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POLICY BRIEFS

Towards sharable and longitudinal medical records for e-health in Indonesia using an Australian-based *open*EHR standard

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About this policy brief

Medical records provide a complete summary of patients' health histories. Ideally, each person has a longitudinal medical record, detailing their health history since birth. Accurate diagnosis often depends on the completeness of this medical history. Indonesia does not have a national standard for the format of medical records, and thus every hospital develops their own way for storing medical records. Another problem is that medical images are not currently linked to patients' historical data, but are stored independently. This is partly because the media storage capacity and communication bandwidth needed to store and access medical images through a network are severely limited. To address these problems, our project has adopted openEHR, an Australian standard that has been recognised worldwide. We designed and tested a system using the openEHR standard, which also features our Pictorial Archiving and Communication Systems (PACS) that compresses medical images efficiently, in two public health centres in West Java with Bandung Institute of Technology (ITB) as the medical data centre. Our results show that the system is potentially scalable to a nation-wide system to achieve sharable and longitudinal medical records.

About the authors

David Taniar holds Masters and PhD degrees in Computer Science. His research expertise is in data management and processing. He has co-authored two books on databases, and has published more than 200 research papers. He is the founding editor-in-chief of six international journals, including the *International Journal of Data Warehousing and Mining*, *International Journal of Business Intelligence and Data Mining*, *Mobile Information Systems*, *Journal of Mobile Multimedia*, *International Journal of Web Information Systems*, and the *International Journal of Web and Grid Services*. He is currently an Associate Professor at the Faculty of Information Technology, Monash University, Australia.

Tati Mengko earned her PhD from ENSERG-INP Grenoble, France in 1985. She has been with the Department of Electrical Engineering, ITB (Institute of Technology Bandung, Indonesia) since 1977. She was Head of Department from 1995-98, Head of Microelectronics Inter University Research Centre in 1999, and Dean of Faculty of Industrial Technology in 2001. She is currently Head of Biomedical Research Division in the School of Electrical Engineering and Informatics. She then became a professor at the School of Electrical Engineering and Informatics in 2007. Her current research interests include image processing, medical imaging, and e-health.

Andriyan Bayu Suksmono graduated with a Master (MSc) in Electrical Engineering from ITB in 1996 and obtained a PhD in Engineering from the University of Tokyo in 2002. He is now an Associate Professor in the School of Electrical Engineering and Informatics at ITB. Andriyan received an APNNA Award for his work on Ultrawideband Neuro-Beamforming in 2004, and the Outstanding Faculty Award, from ITB, in July 2007, and again from the Indonesian Government in August 2007.

Wenny Rahayu is currently an Associate Professor at the Department of Computer Science and Computer Engineering La Trobe University, Australia. Her major research is in the area of object-relational databases, web databases and semantic web and ontology. She has published more than 70 papers in international journals and conference proceedings, and has co-authored two books in data management. Her PhD thesis was awarded the Best PhD Thesis Award 2001 by the Australian Computer Science Association. Currently, she is involved in a number of large projects in software development in collaboration with several industry partners in Australia.

Heather Grain is a senior health informatician with more than 30 years experience, having designed and implemented systems for national health information system infrastructure, in Australia and overseas, for governments, hospitals, community health, district nursing and general practice. She is an active health consumer representative and is active in national and international strategic development of Electronic Health Records having sat in on many national data and information related committees. She Chairs Standards Australia's Health Informatics Committee and international working groups at ISO and HL7 (Health messaging standards) and sits on the Quality Assurance Committee of the International Health Terminology Standards Development Organization. Heather is a Fellow of the Australian College of Health Informatics and is experienced in providing education in Health Informatics in Australia, China and Brazil.

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G.A. Putri Saptawati earned her doctorate from ITB in 2008. She has been with the Informatics Department of ITB since 1993. She was also the Head of the Database Laboratory from 2008-09. Currently, she heads the Informatics Study Programs at ITB. Her research interest is in the field of database technology (especially data mining) and its applications in health and medical informatics.

