CHALLENGES AND OPPORTUNITIES IN SRI LANKAN HEALTH INFORMATICS: AN EDUCATIONAL PERSPECTIVE

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ABSTRACT

Health informatics facilitates data analysis maintaining a better patient-physician relationship, pulling correct information to the surface and bringing new perceptions to current healthcare issues. It makes available the information to health professionals and patients using innovative technologies, streamlined processes with best practices, and meeting regulatory standards.

In this study, we focus mainly on identifying the most prevalent challenges of Sri Lankan health informatics in the strategic lenses of education & training and propose a framework to address the challenges. A need and gap analysis was performed to identify the relevant stakeholders, their needs and the gaps. In building the framework, it focuses on identification of the ways to fill the gaps in healthcare industry and suggests steps to improve current status with proper collaboration and standardization.

A systematic review has been carried out using online databases such as Science Direct, and Pubmed using key words Clinical Health Informatics, Health Informatics Education, Gap Analysis, Challenges, Needs and Opportunities.

Keywords: Health Informatics, Education, Challenges

INTRODUCTION

Health informatics is a discipline of information technology, social science, behavioral science and healthcare. It consists of resources, devices and methods required to optimize the acquisition, storage, retrieval and use of information in healthcare sector. Health informatics facilitate data analysis maintaining a better patient-physician relationship, pulling correct information to the surface and bringing new perceptions to current healthcare issues. It makes available the information to health professionals and patients using innovative technologies, streamlined processes with best practices and regulatory standards.

Health informatics (HI) provides physicians doing ward rounds the accessibility to their each patient's complete medical history on his/her tablet or smart phone. These information can be lab results, x ray images and contact information for other care providers. The physicians will be automatically alerted if his/her patient shows a critical change in their health parameters. (e.g.: blood pressure, sugar level)

It means clinicians can easily improve patient accrual, manage real time alert of critical events and facilitate site and patient monitoring.

Health informatics also provides patients the accessibility to their health records including prescription medications, lab results, radiology and treatment plans on their smart phones. This also allows the communicating of the results from their own device to the providers too.

HI allows efficient access of information of global health and the globally improved quality of care at reduced cost. HI also facilitates epidemiology studies, prevention and early detection.

Consumer Health Informatics
Consumer health informatics is "the use of the modern computers and telecommunications to support consumers in obtaining information analyzing their unique care needs and helping them make decisions about their own health"
(Lewis et.al, 2005). This key definition acknowledges the importance of the use of computer and information technology to support the process of health information delivery in an integrated manner to healthcare consumers. They also consistently focus on the importance of meeting the consumers' personal information needs.

"First because of its' frequent patient-centered approach, consumer health informatics may have an even stronger overlap with public health. In addition, the designs of consumer health informatics applications require more frequent input from patients and consumers" .When the patients have a serious medical concern they do not just accept whatever the treatment their local doctor offers. They will spend hours and hours on internet learning about their condition, communicating with other patients and physicians who share their interests, and tracking down every lead they can find on the best new treatments (Lewis et.al, 2005).

It is delineated 10 levels in which consumers participate in the access and use of healthcare information.

The levels are described as,

Level 1 - e patients search for health information.
Level 2 - e patients exchange e-mails with family members and friends.
Level 3 - e patients seek guidance from online patient helpers.
Level 4 - e patients participate in online support groups.
Level 5- e patients join with other online self-helpers to research their shared concerns.
Level 6 - e patients use online medical guidance systems.
Level 7 - e patients interact with volunteer online health professionals.
Level 8 - e patients use the paid services of online medical advisors and consultants.
Level 9 - e patients engage in electronic conversations with their local clinicians.
Level 10- e patients receive one-way electronic messages from their clinicians.

The model proposed for consumer health informatics places the consumer at the center of the process of information transformation (Lewis et.al, 2005). This model illustrates how relevant and valid information integrated appropriately into an environment of shared decision-making can improve both the satisfaction with the process of care delivery and measurable outcomes reflected in consumers' health status. Information technology, as a mode of message/information transfer, serves to assemble and process the information and act as a catalyst for feedback. Healthcare consumers work with their healthcare providers to assemble and understand the retrieved information in the context of their personal health concerns.

