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Understanding Health Information System Implementation in an Indonesian Primary Health Centre: A Sociotechnical Perspective

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Completed Research Paper

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Abstract

The implementation of health information systems (HIS) faces major challenges in developing countries. These challenges are due to the complex nature of the healthcare sector that involves complex interactions between various professional groups, technologies and organisational interest. This paper explores socio-technical challenges during a HIS implementation in a primary health centre (PHC) in Bandung City, Indonesia. An Actor-Network Theory (ANT) informed qualitative case study is applied to explore how a variety of human and non-human actions influences the stability of the HIS implementation network and what factors preserve the durability of the HIS implementation. We found un-finished translation processes; vendor support and external encounters affect the stability of the network. However, organisational factors (management authority and support, staff adaptation, and local policy) can preserve implementation durability regardless of the limitations of the HIS.

Keywords: health information system, primary health centre, actor-network theory, network stability, the fluidity of software, Indonesia

Introduction

The adoption and implementation of Health Information System (HIS) is of paramount importance to enable evidence-based decision making in health institutions. HIS is defined as a set of components and procedures (such as data collection, data transmission, data processing, data analysis, and presentation) that aim to generate information to improve health care decision making at all levels within a health institution (Lippeveld and Sauerborn 2000).

This research studies the implementation of health information system (HIS) in order to contribute to the growing interest in the use of eHealth in support of universal health coverage, especially in developing countries (WHO 2016). Considering the vital role of HIS for effective health intervention programs, Health Metric Network (HMN 2012) conducted an assessment on HIS performance in developing countries and found that overall score was just at the lower bound of "adequate level." The result indicates that developing countries should improve the quality of HIS. Some pilot HIS

implementation projects are considered successful. However, few projects are sustained at a country or regional level (Luna et al. 2014) which have lead to limited studies on post-implementation projects. A post-implementation study is very important to understand the interrelatedness of social and technical factors at different levels including micro, meso and macro-context (Cresswell 2012). Luna et al. (2014) also identified six major challenges for developing countries in achieving sustainable HIS implementation, namely; 1) resource and infrastructure limitations 2) development of health IT agendas 3) overcoming uncertainty, ethics, and legal considerations 4) lack of use of common interoperability standards 5) lack of a skillfully trained workforce, and 6) regional integration. Most of these challenges are classified as macro factors (except for skillfully trained caregivers). Based on the Luna et al. (2014) review, we can infer that few papers study post-implementation projects involving aspects of the micro, meso and macro-factors.

The context of HIS implementations may vary among countries due to the uniqueness of healthcare system and policies in respective countries. This uniqueness applies to Indonesia. Indonesia adopted a standard integrated recording and reporting system for primary health care (known as SP2TP) to support district HIS in 1981. This standard has been implemented nationally and covers various vertical program reports including nutrition, maternal health, family planning, sanitation, malaria, and tuberculosis (Rambu Ngana et al. 2012). In 2011, the Indonesian Ministry of Health (IMoH) released the first electronic version of the recording and reporting software known as SIKDA (District Health Information System). Even though the IMoH initiated SIKDA nationally, the diffusion of this software to districts across Indonesia is still low (20% or 103 of 514 District in Indonesia). One of the possible reasons is that Indonesia implemented decentralisation policies at the district level to empower districts to manage their fiscal, political and administrative affairs to deliver public services, including healthcare (Heywood and Choi 2010). With this policy, even the Indonesian Ministry of Health does not have a direct authority to push a district government to implement specific HIS software. Consequently, there are many HIS versions at the regional level, which exacerbate fragmentation and integration challenges to support the national HIS. To overcome this challenge, Indonesia launched the National SIK Roadmap as a reference for the central and local governments in the effort to develop and strengthen the national health information system, in the period 2015-2019, in order to realise the ideal HIS (one health data, one standard, one metadata, one portal). The existence of national policies on the one hand (macro-context) and organisational interests (meso-context) on the other hand make the HIS implementation at the local level quite vulnerable to policy changes at both meso and macro-level.

Our research studies the implementation of a health information system in Bandung City, West Java Province. Bandung City is a district municipality that implemented several HIS for primary health centres (PHCs), ranging from a national standard paper-based HIS, electronic-based HIS solutions from different suppliers such as SIMPUS, ePuskesmas, SIMKES and recently SIKDA. This study reports on the findings of the implementation of HIS in one PHC in Bandung City. This HIS has been implemented since 2012 and persists to date, making it is possible to understand how various factors (micro, meso, macro-factors) influence post-implementation outcome. This paper addresses two research questions: *How do different human and non-human actions influence the stability of HIS implementation networks? What factors do preserve the durability of HIS implementation*? A qualitative case study approach was used. It will be explained in the research methodology section. Actor-Network Theory (ANT) is used as a method and theoretical lens to analyse the collected data and to explain the research findings and implications for practice.

