it went through three unsuccessful National Development Plans and did not have a comprehensive strategy for the health care system [10]. It was only until the Alma Ata declaration in 1978 that the country was primed for health reform. Nigeria made official commitment to the Alma Ata declaration which called for a primary (grassroots) healthcare approach in line with providing care for all citizens. The country worked towards a National Health Policy which was only realized ten years later. Within these ten years, there existed 4 successive national governments - three of them being military governments enthroned by coups d'états. As expected, the National Health Policy that was promulgated had primary health care as the central thrust. The policy provided, for the first time, the establishment of a coordinated and robust country-wide Health Management Information System (HMIS).

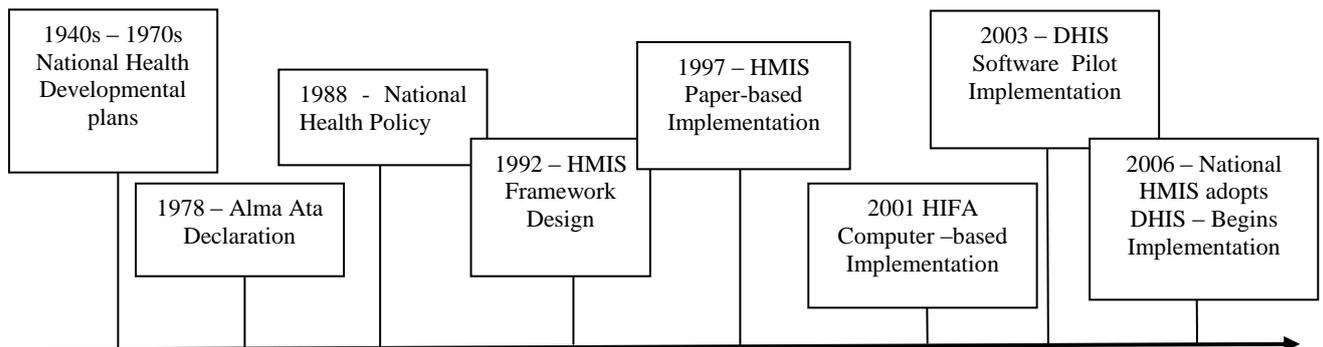


Figure 1. Timeline showing key events in the development of the Nigerian Health Management Information System

In response to this legal platform, the HMIS framework was articulated in 1992. A work plan was devised (in 1996) and implementation commenced (in 1997) in a number of states, with support from donors (World Bank and the UK Department for International Development) [11]. In 2000, when donor support fizzled out, the project failed. However, with a successful transition from military to democratic rule (in 1999), the ban on funding from the United States Government was lifted later in 2000.

HMIS funding came in through VISION, a collaboration between the US-based EngenderHealth, Johns Hopkins University and other partners [12]. Working with the Federal Ministry of Health, the VISION program implemented the country's first computer-based national health information system in 2001 with pilots at Bauchi, Oyo and Enugu states. This system, Health Information For Action (HIFA), was proprietary (not open-source) and was DOS-based. It worked with the EpiInfo 6 and EpiMap 2 software applications [13] and was network-aware [12]. Its implementation represented the first introduction of computer technology for managing the HMIS. However, the implementation encountered a number of challenges that included the use of a dataset that was too large, poor supervision at the facility

level, poor interconnectivity and multiple parallel systems [12]. The project ended after the scheduled time and HMIS activities were again underfunded for a few years.

In 2003, as the VISION pilot projects were ending, the United Kingdom-sponsored Partnership for Transforming Health Systems (PATHS) project started. This program, gaining from lessons of the past and utilizing principles that had been learnt from similar HMIS work in South Africa and other countries in the HISP network introduced the minimum dataset approach. A free and open source software, the District Health Information System (DHIS) [14] was also introduced. During this period, connectivity improved in Nigeria and local capacity to deploy and maintain these systems was developed. The minimum dataset approach and the DHIS implementation were successful and continued beyond the end of the PATHS project in June 2008. In 2006, during the DHIS implementation by six states supported by the PATHS project, based on an open tender process, the DHIS was adopted by the Federal Ministry of Health as national standard [15] for the HMIS and country-wide implementation was planned. The system is being scaled up, in phases, to all states.