Antonius Darma Setiawan completed his Masters degree at ITB in 2007, where he is currently a PhD student. His primary research area is in image compression and he has published a number of papers in this area. He has been a team member of a number of projects funded by ITB and The Ministry of Research and Technology, Indonesia.

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Introduction

Medical records provide a complete summary of patients' health histories (Eichelberg et al, 2005). Accurate diagnosis is often heavily dependent on the availability of a patient's complete historical medical record. Ideally, each person has a longitudinal record, which is a medical history of what has happened to them since birth. It archives diseases, major and minor illnesses, as well as important points during the growth stages of childhood. This medical information gives clinicians clues about the current state of health of the patient.

Longitudinal sharable medical records allow patients to move freely from one healthcare provider to another and still have their new healthcare provider fully informed about their personal health history. Patients might also need to access their own medical records from time to time.

However, patients' medical records have typically been scattered between many health institutions, stored using many different formats, some written, and some electronic. Clearly, this situation undermines the utility of medical records to assist diagnosis. Unfortunately, medical records in Indonesia are fragmented, partly due to the lack of a common standard for organising and storing information. Every hospital has its own way of organising and storing information. This fragmentation prevents patients from having a single complete and longitudinal medical record.

Information technology offers a solution to this problem by storing medical data in a digital (electronic) format. Consequently, electronic health records (EHR) have been emerging as an essential tool of healthcare providers. EHR is now widely used across the world. However, EHR alone does not solve the problem of record sharing because every health institution has its own EHR format. In Indonesia, there is no standard for storing medical records. There are several standard formats for storing medical record data in the world, including the USA-based standard HL7, and a European-based standard, CEN. A new and emerging standard based on a semantic technology, called *open*EHR, has been developed in Australia partly by Ocean Informatics Pty Ltd and has been recognised worldwide (*open*EHR, 2009). This standard enables the exchange of data to and from HL7 and CEN. The *open*EHR standard, as a communication protocol for sharing EHR, has been proven to be clinically accurate. Through this protocol, two or more EHR systems may communicate with each other.

Another problem is related to how Indonesian hospitals record one's health history. A majority of hospitals or health institutions in Indonesia record health history in text format only. Medical images related to each patient are not linked to the patient's historical data, but are stored independently. One of the main reasons for this mutual exclusion between patient's textual records and medical images is that the media storage capacity and communication bandwidth which are needed to store and access medical images through a network are severely limited. Telecommunication infrastructure in Indonesia currently does not support the wide bandwidth that is essential for image data transfer. Hence, to facilitate the integration of medical images with patient records and their sharing between healthcare providers, it is critical to develop methods for compressing medical images that achieve a high compression ratio while retaining important information in the images.

Therefore, Indonesia has two immediate needs for realising a sharable and longitudinal multimedia medical record system:

i. To adopt an *open*EHR implementation; and

ii. To develop an efficient medical image management system, particularly for the storage and compression of medical images. These images should be integrated and accessible through personal computers and other portable devices.

The *open*EHR standard and its adoption in Indonesia

Researchers from Bandung Institute of Technology (ITB) started a pilot project on *open*EHR two years ago with an initial grant from the Ministry of Research and Technology, Indonesia. The recommendation from this pilot project was that the Australian-based *open*EHR standard was appropriate for the Indonesian context to help provide better patient care, especially in terms of sharable and longitudinal medical records (Ministry of Research and Technology, 2007-09). Based on these preliminary findings, the ITB team sought to collaborate with Australian researchers from Monash and La Trobe universities to implement a standard test-bed.

The *open*EHR Foundation (*open*EHR, 2009) is an international not-for-profit company aiming at making the interoperable, life-long electronic health record a reality and improving healthcare in an information-based society. *open*EHR's mission is to promote and facilitate progress towards high quality EHR, to support the needs of patients and clinicians everywhere. *open*EHR is an open standard for electronic health records which consist of two major parts: medical record storing; and medical data exchange.