Theoretical Foundations

Pioneered by Callon and Latour (1981), ANT has roots in science and technology studies. It builds on several key concepts such as group formation, actants, agency, translation, and networks. In this paper, ANT has been used as a method as well as an analytical lens for revealing the network of actors in their natural setting. By following actors, ones can uncover interactions between actants, reveal moments of translation and the networks they form. Cresswell et al. (2010) argue that ANT is appropriate for the study of health information technologies implementations for a variety of reasons. First of all, ANT can help to understand the complexity of reality and the active role of technology. Secondly, it can contribute to understandings of how social effects are formed as a result of interaction between actants

in a network. ANT can also provide a theoretical approach to sampling during empirical work, and it can be used in analysis and provide a basis for interpretation. Thus, ANT is helpful in investigating technology implementations in healthcare settings. In general, social scholars see the world from macro or micro perspectives. However, ANT does not divide social reality into micro and macro context (Cresswell et al. 2010). In this research, ANT helps to examine the micro context (e.g. how individuals directly interact with HIS) and uses the findings to conclude the influence of meso context (e.g. organisational objectives) and macro context (e.g. the political environment in with individual practices are situated). ANT incorporates actants from these contexts into the same network.

ANT helps to describe and understand the fluidity of social reality. A network consists of both human and non-human actants. Actants may join and leave a network and create changes in the network configuration. The collective actions among actants and relationships between them are unpredictable, often result in unintended outcomes, and therefore affect the actor-network stability (Cresswell et al. 2010). Networks are therefore fluid and constantly changing. However, networks may reach temporary stability. This stability is achieved when actants successfully align their interests to achieve a collective goal.

The alignment of interests can be attained through translation processes. Callon (1986) defined translation as the mechanism by which the social and natural worlds progressively take form. In this context, the notion of translation focuses on the continuity of the displacements and transformations which occur in the HIS implementation story. Translation moments consist of several stages, namely problematisation, interresement, enrolment, and mobilisation. In the problematisation stage, a primary actant identifies the problem and seeks a solution. After finding a viable solution, the focal actant tries to convince other potential actors, and negotiate their interests to fit each other. Successful negotiation among actors will result in enrollment to the network. In the enrollment stage, roles are assigned to the actants accepting the solution, collaborating and achieving a certain goal to answer the problem. Post-implementation usually relates to the mobilisation stage where all actants in the network maintain their commitment and use the power of their passive allies (inanimate objects) to speak on their behalf.

Actants' commitments and interest could change over time due to internal and external factors and create controversies in the implementation network. Callon (1986) discusses the importance of studying controversies (dissidence and betrayals) and their role in influencing the network dynamics. Some questions such as "Why and in what conditions do controversies occur? How are they ended?" are helpful in examining the representativeness of an actant in the network and how it influences overall network stability. Callon (1986) did not account for dissidence or controversies formally as part of the translation process. However, we argue that this dimension is valuable to track non-translation process in the HIS implementation. Our argument is in line with the post-ANT approach to understand the complex and dynamic nature of the networks. The post-ANT approach is not only to study the aspects of successful translation, alignment, stabilisation, and closure; but also to deal with inconsistencies and ambiguities that potentially affect network stability (Hanseth et al. 2006; Silvis and M. Alexander 2014). Therefore, this paper discusses controversies (as a separated process) to sense the network dynamics during HIS implementation.

An object, such as a technological artifact, can offer stability to the network, as the collective actors may inscribe their mutual interests into the object and use it as an obligatory passage point (OPP) in the network of actions. An object could be categorised as immutable mobile if it has a substantial property of irreversibility and effects, which transcend time and place (Walsham 1997). However, some studies found that not all objects are immutable and mobile, some are fluid and slowly change over time, and therefore mutable (Laet and Mol 2000; Law and Singleton 2005; Naidoo and Leonard 2014). A fluid object is something that both changes and stays the same (Law and Singleton 2005). According to Laet and Mol (2000), the fluidity of technology can be explained by six properties namely boundary-less, multiple identities, mixtures, robustness, continuity, and dissolving ownership. Naidoo and Leonard (2014) confirmed these properties when studying the implementation of an Internet-based self-service technology at a private healthcare insurance company. They suggested that the study of ICT implementation should move the emphasis from a black box to the nature of its fluidity. In other words, researchers should also observe how technological artefacts could be translated over time in response

to the changes in actors' interest and pressure from external macro-environment (e.g. regulation, technology trends, new encounters).

Research Methodology

This research follows a qualitative case study research methodology. An in-depth case study can be used as a vehicle to conduct 'interpretive' investigation, where one of the researchers visits the field site over a period (Walsham 1995). An interpretive case study method is also selected because it allows the identification of the essential characteristics of health information system implementation within its natural setting, where the boundaries between phenomenon and context are not clearly evident (Yin 2014). Implicitly, the data source for this research is a natural social setting where health care staff use health information system in a 24-hours PHC in Bandung City (the rest of this paper will use IBRA PHC). IBRA PHC was chosen based on the recommendation from Bandung City District Health Office, from whom the researchers got an official permit to conduct the study. Furthermore, the PHC implemented the HIS over three years previously and could provide rich data.