2. METHODOLOGY

This study adopts a qualitative case study approach. This is in order to aptly describe the context, the observed events, actors and processes. Data for this work have been collected through direct and participant observation as well as relevant documents the authors had access to during fieldwork. Thus, this analysis is based on both primary and secondary data. Because of secondary elements in the empirical data, it is difficult to draw clear-cut distinctions between phases of the action research cycle. This work is primarily aimed at laying the foundation for the analysis of ongoing and planned study. The underlying participatory action research framework in which this work was done is a long-term project called the Health Information Systems Programme (HISP) [16, 17]. The HISP project was initiated by universities in Cape Town and Oslo in 1995, and is now present in a number of developing countries. Within each country (e.g. Nigeria) the projects are comprised of various actors in the health administration (community, sub-district, district, provincial, and national), universities, non-governmental organizations (NGOs), and funding providers. At the global level, with the Norwegian and South African nodes as the major coordinating bodies, HISP has over the last decade been engaged in the development and implementation of health information systems with emphasis on facilitating sharing of software and best-practices. In the specific case of Nigeria which is the focus of this paper, the HISP project played a major role in supporting the development of the new HMIS. The authors, working within HISP, have been involved in the development and implementation process and performed numerous field trips to many states in Nigeria, and worked in close collaboration with the various stakeholders at national, state, district and primary care centre levels.

On the whole, using action research as the underlying framework allows one to take an active role in understanding an information system while being able to do lots of self-reflective inquiry. Action Research is a disciplined process of inquiry conducted by and for those taking the action. Such participatory approach assists the researcher-participant in improving and refining his/her actions [18].

3. FINDINGS

The Nigerian health management information system (HMIS) is structured in accordance with the national health policy and can be discussed as being made up of a number of components. These components include the people working in the system, the tools they use, the data

involved and the processes used to handle these data - all of these occur at the different levels of hierarchy as stipulated by the national health policy which follows the civil service system.

3.1. People

HMIS human resource is structured along the lines of the tiers of government. At the local level, the HMIS component is housed in the local monitoring and evaluation department where the local government (district) information officer works. Health staff that report to this level include community health extension workers, community health officers, medical officers of health, community nurses and a host of trained and untrained community workers. At the state and federal levels, the HMIS unit is housed in the planning, research and statistics department. At these levels, one finds more skilled information workers – including epidemiologists and public health staff. It is important to note that the HMIS unit and its enveloping health service structure is tightly coupled and embedded within the political structure. This is because they report to elected politicians who in fact make the final decisions on HMIS financing and health policy as well as decisions bordering on recruitment and appointment of staff. This has immense significance for the allocation of resources for information systems activities - decisions tend to be made by politicians who are influenced by financial considerations, special interests and external pressures, rather than evidence coming from service delivery or surveys [15]. It has been said that “the health care sector in developing countries is intrinsically political. It circles around the inherent scarcity of resources and involves a number of actors with different agendas such as donor agencies, health activists, nongovernmental organizations, vendors, consultants, and politicians” [17]. This aptly describes the Nigerian case.

In summary, the actors exist in a complex mix of cooperative and competitive behavior. These tensions when extended to the entire health system give a complex mix of competitive and cooperative behavior between actors which include health workers, local government monitoring and evaluation (M&E) officers, primary health care (PHC) department officers, local decision makers, the local traditional institutions, state ministry of health decision makers, government ministries of health at federal and state government levels, donors, international and local non-governmental organizations (NGOs), software vendors and consultants. The table below outlines some of the important human actors in the system.