At the moment, there is no national policy in Indonesia that sets a standard for the format of medical records. This means every medical institution develops its own medical record formats. To implement an *open*EHR system therefore requires extensive modifications. Our research has designed an architecture of medical data exchange based on *open*EHR.

Using *open*EHR specifications, we can develop adapters to export any medical format into an *open*EHR format (Leslie, 2008; Gök, 2008). Adapters are installed in health institutions to export data into an *open*EHR format to an *open*EHR server which is located in a data centre. Figure 1 gives a brief illustration of a proposed

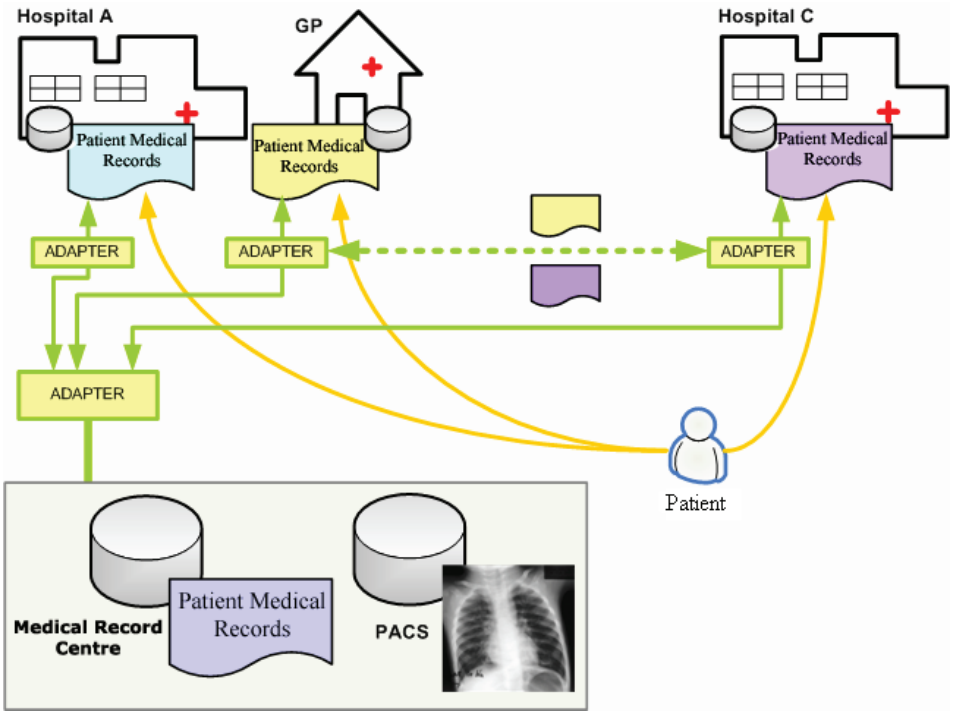

Figure 1 **A brief diagram of *open*EHR implementation in Indonesia**

*open*EHR architecture for Indonesian health institutions. A patient that has visited and received care from Hospital *A*, a GP, and Hospital *C* has his/her medical records stored locally in each of these locations. An adapter in each location is installed as a gateway to facilitate communication with a medical records centre, which stores the complete longitudinal medical records, including medical images in a Picture Archiving and Communication System (PACS). Through these adapters, *open*EHR allows exchange of medical records between healthcare providers that are part of the system.

This design has been tested with two healthcare providers, both public health centres, in Bandung and Banjar cities in West Java province. The medical record centre server was located at the Bandung Institute of Technology. The results demonstrated that we could exchange medical record data between institutions with different formats using *open*EHR. This result indicates that we do not have to change all medical standards in Indonesia into HL7 or CEN format to form longitudinal medical records.