The ANT sociology of translation (Callon 1986) guided the tracking of the translation process during data collection and analysis. This strategy overcomes the limitation of summative evaluation that is usually limited to the exploration of the overall impact of the system, rather than the process. By focusing on the translation process, researchers can study the dynamics of pre-implementation (problematisation, interessement, and enrolment) and post-implementation (mobilisation and controversies). However, insight drawn from people's memories is still limited compared to a longitudinal study in formative evaluation. Despite this, by being able to describe and understand nuances in pre-implementation, it improves understandings of individual actions and practices that are currently occurring, for example, why electronic and paper-based recording practices are still in play alongside electronic-based ones.

Data collection was performed in 2016 via semi-structured interviews, direct observation and document analysis of publicly available documents. This triangulation was beneficial for verifying findings and providing a deep understanding of the phenomenon. Interviews were conducted with twelve participants who include ICT policy officers from Bandung District Health Office (DHO), PHC management, General Practitioners (GPs), Dentists, Midwives, Nurse, Pharmacist and Administration staff. Most of the participants were female caregivers, and only three of them were male. Most of them have worked for the PHC more than five years, only two of them with tenure of less than four years. The interview participants were selected based on snowball sampling, starting with DHO, PHC and HIS users from different healthcare units and professions in IBRA PHC. Most respondents had been using the HIS since it was launched. The participants also represent the users of four core PHC reports, namely morbidity report (GPs), pharmacy report (pharmacists), maternal-child health report (midwives) and health-care activities report in the PHC (Admin staff and Dentist). The interviews were conducted in Indonesian, lasting for 60 to 90 minutes each, and were audio-recorded. In order to provide a better understanding of healthcare services in the PHC, twelve hours of direct observation were conducted in five healthcare units (register unit, general clinics, dental clinics, maternal-child health care unit and pharmacy).

The data collected in this research includes audio interviews, observation notes, and documents. All audio interviews have been transcribed for further processing. Nvivo software was used to assist the process of organising, memoing, codes and themes. Process coding and in-vivo coding were employed to capture the participants' translation processes, concepts, beliefs, meaning, and understanding about the use of the HIS. ANT as a theoretical lens influences how to classify codes to reveal the network of interactions. We also coded actors, actions, interactions among actants and major events and mapped them into each translation stages. In each stage, factors (as themes) that influence translation processes and the stability of the HIS implementation were identified and analysed.

Research Findings

The ANT concept embraces a relational ontology, which should be supported by empirical foundations. As a result, the founders of the theory strongly support the descriptive nature that drawn upon traceable

actions of actants in real life (Latour 2005, p. 144). Therefore, in the research findings section, part of the findings were written in a narrative style to bring the empirical data alive and "*to let the actors have some room to express themselves*" (Latour 2005, p. 142). More analytical debate and comparison with literature are presented in the discussion section.

Problem Identification, Solution & Implementation Goals

Organizing and running a PHC requires the integration of institutional management, patient management and regional-based program management (The Ministry of Health of the Republic of Indonesia 2015). These three elements form what are called "***PHC management".*** To optimise PHC performance; data and information must be collected from primary and secondary data sources. Primary data is collected while performing medical services in PHCs and communities. Secondary data is gathered from national/regional survey results. To support this process, a PHC must have an integrated recording and reporting system.

However, according to participants, there are several issues with the paper-based system. One of the problems associated with patient management is the archiving of medical records. A DHO representative described the problem by saying "*If we look at the archive of medical records in the registration, they are massive. If there are only a few, it doesn't matter, but when it thousands or tens of thousands of medical records, they are going to be piled up (in the PHC).*" The PHC must keep medical records for five years. After this period, the records can be destroyed.

The PHC management commented on another problem related to timely reports submission within the regional-based program management. "*PHC reports are complicated because there are many programs, many activities at the health centre. Previously, DHO asked that reports be submitted before the 5th (of every month), now by the 25th. So that means the DHO has update data for the next month.*" When using a paper-based recording system, reports can only be generated after all the records have been completed, collected and calculated manually, at the end of the month. "*There are more than 60 monthly reports*". PHC management raised fragmentation of reports within program management as a related problem. "*Previously, the recording and reporting system was fragmented between programs. The immunisation program had its own system. The nutrition program had its own system.*"

Based on the above problems, the DHO sought a solution by implementing an electronic HIS for PHCs that complies with the SP2TP standard. It is expected that by implementing this solution, PHCs can collect health data while serving patients. Consequently, at the end of the month, PHC could generate SP2TP reports automatically from the HIS.

According to the interviewee in the Bandung DHO, there were three factors that led to Bandung's DHO decision to adopt a HIS. First, there was funding support. This funding was part of the 2010 health Information development program for districts in the West Java Province, and it triggered HIS roll out in Bandung. However, at that time (2010), there was few HIS that fully implemented SP2TP standards. The Head of DHO Health Program Management Department decided to choose a system that was ready for implementation. This consideration leads to the emergence of the second factor was timing, as the availability of funding support coincided with the ongoing trial of in a different PHC (coded as BLG PHC). The HIS trial led to a possibility of accommodating staff user requirements at the PHC level, as well as of entering into direct negotiation with the software developer. The third factor relates to a successful implementation of e-prescription, a pharmaceutical decision support system, at Babakan Sari PHC, which led the DHO to support the development of the HIS to fit the needs of PHCs.