Table 1. Human actors in the Nigerian HMIS

Level	Human Actors
Federal	Epidemiologists, information officers, elected officers, health administrators, international partners, local NGOs, consultants, researchers, program officers
State	Epidemiologists, information officers, elected officers, health administrators, partners, local NGOs, consultants, researchers
Local (district)	Local Monitoring and evaluation (M&E) officers, district information officers, PHC Department Officers, District head (traditional ruler), Local government chairman (elected district

	government), vertical program officers
Facility	Patients, health workers, health records officers, the community

3.2. Data

The National HMIS is built in the context of the national health strategy, which currently focuses on the MDGs. That is, focus is on data that are important for achieving primary health care goals and targets and other goals based on the MDGs. This has motivated the use of a small essential dataset in the HMIS with data elements that are clearly defined and standardized. This approach is the minimum dataset approach that has been successful in the HISP projects in South Africa [19, 20]. It is based on the use of only appropriate data elements at each level of reporting – appropriateness being defined by the need for information to inform and drive action at that level. We found this approach to be successful and contributory to the harmonization of the data collection forms used at the levels of reporting (i.e. at facility, district, state and federal levels).

3.3. Processes

A process is a series of actions that are performed in order to achieve a particular result. Within the HMIS space, the processes include those that are taken in order to produce information for decision-making and action. These processes guide the day-to-day running of the Nigerian HMIS system.

The processes include data collection, processing, analysis, presentation, interpretation, use and feedback. Collection involves the gathering of data from relevant sources. These sources include routine data reports from health facilities and surveys in a wide variety of settings. Processing involves collation, the aggregation of data for processing and onward flow; and data quality checking. Quality checking normally involves ensuring that data is correct, complete and consistent.

Analysis involves the calculation of rates, ratios and proportions and other operations on the data to make it useful for action. It normally involves the generation of key performance indicators useful for monitoring and evaluating progress. The data can then be presented for discussion using different kinds of illustrations, graphs and charts. The use of the information for action is important for the information handling process.

Feedback is an ongoing process that works in the opposite direction, with the processes feeding back to the step that led to them.

3.4. Tools

Here we found and used paper forms, computer hardware and software.

3.4.1. The Paper Based System

This system is based on paper forms for collection of data at different levels. Health information handling has traditionally been practiced in Nigeria the ‘paper’ way and paper-

based records are still by far the dominant record keeping system. However, the use of data stored in this form has been a persistent problem as it is difficult to analyze to derive the information needed to drive the decision making and governance process.

However, the paper forms are well integrated into the workflow and do not need any electrical power to run, no antivirus and no special operating systems, as opposed to the computer-based system. However, there are a number of perceived problems with this system, as was revealed in surveys of health workers in Nigeria [21]. These problems include poor access to the stored information; data in paper forms are not easily presentable; take a lot of time to extract; are not durable; require too much space for storage and are generally ineffective. These are major problems the computer-based system aims to solve.

3.4.2. The Computer-Based System

The DHIS is a software application developed for public health management information systems by the international HISP group [14]. It has been continuously adapted for field conditions by participatory effort between health care and software professionals in several developing countries since 1994. This has resulted in the DHIS software addressing vital issues such as user friendliness, data accuracy, and the design and use of indicators based on local need. This software allows data to be transmitted to other users, both horizontally or vertically up the hierarchy.

Keeping in mind the dynamic nature of health care management, the software was designed to be extremely flexible to address changing needs at the field level over time and space. Besides serving as a tool for gathering, transmitting and storing data, the DHIS is designed especially to address data analysis and hence the use of health information. It supports functions of accurate and valid data collection, aggregation, storing, sharing, transmission, analysis, reporting, display and use of health data at and between every level of a district health system from sub centre to district and at the state level. It allows drilling down or aggregation of data at any and every level of the health system such as PHC, district, state and national levels. Essentially, it addresses the need for a national health information system.

The DHIS is constantly configured to reflect the paper-based HMIS that it interfaces with, ensuring that users of computer-based system who are familiar with the paper-based system find it easy to combine both as necessary. This is what forms the paper-computer gateway.