The ideal system output is an informed healthcare consumer who is making health choices based on personal health goals that leads to improved health outcomes.

Public Health Informatics

Public health includes responding to the health needs of individuals as well as populations. Prevention is a primary focus. The Internet, computer resources and mobile devices such as cell phones and personal digital assistants (PDAs) are increasingly available in the developing world. Public health professionals are adapting these technologies to the health care setting.

The avenues of technology and public health meet at the intersection of public health informatics (PHI). PHI is the systematic application of information and computer science and technology to public health practice, research and learning. PHI strategies are increasingly used to obtain a complete picture of a population's health and risk status and to support effective public health data flow and decision making in both urban and remote locales (Becker et.al, 2001).

Pharmaceutical systems informatics

Pharmaceutical systems informatics sits at the intersection of data, science, and technology and includes the basic functions of the pharmaceutical management framework, such as selection, procurement, distribution and use. Medicines are an essential component of health care systems in developing countries, accounting for one-third or more of a government's health services budget. It is common for 20 to 50 percent of the recurrent government health budget in developing countries to be used to procure drugs.

Like other parts of the world, developing countries need essential, quality-assured medications to be available continuously and distributed in a timely manner to those who require them. Stakeholders are at every level need information to make decisions that affect the overall functioning of medication systems. For example, a good pharmaceutical management information system should alert staff to problems and trigger critical actions on multiple levels whether the problem is related to the supply chain or to patients' use of prescription drugs (Falkenberg & Tomson, 2000)

Bio Informatics

Bio informatics is the application of computer technology to the management of biological information. Computers are used to gather, store, analyze and integrate biological and genetic information, which can then be applied to gene-based drug discovery and development. The need for Bio informatics capabilities has been precipitated by the explosion of publicly available genomic information resulting from the Human Genome Project. The science of Bio informatics, which is the melding of molecular biology with computer science, is essential to the use of genomic information in understanding human diseases and in the identification of new molecular targets for drug discovery (Bhuyan, 2010)

Clinical Informatics

Clinical Informatics is the scientific discipline that seeks to enhance human health by implementing novel information technology, computer science and knowledge management methodologies to prevent disease, deliver more efficient and safer patient care, increase the effectiveness of translational research, and improve biomedical knowledge access.

Health informatics has become an interesting and widely used topic in health care sector lately. Physicians and other healthcare providers tend to use and practice health informatics solutions as it makes the healthcare process efficient and more quality.

Although Sri Lanka understands the potential benefits of embracing HI, there are many challenges prior to its adoption. When continuing the literature review it seems that most of these challenges are included in health informatics education sector and implementing health information systems and data management.

When it comes to health informatics education in Sri Lanka, there are less opportunities to receive a proper education in health informatics. Currently only one post graduate degree program is offered by University of Colombo, which is MSc in Bio Medical Informatics. Apart from that, many sessions and conferences are conducted to educate physicians and nurses on health informatics by Health Informatics society of Sri Lanka (HISSL). Some of the challenges are computationally and storage intensive in nature and are further complicated by an increasing emphasis of faulty tolerance, data redundancy and scalability. Although, there are many opportunities from implementation of health informatics to health care sector these are not properly identified and implemented. So there is a growing need of addressing these challenges and making them future opportunities.

When it comes to health informatics education in Sri Lanka, there are less opportunities to receive a proper education in health informatics. Apart from degree programs like MSc. in Bio medical informatics offered by university of Colombo, many sessions and conferences are conducted to educate physicians and nurses on health informatics by Health Informatics society of Sri Lanka (HISSL). Some of the challenges are computationally and storage intensive in nature and are further complicated by an increasing emphasis of faulty tolerance, data redundancy and scalability. Although there are many opportunities from implementation of health informatics to health care sector, these are not properly identified and implemented. So there is a growing need of addressing these challenges and making them future opportunities.