According to the interviewees from DHO and PHC management, the goals of HIS implementation in Bandung City are:

- To computerise health care services that flow from the register, medical clinics and conclude in a pharmacy unit.
- To support the PHCs management of medical records (record, store, and retrieve) and to minimise paper-based records
- To provide a system that supports recording and reporting tasks which can be done simultaneously in a real-time, and generate monthly reports.

In the early stage of HIS adoption, negotiations were between two key players; the HIS vendor and DHO Management. While the DHO wanted to use the funding to solve PHC problems, the developer's interest was to build a HIS program that runs well and could be accepted by PHC staff in a BLG PHC. The developer found that Bandung was attractive as a live laboratory and testbed to advance the HIS software. He was hoping that the software could be accepted and implemented in all 73 PHCs in Bandung City.

Table 1. Interests of various group of staff in IBRA PHC

Actor	Interest	PHC Management Actions
General Practitioners	Report their patient-related activities to determine the number of credits for employment promotional purpose (six-monthly) and to maintain a GP professional license (five-yearly).	Asked the vendor for software customisation such as UI improvement and reports customisation. As a result, GPs use the HIS, and the PHC benefits various reports, e.g., morbidity report, the ten most frequent disease report, etc.
Registration Staff	A tool that allows them to create, maintain and search patients' medical records (MRs) efficiently. However, they had computer literacy problems, no formal training in ICT.	Persuaded the staff that the HIS is easy to use. Management provided supervision, coaching, and support.
Pharmacist	A tool to input, manage, calculate and report medicines stocks effectively. Previously, they kept drug inventory information on paper, and every day after healthcare service hours, they counted the remaining stocks (about 300 – 400 items). Every month they report to the DHO using a standard format.	Persuaded the pharmacists that the HIS could meet their needs. The management asked the vendor for customisation if required. As a result, the pharmacists have a real-time drug stocks information to support electronic prescriptions flowing from clinics to the pharmacy.
Midwives	A tool to maintain MRs for maternal-child health care (MCH) as well as to monitor the MCH program at both the facility and community levels. Every month they need to report in the formats of in-facility MCH report and area-based MCH surveillance report.	Persuaded the midwives that the HIS could PARTIALLY meet their needs that are for in-facility health service. Midwives should be able to develop the MCH report. The vendor was asked to improve the module and reports to meet midwives needs gradually.
Dentists	A tool to maintain MRs including diagnostic and dental care treatment. Every month they should report the dental health program in a dental-care reporting format.	Persuaded the dentist and nurse to use the default HIS module for the dental clinic. The vendor was asked to customise the module gradually based on staff input.

Alignment of Interest in the Early Phase of HIS Implementation

In this stage, DHO management acted as a focal actant and pursued new allies for HIS implementation. The DHO chose 10 PHCs, one of which was IBRA PHC, a 24-hours PHC where the research was conducted. The DHO respondent stated that the selection criteria was based on representation from eight sub-city regions. DHO also selected two PHCs from 30 sub-districts. Overall, PHCs were chosen based on human resource, building, and infrastructure readiness, including electricity supply and computers.

According to DHO respondents, among 10 PHCs management attitudes fell into two groups with respect to adopting the solution mandated by DHO. The first group reacted conservatively and implemented the software package on the basis of the initial software version. The second group proactively engaged with the vendors to customise the software to align with the PHC needs. IBRA PHC was in the second group.

The HIS implementation contract covered one year for software development and another year for support. IBRA PHC management argued that HIS implementation would benefit those staff who entered medical records and the PHC in the sense that PHC would capture and report their health care

activities. IBRA PHC management identified the interest of the different groups of staff as shown in Table 1. In most cases, medical staff obeyed the management's decision to use the HIS in the PHC. This pattern equates to mandatory adoption (Rogers 2003), where the authority in the DHO made the adoption decision, and both PHC management and healthcare staff were mandated to use the software. However, PHC management used their power to align various actors' interest in the PHC, by incorporating the actors' interest into the software as much as it could. By customising the software, IBRA PHC developed HIS to a more advanced state than other PHCs.

Enrollment of Actants

During the enrolment stage, PHC management and the vendor faced several issues. The first was how to introduce the new system to all staff, with different levels of computer literacy. The second was how to use electronic medical records (eMRs) in place of the paper-based MRs, without disrupting health care services. Sending all staff for training was not a possibility for the PHC because it provides 24-hours services, and serves 200 – 300 patients per day. The strategy chosen by PHC management and the vendor was radical and high risk. The PHC management decided to have nine days of training during which staff received supervised training from the supplier while serving patients. The first three days were for the registration unit where there was four staff serving the customers. Two computers were available, so only two staff could be trained and served patients using the HIS. Most of them were not experienced in using computers. The tension expressed by the registration staff shows in the following;

> "*It was difficult in the beginning; later I can do it. Then, I also found a difficulty to save (the MR)*. The vendor said to me '*It is OK Mam, you can learn by doing it'. It took a long time to enter data because it was my first time to use a computer. Patients were piled up in a long queue. Usually, I wrote manually in yellow cards. Because I was using a computer, it took a long time, until patient complained, 'Why do you use this (computer)? Please go back (using yellow cards) to speed up*'."