Since the pilot of the DHIS in Benue State, a massive scale up has happened – the neighboring Enugu state adopted it, Jigawa followed and later Ekiti, Kano and Kaduna states joined. In October 2006, the DHIS was adopted for the “new NHMIS” under the health systems development project. But today, the scaling up of the system has become a “pre-requisite and not just a luxury”. This is because, in order to make sense of data from facilities and services in a region, province, or country, more data is needed to provide a complete and more useful analysis [17]. As more data are collected and made available, more data are needed to significantly test hypotheses and calculate key performance indicators, allowing for informed decision making.

4. DISCUSSION

The Nigerian health management information system has evolved in the context of the health system and its socio-political environment. It has been affected by external influences such as donor support and technological events such as global commons-based open-source software production within HISP. Some of these are illustrated in figure 2 below.

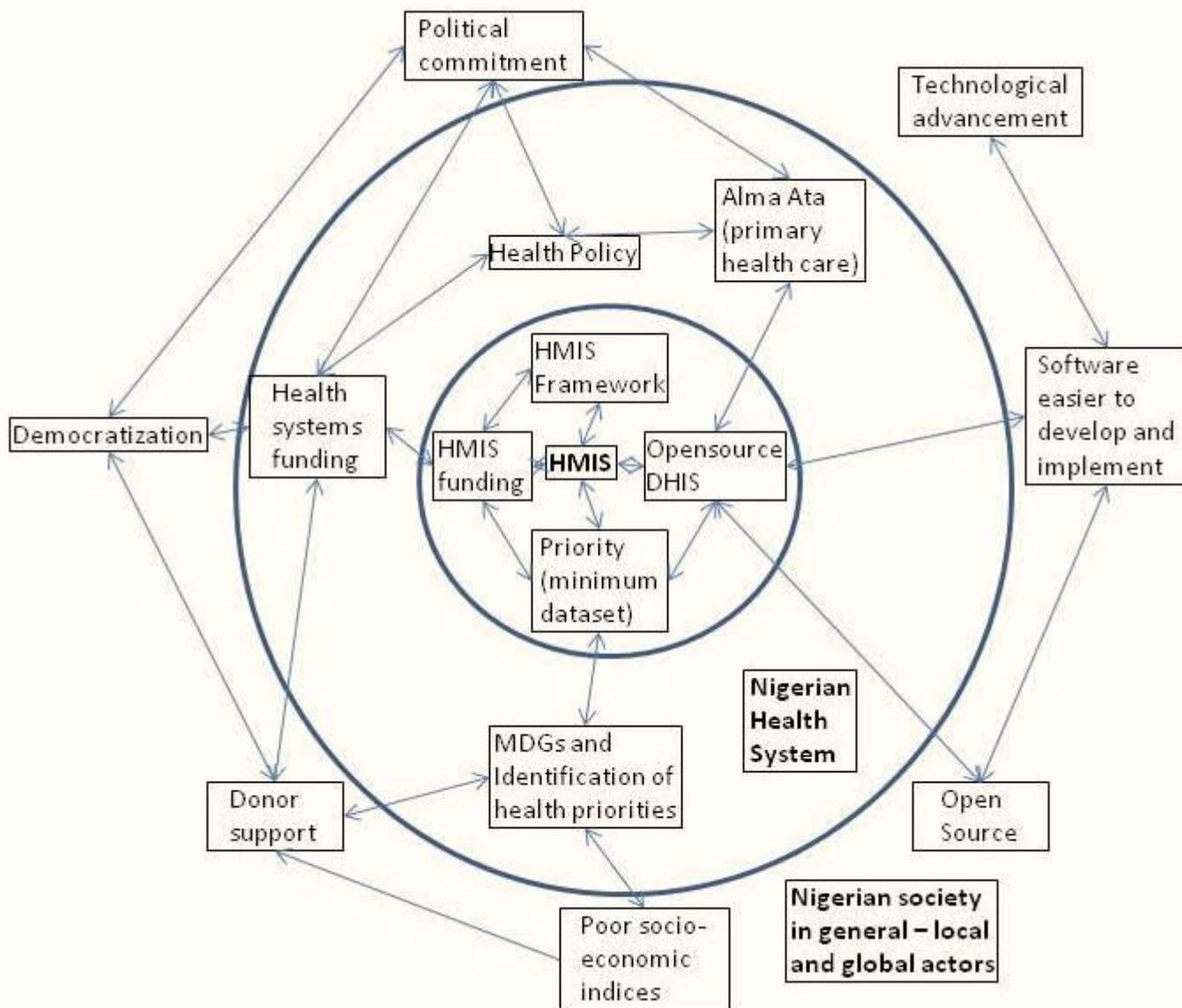


Figure 2 is a diagram illustrating some of the numerous influences that have shaped the health management information system (HMIS) in Nigeria. The inner circle contains factors very specific to the HMIS, the outer contains those specific to the health system. Outside the outer circle are a few important ‘external’ factors discussed also in this paper. It is important to note that this last group of socio-technical factors is unbounded – to show that it is a shared open heterogeneous system in the manner of an information infrastructure as described by Hanseth [22].

There are key lessons to be learnt from this case:

1. The system is continuously evolving:

The health system with its embedded information system is an ‘installed base’ consisting of an extremely heterogeneous socio-political setting with interdependent and interconnected actors and actions. According to information infrastructure (II) theory, the installed based "implies that infrastructures are considered as always already existing, they are never developed from scratch". It is composed of tightly interdependent and interconnected collections of socio-technical components [23, 24]. Essentially, it develops gradually over time. It does this through a process involving gradual expansion, improvement and replacement of its parts. Really, no single actor is in control and the infrastructure has not