Therefore, main objectives or carrying out the research include;

- Identify and analyze gaps and needs of health informatics practices and processes in healthcare sector.
- Conduct a survey on literature to see the prevalent challenges and opportunities in health informatics education sector. The applicability of the solutions implemented for other countries to the Sri Lankan context.
- Create awareness about opportunities and benefits of proper implementation of health informatics in Sri Lankan healthcare sector as it will contribute to decision-making process in healthcare sector.

Scope of the study is limited to Sri Lankan government sector where government healthcare sector and government health informatics education will be concerned. Currently as Sri Lankan government is more concerned with clinical informatics in the sense of health informatics, the outcome for the Sri Lankan context will be focused mainly on clinical informatics processes.
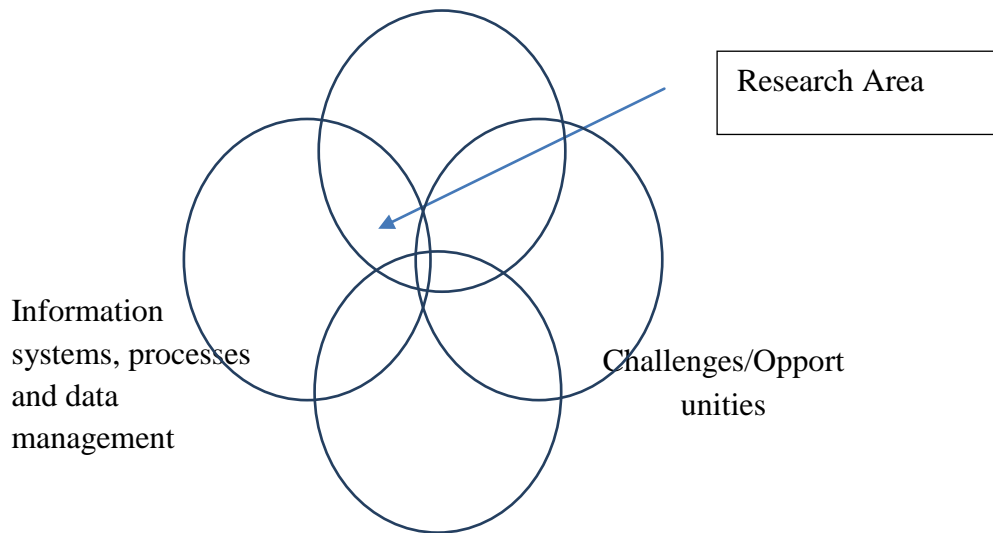
Clinical Health Informatics

Figure 1: Scope of the project

Here, main areas will be concerned.

Those are,

- Gap and need analysis in clinical health information systems and processes related with government healthcare sector.
- Challenges /opportunities in health informatics training and education.

These areas will be critically analyzed aligned with Sri Lankan context to arrive at conclusions.

The stakeholders benefited by the research are shown below.
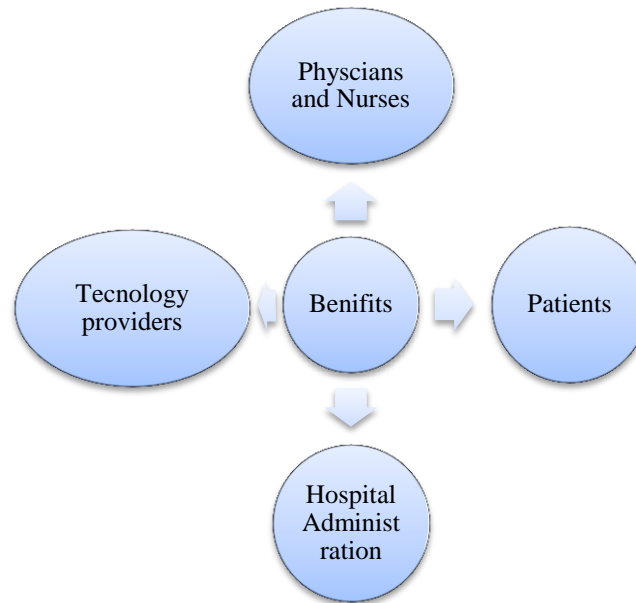
Figure 2: Stakeholders benefited by the research

Some benefits for the stakeholders that could be expected are described below.