Compression of medical images: challenges in data storage and network capacity

Storing medical images with medical records is not required by law in Indonesia, and there is no format standard for storing medical images. Most medical institutions do not retain medical images on behalf of their patients, but are the responsibility of patients themselves to store.

Storing and transferring medical images electronically requires large capacity storage media and telecommunications bandwidth, because the size of digital medical image is generally very large. In Indonesia, where the telecommunications

bandwidth is narrow, coupled with a severely limited storage capacity, storing medical images in conjunction with medical records is very difficult. Efficient image compression is needed to overcome the storage capacity and telecommunication bandwidth problems.

Medical images should be stored and viewed without loss of information, as missing information could affect physicians' diagnoses. Medical images cannot be compressed using a lossy compression, where some features of the image are lost during the compression. A lossy compression generally produces a maximum compression ratio – that is, the size of a compressed image is far smaller than that of the original image. Medical image compression cannot adopt a lossy compression for the aforementioned reason, however, the narrow network bandwidth requires images to be compressed.

As there is no standard or policy regarding the storing of medical images, we developed the *Pictorial Archiving and Communication Systems* (PACS) over a scalable scheme image compression. Image compression is applied to minimize the capacity of image storage and also the transmission bandwidth. The network architecture of PACS is shown in Figure 2. PACS is designed to be accessed using a PC (personal computer) or PDA (personal digital assistant). Making it accessible via a PDA (see Figure 3) is designed to support a user's mobility.

Our work has demonstrated how a lossy-to-lossless, or scalable, image compression can be created that is suitable for medical images. This scalable scheme will help physicians to enhance the reconstructed image to the same quality as the source image. If a physician needs a closer view of a certain area, a *Region of Interest* (RoI) covering that area will be enhanced using an image residue. The residue data of the chosen RoI is added to the reconstructed image (see Figure 3d).

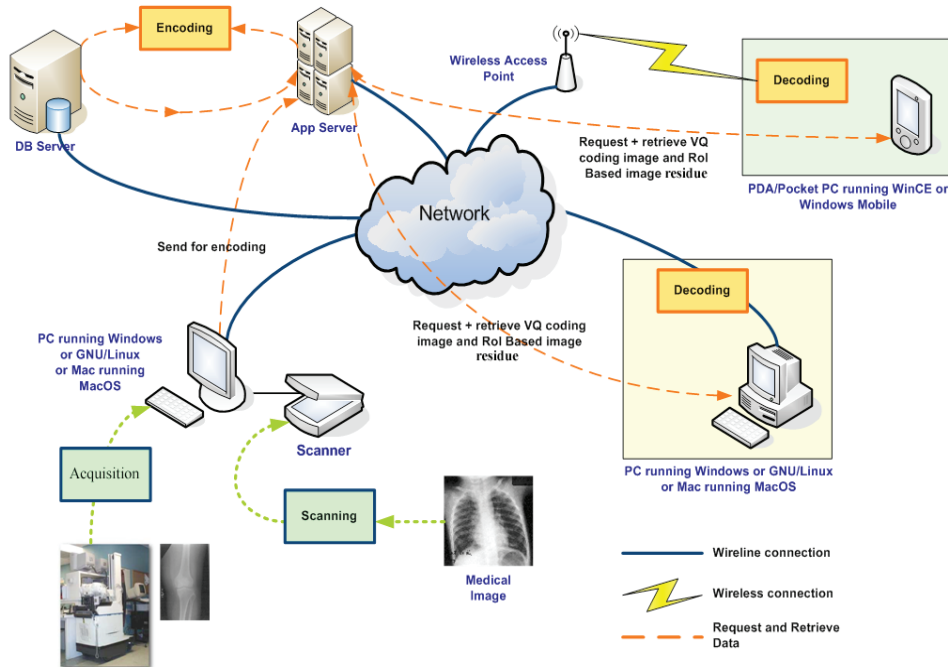

Figure 2 **Architecture of the PACS system**

Expected benefits

A sharable and longitudinal multimedia medical record system offers benefits for patients, healthcare consumers, providers and policy-makers. An obvious benefit to patients is that a longitudinal multimedia medical record gives a patient a complete view of their entire medical history. Providing patients with information about their health history encourages patients to take responsibility for their health and exercise self-care to reduce the likelihood of preventable illness. In