been built from scratch within one project. In essence, the Nigerian health information system and its enveloping health system have continued to evolve with the socio-political system. The HMIS has not been built from scratch but has used components from health policy and the primary health care system. The HMIS has a large number of actors including people, tools, data and processes which have all evolved through time as evidenced by the change in policy as shown in figure 1. This installed base, as Edwards et al [25] have put it, consists of all the organization processes, technical infrastructure and social norms that collectively provide for the smooth operation of the system. A major component of this installed base is the political practices and governmental bureaucracy.

2. Political buy-in is crucial for success:

Political buy-in was instrumental in establishing the system. Most policy makers began to see the need for dynamic reform based on evidence. This political buy-in, in such a top-down system as is obtained in Nigeria's governmental bureaucracy, helped to push health policy reform and the attendant HMIS development. The role of Alma Ata in shaping health policy has been described in this paper, as well as the government's commitment to its principles and the prioritization of primary health care. This allowed more funding to come into primary health care information systems development and implementation as the government was supportive. Some of this funding has come from donor support, which has increased since the ban on funding was raised when Nigeria moved from a military dictatorship to a democratic system.

3. Democratization and political decentralization contributed to the success of the primary health care-based information system implementation:

A democratic system means that more people become involved in decision making and communities become empowered. If the health care system and the polity are thus decentralized, then the information system (HMIS) that drives these systems needs a concomitant decentralization to the primary levels. No wonder it has been recommended that a health information systems should be designed to work at the lowest level to ensure decentralized management and coordination of the health services [26].

However, it has been argued by Soriyan et al that for any information system based on primary (decentralized) health care to be acceptable and appropriate, it must be developed based on right requirements [27]. This is applicable to the development of the district health information system (DHIS) software and its use in the setting of the Nigerian national HMIS. It started as a practical project to solve a real need and the requirements were in keeping with the primary care approach and evolved and grew with it.

4. The implementation of an open-source solution reduces total cost of ownership

By virtue of the nature of the development of the DHIS, being based on a free and open-source philosophy and a distributed international network of learning, the ownership of the system is made cheaper on the long term. This in itself drives technological innovation and advancement and can allow for 'self-sufficiency' by local teams using it.