The registration staff complained to the vendor, asking why there was no training outside service hours, to avoid bottlenecks in the registration unit. The vendor was convinced that learning by doing was more effective and efficient than conventional training. "*This is to speed up Mam. If you do training first, you will forget and tend not to use it. If you learn by doing it, later you can do it.*" The vendor argument was correct, and after two weeks, registration staff became more confident in using the system.

After registration staff had been trained in the system, the developer helped GPs to use the system for another three days. Most of the GPs were familiar with computers, and it took them less time to understand and use the system. The last three days were used to train pharmacists and their assistants. After nine days, the PHC was successfully using the HIS software for registration, GPs clinics, and pharmacy. During the enrolment stage, the PHC management strengthened the existing roles and job responsibilities to fill out medical records completely. Since the rollout, paper-based medical records have not been used in registration and GP clinics.

Mobilisation

During the mobilisation stage, the role of the HIS became more important, as most of the actors' interests needed to be inscribed in the software. However, in the context of HIS implementation in IBRA PHC, the software was not mature enough. The PHC management commented, "*The HIS implementation is not 100% successful because there are many things (requirements) that cannot be performed (by the software)*".

The contract between DHO and vendor was only for two years, one year for software development and one year of support. After the support period ended, PHC had to take over the funding and support for the HIS. In the early stage of implementation, HIS was designed to support recording for general medical services from registration unit, medical clinics, and pharmacy. As a 24-hour service, PHC has several other clinics and support units, and the PHC management thought it important that all clinics implement the HIS to support the existing health care business processes. Thus, the alignment of

interests was still taking place after the HIS was implemented, due to the need to preserve network durability as well as to extend the actor-network beyond GP clinics.

Several factors contributed to the HIS lasting for more than three years, even though the formal one-year contractual support had elapsed. One of the factors was the continuous support for the HIS implementation shown by the PHC management, vendor and peer support in the PHC. PHC management exploited the interest of developers in customising the HIS software by giving full access to staff to learn health reporting practices in the PHC and tailor the software by using a "*social partnership scheme*." This action successfully overcame PHC budget limitations to extend the contractual support for software customisation. As a result, the HIS software was customised beyond the initial software release. PHC management let the staff contact the developer to discuss change requests. For example, GPs asked for changes on the user interface in the GP module and reporting format. Others sent change requests through PHC management. The vendor accommodated those change requests and updated the software. As a result, the GPs could speed up the data input by employing default settings for normal conditions, and only entered abnormal indications based on their diagnostics. Furthermore, many customised reports became available particularly for morbidity and PHC activity reports. These vendor and staff interactions encouraged software customisation and maintenance. As a result, the PHC successfully discontinued the use of paper-based medical records for general health care services and used the HIS for the new recording and reporting practices.

Various staff adaptations also contributed to the mobilisation of software usage. Regardless of their ICT literacy level, after becoming familiarised with the software, most staff could use the HIS software in their daily work. There are two types of HIS usage in the PHCs. The first type is a direct use by staff, such as GPs, registration officers, and midwives in Child Clinic where the employee enters medical records by herself while doing medical jobs. Another type is a collaborative usage, where one worker enters the data while others perform medical services or do other jobs. Why do collaboration patterns occur? Collaborative usage occurs for several reasons. First, it is impossible to input medical records while serving patients, such as in Dental Clinics. The dentist consults or performs some dental treatment to a patient while a nurse enters data into the HIS. In this case, the dentist uses HIS indirectly, due to the nature of work. Second, there are plenty of staff working in the same unit so that they can split the jobs accordingly and let one staff do the data entry. This practice observed in MCH clinics where there was only one computer to support three consultation tables for maternal patients. Third, other assignments require different staff to work on them, such as preparing paper-based records, preparing medicine in pharmacy units, doing one-on-one counselling service with patients and so on. Finally, the number of computer available in the unit affects this collaborative pattern. With fewer computers than the number of staff, the data input process is performed by a nominated staff member (by a nurse, as in dental clinics) or take turns (by midwives, as in MCH clinics). When the number of computers is equal to the number of staff (as in GP clinics, Registration Unit, Child Clinic), the individual usage pattern is likely to occur, except when the nature of work does not permit it (e.g. dental clinics).

Organizational bonding occurs when most actors work to fulfil PHC objectives in delivering health care services. Assigned staff roles and responsibilities, formal or informal communication channels, quality management, and employee's loyalty attitudes preserve the bonding. When human errors occur, such as inputting the wrong patient data in the registration unit or allocating the wrong dose of medication by GPs, the person who notices the errors usually communicates the errors to the respective units for correction. Management also monitored the HIS to make sure that all outstanding patients had been served and the medical records were inputted to the HIS. Another organisational factor that is important is the determination of management and staff to maintain the organisation's compliance with ISO 9001, obtained in 2008 and 2014. The PHC is currently in the process of getting accreditation from the central government (IMoH). Therefore, documenting all healthcare activities including medical records is very important in order to comply with ISO 9001 and PHC accreditation. The existence of regional policies including standard operating procedures is essential to provide a justification for actions and simultaneously to comply with ISO certification.