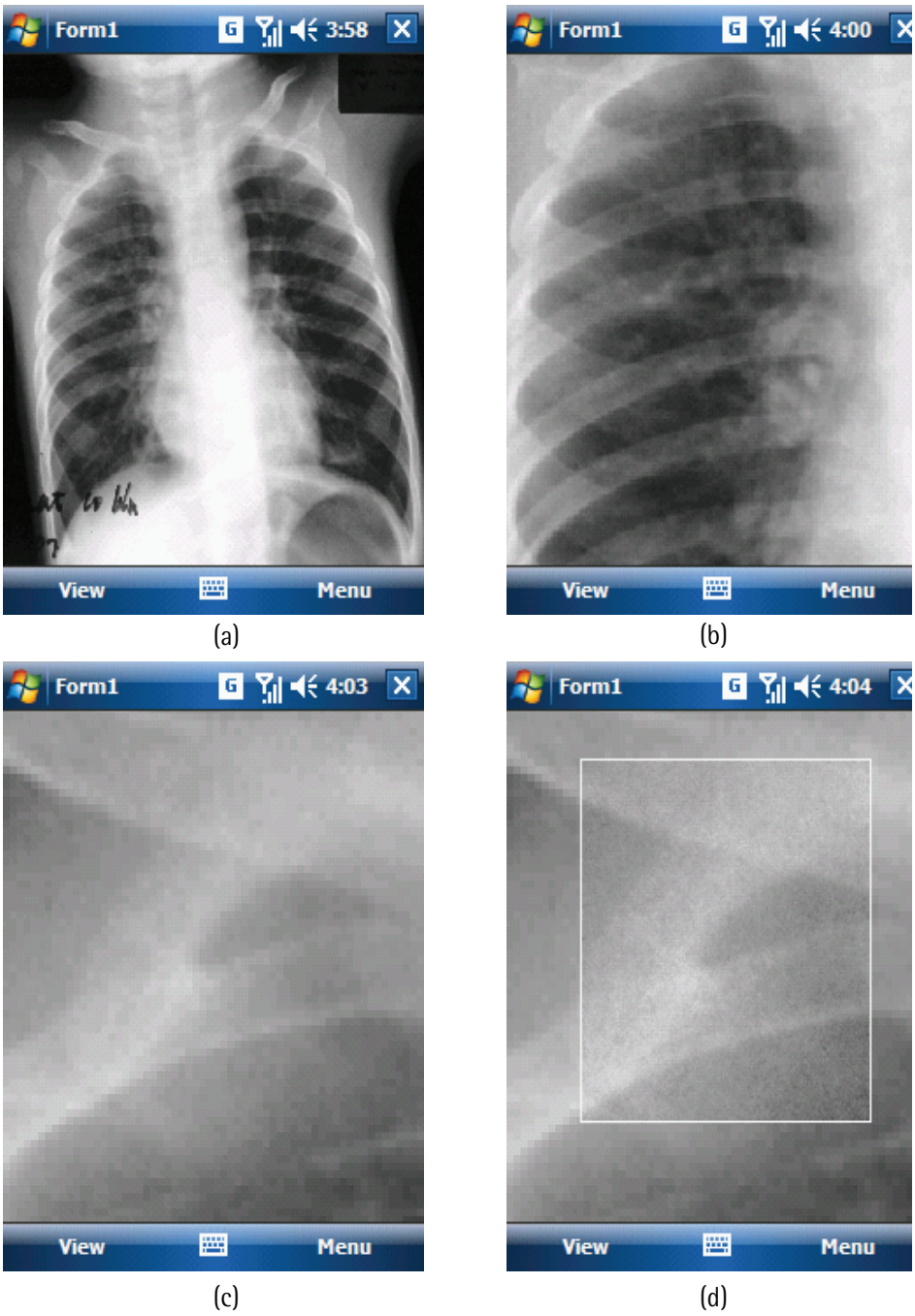

Figure 3 **The implementation of PACS based on a scalable image compression on PDA: (a) image sized to fit screen size (b) zoomed in at 33% (c) zoomed in at 100% (d) enhanced image over the Region of Interest (RoI) selection.**