5. CONCLUSION

The socio-political environment, health policy and HMIS implementation are tightly interconnected. Substantive progress has been made in strengthening the HMIS; health policy

needs to respond by harmonizing multiple efforts by funders – that is, building cohesive systems, and thus, limiting fragmentation and *vertical-ization*, fashioned by administrative, economic or donor pressures. For a robust HMIS, a robust policy and framework needs to be present. It is important to build health policies that allow the HMIS to achieve the overarching goals of the socio-political system, with an understanding that the decentralizing socio-political structure of the country and global influences play important roles.

With continuing investments by donors in the country's health system, there is pressure to show genuine progress towards achieving the millennium development goals. Health care departments and programs are obligated to show progress as pre-requisites for extended funding support. The resource proliferation will present opportunities and challenges in good measure. Capacity will continue to be strengthened, infrastructure will improve, integration challenges may arise and the socio-economic dynamics will continue to play a role in the system. A continuing challenge is to roll-out the system nationally by strengthening information management through improving access to, and use of reliable information for the management of health programs and services at all levels.

According to Orobaton, a manager with the WHO-hosted partnership, Health Metrics Network, a mistake that was made in the past was to focus on the mainstream health sector at the expense of other sectors; "future implementation of primary health care in Nigeria will have to address the considerably more decentralized political system, a much more dominant private sector, increasing demand for a reliable health information system and expanded roles for non-health sectors" [28]. A successful system would be one based on practical, scientifically sound, socio-politically acceptable and economically sustainable methods and technologies that make information on health-related activities accessible at the different levels and/or aspects of care with the necessary level of relevance at every stage of the system's development.

From the foregoing, an important consideration for further research would include exploring how actors can be aligned towards the goal of tilting the socio-political equation in favor of health policy that would permit more decentralized HMIS structures as well as a culture of information use. The question of how sustainable infrastructures can be best built is also an important one.

ACKNOWLEDGMENT

The authors thank interviewees and members of the HISP team, who confirmed parts of the historical accounts and made comments on the paper.

REFERENCES

- World Health Organization Declaration of Alma-Ata. International Conference on Primary Health Care, Alma-Ata, USSR, 6–12 September 1978. Available: http://www.who.int/publications/almaata_declaration_en.pdf
- Stansfield SK, Walsh J, Prata N, Evans T. Information to improve decision making for health. In: Jamison DT, Evans DB, Alleyne G, Jha P, Breman J, Measham AR, et al., editors. Disease control priorities in developing countries. 2nd ed. London: Oxford University Press, 2005.
- United Nations Statistics Division. World Statistics Pocketbook 2008. Available: <http://data.un.org/CountryProfile.aspx?crName=Nigeria>