Controversies

In the context of HIS implementation, internal controversies occurred due to software limitations and the change in vendor support arrangements. The HIS was designed to support recording for the healthcare activities at the *in-facility* level. With this constraint, midwives utilise two recording systems; namely the HIS and paper-based records. The use of two systems is because the HIS was not designed to support health care activities from outside-facilities (e.g. community health posts). Neither could the HIS completely accommodate the requirement of dentists to record the diagnostics of dental patients. As a result, dental clinics continued to maintain paper-based medical records internally. The second controversy came from the changes in vendor support. The nature of social partnership scheme was loose in the sense that there was no definitive contractual service level agreement. In the early stage of HIS implementation, the vendor was actively supporting modification requests in the PHC. As soon as the supplier had more implementation projects outside Bandung City, the vendor supports weakened. The vendor would only come to the PHC in the evening or after working hours which created another problem. Some modifications were made without proper supervision from key staff (midwives, dentist, and pharmacist). This lack of support impacted the software design and stability, particularly in pharmacy module. The pharmacist described this issue as "*Actually before being replaced with the current version of the HIS, before October 2015, (the HIS) is good, no problem. Well, in November 2015 the HIS was changed. It (the system) becomes messy until now".* The problem related to the synchronisation of drugs stock information between the pharmacy unit and other clinics. The drug stocks displayed in other units did not match with the real stock information input by the pharmacists. As a result, GPs usually used a paper-based prescription when the HIS indicated that no particular drugs were available to perform an electronic prescription. It took almost ten months to follow up and fix the problem in the module. Thanks to the organisational flexibility to tolerate the use both electronic and paper-based prescription, with the cost that the pharmacist had to reconcile actual drugs expenditure every day and perform a monthly inventory taking. Regardless those limitations, the HIS software is still used in the PHC.

Other controversies arose due to external factors. One of the factors was the development of the PCARE information system. PCARE was launched nationally in 2014 by *The Social Security Agency of Health* (called BPJS). BPJS is a state-owned enterprise which was assigned exclusively by the Indonesian government to administer health care benefits for all Indonesian people. PCARE or primary care information system is a patient information system that is to be installed in all PHCs in Indonesia. The purpose of PCARE is to provide an Internet-based patient information system so that the collection and processing of patient data from all health facilities could be well coordinated. As soon as PCARE was launched, all PHCs in Bandung city implemented it. PCARE implementation benefits PHCs by capitalising the health care cost occurred when serving BPJS members in the centre. As a result of this implementation, all staff in the registration unit, GPs, dental-care, and MCH clinics had to input patient data in both The HIS and PCARE. This practice created an extra workload for staff. Even though it would be possible to integrate PCARE and the HIS, PHC management could not do it without additional funds to upgrade the HIS software and a permit from DHO. This solution was not possible as DHO decided to implement SIKDA, and the integration with PCARE system can only be done through SIKDA.

In 2014, DHO decided to roll out SIKDA as proposed by the Indonesian Ministry of Health (IMoH). To support this decision, DHO took SIKDA v1.3 source code from IMoH and enhanced it to adapt to DHO's needs. DHO then recruited software developers to improve and maintain the SIKDA software. This in-house strategy was chosen because previous experience showed that using a third party vendor would result in dependency on the vendor for software maintenance and customisation. Furthermore, DHO got support from a smart city advisory board (containing experts from universities) to discuss the roadmap and other technical issues during its implementation. By the end of 2016, eleven PHCs had implemented SIKDA. The DHO adopted a gradual implementation strategy and prioritised PHCs that have not previously had HIS software installed. DHO expects that, before 2019, all PHCs in Bandung City including IBRA PHC will have implemented the SIKDA.

The IBRA PHC Management responded to PCARE by directly implementing it, even though it caused extra workload for the staff. PCARE will have a direct impact on the PHC's income and also on the staff incentive. The capability to capitalise health care activities will become more important in 2017 since IBRA PHC will be acknowledged as a Regional Public Service Centre. With this new accreditation, IBRA PHC will have the flexibility to manage their finances more independently to improve its health care services. Concerning the rollout of SIKDA, IBRA PHC management agreed to migrate to SIKDA with conditions attached. First, SIKDA would have to reach the same level of maturity as the HIS particularly about its reporting capabilities. Second, SIKDA needed to be integrated with PCARE. This standing position was accepted by DHO and in line with DHO's strategy to roll out SIKDA gradually, giving lower priority to the PHCs that already had existing HIS.

Discussion

ANT says that network stability and durability are important when examining the viability of "*solutions*" in the context of technology adoption in IS research (Silvis and M. Alexander 2014). Network stability is achieved through the attributes of performativity or continuous process of translations. Tatnall and Gilding (1999, p. 962) describe network durability by saying "a *network becomes durable when actors feel no need to spend time opening and looking inside black-boxes, but just accept these as given*". We will now explain how these occur in the IBRA PHC HIS, how they were maintained in the face of controversies and the impacts this had on the consequent stability of the network and durability of the HIS.