other words, healthcare consumers are empowered to take a proactive approach to managing their own health. Better quality and more complete medical records also encourage accountability of health professionals, leading to improvements in standards of diagnosis and care.

Efficient exchange of information among healthcare providers regarding a patient's medical history supports a collaborative care and case management approach to providing healthcare services. Longitudinal, sharable medical records also support continuing assessment of individual cases, and form important medical knowledge databases, which support clinical research and medical education, as well as assist clinical audits.

Sharable and longitudinal multimedia medical records will help the Indonesian government to create an accurate statistical picture of the state of the nation's collective health, which is essential for effective decision making and health policy development, as well as evaluation of impacts of national health programs. Better targeted public health policy is likely to lead to a more healthy population.

Moving to a shareable medical records system based on the Australian standard *open*EHR would make it possible for health institutions in Indonesia and Australia to exchange medical record data (especially in treating Indonesian patients in Australia). This would suggest new opportunities for improved collaboration between health departments and healthcare providers in the two countries.

Recommendations

Our recommendations are categorised into the following areas: (*i*) systems, (*ii*) models, (*iii*) personnel and training, and (*iv*) policy considerations.

Systems

The Australian-based standard *open*EHR should be adopted, as it is highly suitable for the Indonesian context, and would provide a means of sharing medical records data currently stored in different formats. By adopting this standard, the Indonesian system would also be able to communicate with not only Australian health institutions, but American and European institutions, as *open*EHR bridges the American and European standards. A scalable image compression system for medical images which utilises a lossy-to-lossless scheme should be adopted. With this compression method, not only does the medical image retain high fidelity during the coding and encoding process, but a maximum compression ratio is attained. Our *Picture Archiving and Communication System* (PACS) is recommended.

Models

Three possible models for implementation of a sharable and longitudinal multimedia record system incorporating PACS should be considered.

Model 1 (*Centralised Model*): A centralised model consists of a central medical data centre collecting medical records from each participating health institution, which gathers patients' medical records using an *open*EHR standard. These records are then transmitted to a centralised medical data centre through *open*EHR adapters. When a patient visits a health institution, his/her longitudinal record is provided by the central medical data centre. Figure 1 shows an illustration

of a centralised model. The main drawback of this model is that it puts a heavy workload on the central medical data centre, as it needs to communicate on a one-to-one basis with each participating local health institution and to maintain global data consistency. For nationwide coverage, this model can be regarded as the most expensive system.

Model 2 (*Autonomous Model*): An autonomous model is exactly the opposite of the centralised model. An autonomous model gives each health institution full autonomy to maintain the medical records of its patients. Peer-to-peer communication with other health institutions needs to be established in order to form complete medical records of some patients. The rationale for this model is that the majority of patients will only visit a small number of health institutions (and normally one 'home' health institution), and hence communication is only needed with a small number of other health institutions. The main drawback is that many rural health institutions do not have the capacity to run their own autonomous medical records system, and requiring them to maintain a complete computerised system might be a difficult burden.

Model 3 (*Hierarchical Model*): A hierarchical model combines the centralised and autonomous models. This is perhaps the most suitable model to be adopted in Indonesia. A hierarchical model consists of clusters of centralised models, whereby rural health institutions are grouped according to their geographical regions, and each of these clusters is autonomous. Using this model, a relatively large hospital in each region acts as a medical data centre gathering medical data from rural areas. It must be stressed that this 'medical data centre' plays a role as *data mediator*, and might not necessarily maintain the data itself. Instead, it acts as a *data conduit,* receiving data from the various institutions within its cluster, which is then transmitted to the proper organisations. These medical data centres would then communicate with other medical data centres when necessary.