- Nigeria Country Brief. 2008 The World Bank Available: <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/NIGERIAEXTN/0,,menuPK:368906~pagePK:141132~piPK:141107~theSitePK:368896,00.html>
- UK Department For International Development (DFID) Nigeria Country Profile 2008. Available: <http://www.dfid.gov.uk/countries/africa/nigeria.asp>
- Gross National Income Per Capita Table. The World Bank 2008. Available: <http://siteresources.worldbank.org/DATASTATISTICS/Resources/GNIPC.pdf>
- Library of Congress Federal Research Division. Country Profile – Nigeria 2008. Available <http://lcweb2.loc.gov/frd/cs/profiles/Nigeria.pdf>
- United Nations. The Millenium Development Goals Report New York 2008. Available: <http://www.un.org/millenniumgoals/pdf/TheMillenniumDevelopmentGoalsReport2008.pdf>
- The Official Information Gateway of the Federal Republic of Nigeria. President Yar'Adua's 7-Point Agenda. Available: <http://www.nigeria.gov.ng/NR/exeres/59AA73E9-CEC6-43B3-B153-27D568A56B7D.htm>
- Asuzu MC The necessity for a health systems reform in Nigeria. *ournal of Community Medicine & Primary Health Care*, 1-3 June 2004 16(1)
- PATHS Project Report. Implementing HMIS In Nigeria – The HISP Approach Available: http://www.pathsng.org/work_multi/HMISimplementationManual2006.pdf
- Akpan T, Searing H, Adetunji A. Nigerian Case Study: Lessons Learned in Piloting the National Health Management Information System in Bauchi, Enugu and Oyo States. *Proceedings of the 37th Hawaii International Conference on System Sciences (HICSS) Track 6 Vol 6*. 2004. Available: http://media.shs.net/globalaids/pdf/Article_2n-Akpan_Nigerian_Case_Study.pdf
- Center for Disease Control. Epidemiology Program Office – Publications and Software. Available: http://www.cdc.gov/epo/pub_sw.htm
- The DHIS wiki. Available: <http://www.hisp.info>
- Technical Brief. Developing an Information-Based Culture: HMIS and PATHS 2003 – 2008 <http://www.healthpartners-int.co.uk/documents/HMIS.pdf>
- Braa, J., Hanseth, O., Mohammed, W., Heywood, A., and Shaw, V. "Developing Health Information Systems in Developing Countries. The Flexible Standards Strategy.," *MIS Quarterly* (31:2) 2007, pp 381-402)
- Braa, J., Monteiro, E., and Sahay, S.(2004) "Networks of Action: Sustainable Health Information Systems across Developing Countries," *MIS Quarterly* (28:3), 337-362
- Checkland, P. and S. Holwell, *Action Research: Its Nature and Validity*. *Systemic Practice and Action Research*, 1998. 11(1): p. 9- 21.

Braa, J., and Hedberg, C. "The Struggle for District-Based Health Information Systems in South Africa," *The Information Society* (18:2), 2002, pp. 113-127.

Williamson L, Stoops N, Heywood A, *Developing a District Health Information System in South Africa: A Social Process or Technical Solution?* Available: www.hisp.org/ftp/download/Developing%20a%20DHIS.doc

Asangansi IE, Adejoro OO, Farri O, Makinde O, Computer Use among doctors in Africa: Survey of trainees in a Nigerian teaching hospital. *Journal of Health Informatics in Developing Countries*, 2(1) 2008.

Hanseth, O., Lyytinen, K. (2004). "Theorizing about the Design of Information Infrastructures: Design Kernel Theories and Principles," Case Western Reserve University, USA. *Sprouts: Working Papers on Information Systems*, 4(12). <http://sprouts.aisnet.org/4-12>

Ole Hanseth. *Infrastructures: From Systems to Infrastructures*. In K. Braa, C. Sørensen, B. Dahlbom (eds.). *Planet Internet. Studentlitteratur*, Lund, Sweden, 2000, pages 193 – 212.

Ole Hanseth and Eric Monteiro (1998). Changing irreversible networks: Institutionalization and infrastructure. In Kristin Braa and Eric Monteiro. *Proceedings from 20th IRIS*. p. 21 – 40

Edwards, P.N., Jackson, S.J., Bowker, G.C., & Knobel, C. (2007). *Understanding infrastructure: dynamics, tensions, and design*, NSF Report of a Workshop: History and theory of infrastructure: lessons for new scientific cyberinfrastructures. <http://hdl.handle.net/2027.42/49353>.

Lippeveld, T. and Sauerborn, R. "A framework for designing health information systems" in Lippeveld, T. et al.: "Design and implementation of health information systems", WHO, Geneva, 2000.

Soriyan, H.A., A.S. Mursu, A.D. Akinde and M.J. Korpela (2001): *Information Systems Development in Nigerian Software Companies: Research Methodological and Assessment from the Healthcare Sector's Perspective*. *Electronic Journal on Information Systems in Developing Countries*, vol. 5, no. 4, pp. 1–18 and f.1–3.

World Health Organisation. *Nigeria still searching for right formula* In: *The Bulletin of the World Health Organisation*. September 2008, 86(9). Available: www.who.int/bulletin/volumes/86/9/08-020908.pdf.