Appendix-A summaries the contributing factors influencing HIS implementation stability. In the context of the HIS implementation in IBRA PHC, it appears that the actor-network is fluid in the sense that the stability can change over time. Therefore the alignment of interest should not only happen in the early implementation of the software (for example during the interresment stage) but also occur throughout the implementation periods, primarily when events or controversies arise. Every human actor and non-human actant should embark on the translation process to fit with overall implementation goals. The findings show that software customisation plays an important role to align (or not) with health workers' interest, requirement changes, and internal/external encounters. This continuous translation of animated objects can be explained by the fluidity concept of an information technology artifact (Laet and Mol 2000; Naidoo and Leonard 2014).

The fluidity of the HIS Software

The HIS software corroborates fluid characteristics such as boundary-less, multiple identities, mixtures, robustness, continuity and dissolving ownership. The HIS software was designed to support various modules such as registration, GP, dental, MCH, and Pharmacy module. Each module evolves according to the request from users and the PHC management. With the nature of user-based customisation, software development is boundary-less in the sense that the boundary between the old and the new software versions becomes unclear. Each module represents multiple identities, advancing at different speeds (mixtures) depending on the module's complexity and the developer capacity to translate the requirements into the software. The registration and GP modules continuously evolved and were robust enough to support the practices in GP clinics and Registration clinics. They can be considered as the most mature modules and were accepted by the staff and the management. Different actors contributed to the evolution of these modules. They released their ownership and let the vendor inscribed the requirements into the software.

The HIS software customisation, however, was limited by the vendor support and partnership schemes. The performance of the pharmacy module was unstable because the customisation process had caused an unexpected error in the medicine inventory databases. The change of vendor supports had slowed down the bug fixing process. Because the problem existed for an extended period (almost one year), it created a disruption in the automation of prescription process from clinics to the pharmacy unit. The software error damaged the robustness of the software. As a result, it influenced the e-prescription network in the PHC, so that paper-based prescriptions had to be used again. The use of old practice

threatened the stability of HIS implementation because the network became reversible or accommodated alternative translations.

Only relatively mature modules can contribute to the new recording practice. As a result, the health workers can automatically generate reports directly from the HIS. The maturity of modules was the output of repeated software customisation until they reached an acceptable level. Here the HIS demonstrates its influence as a non-human actant with agency (to automate eMR flows, report generations) especially in the registration unit and GP clinics, while the HIS modules for other units still need some improvement to meet the user requirements. The software translation process has not finished yet. As a result, the HIS functions as data container rather than a perfect actant with agency to influence recording and reporting practices. Thus MCH, Dental Clinics, and Pharmacy still use paper-based recording along with the HIS to form a double-recording practice.

This paper primarily responded to the research agenda fostered by Naidoo and Leonard (2014) that the existing fluidity concept of ICT artifact (Laet and Mol 2000) should be further explored with regard to its spatiality and mobility within a dynamic environment. Mobility characteristics challenge the current concept in ANT that animated objects can lend stability to a network because they are immutable. However, in the context of software as an IT artifact, mutability is also crucial as a means of maintaining actants' interest in the network. When there is a change in the network, each actant should adapt to the new configuration, including software. The findings from the data suggest that if the software can continuously evolve in response to organisational dynamics, it will preserve durability of the network. On the other hand, if the software is static, immature, immutable, or immobile, it will lose its power to maintain network interest, and so affecting the network stability. In the context of HIS implementation, this mobility nature of HIS software can be directed by user/organisational requests, the need of integration with other systems (such as PCARE), and internal bugs arising from the growing complexity of the HIS database.

The Role of Organisation and Staff Adaptation

The stability of the HIS implementation network can also be explained by various types of staff adaptation reflecting internal motivations and teamwork. In the registration unit and GP clinics, the perfect match for the HIS design, human factors, and professional tasks allow the administrative staff and GP to use the HIS directly and get benefit from it. The lack of ICT literacy in the administration staff only affected the speed of adaptation process. They just need more time to become familiar with the computer and its software. As for GPs who have better ICT background, they tend to adapt faster and use the software. The result is the same for both the administrative staff and GPs. Both groups can simultaneously serve patients and record either through the HIS or the PCARE. As for the other groups, such as dentist and midwives, they use the HIS because the organisation mandates it and they respect the overall recording process in the organisation. Since they did not take full benefits from the HIS, they use dual recording system by using teamwork fashion. As long as at the end of service hours, all patients' records were entered to the HIS; it means they have fulfilled their jobs.

The stability of network is also affected by external encounters such as SIKDA and PCARE implementation. The decision of Bandung DHO to adopt SIKDA in all PHCs could not be separated from the Indonesian Ministry of Health's actions to promote SIKDA in the national HIS road-map. The decision has affected the HIS implementation stability in two ways. First, it prevents the integration of PCARE and the HIS software. As a result, the health staff need to input patients´ data into two systems creating an unnecessary workload. Even though, technically the HIS developer can integrate the systems, DHO decided that the integration should be done through SIKDA implementation. Secondly, it affects the vendor's interest in expanding the HIS software in all PHCs in Bandung City. This situation has led the software developer to focus on other HIS implementation projects that are more promising. As a result, the vendor support under the social partnership schemes weakened and thus slowing down the software translation process in the IBRA PHC.