Personnel and training

Three types of personnel are involved in this system:

Operators: Training for computer operators could be conducted through currently available training structures in the Department of Communication and Information.

Clinicians: Clinicians need to be actively involved in the EHR design process. Their input on improving the accuracy of medical images must be sought.

Management: Establishing an *openEHR* adoption policy for health institutions in Indonesia would need to include development of structures and practices regarding the management and maintenance of medical record data.

Policy considerations

We recommend consideration of two types of policy approaches to issues of EHR interoperability.

Voluntary participation: This approach would not involve nationwide regulations from the National Department of Health to impose EHR interoperability. It is generally accepted that the more information clinicians have about a patient's health history, the more likely they will be able to accurately diagnose the patient's

current condition. However, many patients are reluctant to provide a complete medical history, due to privacy, security, or political concerns. A voluntary scheme allows patients to choose whether to opt in and have their records on the system, or opt out and not have them on the system.

Compulsory participation: Under this approach the Department of Health would determine policy for governing use of information with an Electronic Health Record (EHR) system. There are potentially many issues raised by compulsory participation, such as governance of the health record environment. A recent study by the Canadian Health Infoway (2007) addresses some of the issues of information governance with privacy and security implications for personal health information, requirements for information governance, and information governance structures and mechanisms. It is imperative to consider where responsibility for information governance will reside. As sharable and interoperable EHR changes the environment within which information flows, the rules related to information collection, use, disclosure and management in a sharable and interoperable EHR environment must bear careful consideration. All of these issues require complex legislation, and must address regulatory and ethical matters.

Potential obstacles

Although it was beyond the scope of this research to attempt to estimate the cost of the proposed system, costs for computing power, data storage, and network communication are constantly declining, due to widely available equipment in the market place. Further, the fibre optic telecommunications network, which is already in place in Indonesia, initially planned for e-Learning, can also be used for e-Health.

One of the biggest obstacles is actually not related to the infrastructure itself, but to effecting a complex transition involving large numbers of personnel and requiring cultural and attitudinal change among them. Health clinics in rural areas have limited qualified personnel to operate a computer system. Larger hospitals where the computing infrastructure is already available may refrain from sharing their data to other institutions, for various reasons, such as trust, privacy, and financial issues. Radiologists and clinicians might still rely on hardcopy medical images, rather than electronic versions. However, by providing adequate training, and raising awareness among management and clinicians of the benefits of the system, it should be possible to affect an attitudinal shift toward acceptance of the new technology. Privacy is a major issue when people's medical records are involved. Appropriate legislation and safeguards will need to be developed to ensure personal medical information is not shared with parties other than healthcare providers.

References

Canada Health Infoway, 2007. *White paper on information governance of the Interoperable Electronic Health Record (EHR)*, Canada Health Infoway.

Eichelberg, M, Aden, T, Dogac, A, and Laleci, GB, 2005. 'A survey and analysis of Electronic Healthcare Record Standards', *ACM Computing Surveys*, 37(4):277-315.

Gök, M, 2008. *Introducing an openEHR-Based Electronic Health Record System in a hospital – case study Emergency Department, Austin Health*, Melbourne. Unpublished Masters Thesis, The University of Göttingen.

Leslie, H., 2008. 'International developments in openEHR archetypes and templates', *Health Information Management Journal*, 37(1):38-39.

Ministry of Research and Technology, 2009. *Rekam Medis Multimedia berbasis openEHR Untuk Pengobatan Komplementer/Tradisional dan Modern, Research Incentive Report*, Ministry of Research and Technology, Indonesia.

*open*EHR, 2009. The *open*EHR Foundation, viewed 7 November <http://www.openehr.org>.

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