The role of the organisation and staff adaptation proves to be very important to maintain network durability. The purpose of the institution is not only to set the implementation goals but also to resolve the dynamics around the HIS implementation. In the mobilisation stage, all actors retained their

commitment to using the HIS to improve the recording and reporting system. This commitment could only be achieved through the active leadership from the management and support from staff. Likewise, the HIS should be able to show its benefits and influence to help healthcare staff to support recording and reporting system in the PHC. The bonding among actors to use the HIS affected the durability of the new actor network. Regardless of the limitation of the HIS, the organisation role in providing continuous support, adjusting the local policy for dual recording systems and negotiating to delay SIKDA implementation, have successfully extended the durability of the HIS application in the PHC.

Conclusion

This study found that the HIS implementation network is a very dynamic process. The stability of network is affected by unfinished translation process, software errors, change requests, and external encounters. In order to overcome the dynamic environment, all stakeholders should adapt to those encounters through a continuous alignment of their interests.

ANT suggests that a stable network, in this case, the HIS, can be sustained as long as the network continues to satisfy the interests of the actants and is fluid enough to react to encounters that arise. In the case of the HIS implementation in IBRA PHC; network fluidity was maintained primarily by PHC management through allowing staff to create their own workarounds to meet weaknesses in the system that threatened overall stability, for example, the problems which arose in connection with e-prescriptions. The final challenge described, that of the mandating the use of a new system (SIKDA) by the Bandung DHO, meant that the new situation was irreconcilable to the needs of one of the main actors – the software vendor. It also had the potential to destroy network stability, but management realised that in the short term. SIKDA has not aligned with its needs in relation to SP2TP standardised reports compliance. So the management acted to extend the life of the system through management action both to negotiate a later implementation of SIKDA and ensuring that the role of the original software vendor was met by a new actant.

HIS software can play a significant role in network stability. When software can successfully accommodate users and organisational requirements, it can function as an obligatory passage point and therefore function as a mediator to transform existing practices. However, when the software is immature or immutable, it cannot function as a perfect actant and loses its agency in the network. As a result, the degree of irreversibility of the network is damaged, as human actors can easily go back to using old practices to meet their interests. The software developer has an important role not only to develop the software but also to update the software against errors and emerging requirements continuously. We suggest that HIS software should be treated as a fluid product. It should not support only the six core characteristics (boundary-less, multiple identities, mixtures, robustness, continuity and dissolving ownership), but also mobility so that the software could be updated over the implementation period.

The findings demonstrate that ANT is capable of providing rich data enabling the identification of key stakeholders, describing the HIS implementation process, and explaining the influence of actions to the network implementation stability. It is capable of capturing the dynamic environment and the risks of consequences of the tensions and controversies that arise. In this case, it has shown how network fluidity, and so system durability, has been maintained through the responses not just of key actants such as management, the software vendor, local policies, but also staff who have acted to meet both internal and external encounters.

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Appendix A: Contributing factors and their implications for HIS implementation stability

Organization	Human	Technology	Implications
Mandated adoption, strengthening existing roles and responsibilities, direct mentoring strategies during the HIS roll-out	"Learning by doing" to overcome tensions between patients, healthcare practices and ICT literacy levels; staff loyalty; internal motivation and teamwork	Vendor support for training and problem solving; infrastructure readiness (PCs, LAN, Software, Electricity)	Staff enrolment, HIS enrolment and change in recording practices
	Collaborative patterns depended on the number of staff per unit and nature of works	Number of computers in the unit	Individual usage (GP Clinics, registration unit) or collaborative usage (MCH, dental, pharmacy)
Social-partnership schemes with the vendor, PHC funds HIS implementation, Leadership, set up a local policy to justify HIS, and paper-based medical records	Staff's interest listened	Software customisation	No-paper-based MRs in Registration and GP Clinics
	Staff's interest gathered but could not be fully inscribed into the HIS software	Partial software customisation in dental and MCH modules (immaturity, not fully align with existing standard and practices)	Paper-based recording and reporting systems are still used in MCH clinics and Dental Clinics
Management support	Peer support	Vendor support	Maintaining interest and overcome implementation dynamics
Limited support for software errors due to high dependency on the vendor	Staff adaptation (self-support) and uses paper-based practices as a backup during system errors	Change in vendor support after 2015	Paper-based usage to support the inter-units referral system, paper-based prescription, manual inventory taking in the pharmacy
The DHO decision to implement PCARE. DHO did not support PCARE integration with the HIS but SIKDA	Staff adaptation to Use PCARE along with the HIS	PCARE could not be integrated with the HIS, due to platform limitation (client-server)	the extra workload for staff to input the same data into two HIS
DHO decision to implement SIKDA in all PHCs by 2018/2019. IBRA PHC negotiated the condition for SIKDA migration (until it is mature enough)	Staff readiness with some notes that SIKDA should be better than the existing HIS	HIS is still used and influence recording and reporting in GP clinics (morbidity reports) and registration unit	The existing HIS is still used along with the paper-based system and PCARE implementation

Notes: Black font indicates contributing factors to network stability. Blue font indicates contributing factors to the network instability