Table 1: Benefits received by each stakeholder

Stakeholder	Benefits
Physicians and Nurses	• Improves quality by giving timely access to important clinical information. • Mobilizing new resources. • Ensuring accountability and accuracy of the data and information. • Convenience of handling big data. • Reduce the need of paper based systems.
Hospital Administration	• Help detect and control emerging and endemic health problems. • Monitor progress towards health goals. • Promote equity in health care by empowering the citizen with timely and relevant health-related information. • Drive improvements in quality of service. • Strengthen the evidence base for formulating effective health policies, permitting evaluation of scale-up efforts. • Enable innovation through research and improves efficient use of resources by way of effective stock controls.
Patients	• Build trust about health informatics systems. • Experience convenience.
Technology Providers	• Provide more quality technology solutions. • Able to cater to the needs of consumers.

LITERATURE REVIEW

Health Information Systems

Health information systems refer to any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organizations that

Some of the actual benefits of current and future health information systems can be summarized as follows:

Table 2: Benefits of Information Systems

Health Information Systems	Benefits/Challenges that can be minimized
EHR (Electronic health record) Systems	• The benefits will be accrued by several stakeholders such as physician practices, ancillary services, pharmacies and most importantly patients • Reduction in average length of stay • Reduction in cost of clinical documentation with EHR • Gaining significant benefits in reallocation of nursing time from manual documentation to direct care
E-Prescriptions	• Many errors occur because of handwritten prescriptions that can be easily misunderstood and can result in adverse drug events or complications. • Ambulatory care deaths and many deaths in acute care attributed to medication error can be minimized. • National savings from universal adoption could be as high as $27 billion annually.
Computerized Provider Order Entry (CPOE)	• Eliminates over 2 million drug events per year. • Avoid nearly 13 million physician visits, 190,000 admissions and over 130,000 life-threatening adverse drug events per year and save $44 billion per year. • 55 percent reduction in serious medication errors and 17 percent reduction in preventable Adverse Drug Events. • Children's Hospital of Pittsburgh has eradicated handwriting transcription errors completely and cut harmful medication errors by 75 percent.
Complementary & Alternative Medicine (CAM)	• Application of CAM procedures into a patient's electronic health record (EHR), more accurate measurements of outcomes can be generated.
Wearable Intelligent Technology Systems (WITS)	• Pervasive computing and wearable technologies will have a radical impact on future healthcare delivery systems. • Allow physicians to treat patients and complete their rounds, while connected via wireless networks to computerized patient records. • Allow physicians to remotely observe patients' vital signs and monitor progress of surgery from outside of the operating room using handheld devices.
Genomic Information Systems & Bio-Repositories	• A goal for genomics will be to transform knowledge about the human genome into improvements in clinical practice, moving it from bench, to bedside, to bedside a patient anywhere. • Collaboration within this community of genetic researchers, biomedical drug developers and clinicians is essential to make the usage effective.

eHealthcare, Telemedicine	• Reduce the number of visits to actual doctors and providers, and allow patients to be seen and treated at locations of their own choosing. • Lower the per unit cost of care while delivering high quality care conveniently.

Source: (Goldstein et.al, 2008)

Challenges and Benefits of Health Informatics Systems Adoption and Data Management.Challenges related with health informatics differ from country to country. These include internet penetration, low bandwidth, lack of acceptable global standards and privacy, confidentiality and security concerns and lack of patient unique identifier
(Omary et. al., 2010). Though, many countries have identified many challenges related with Health informatics most of all there are many challenges to identify before adoption. Health informatics term varies with respect to its specified functions, stakeholder focus and specified technologies (Pagliari, 2005).

Eisenach highlights 10 promissory e's in e health. Efficiency is one of them. Others stand for enhancing quality, evidence based, empowerment, encouragement, education, enabling, extending, ethics and equity.

Patients can search for medical information like knowledge of healthy life styles, health and self-treatment. The physicians can also search for health information on web for education and research. Another way of improving health care is through collaboration between physicians in different areas within the country. This can be done through video conferencing and discussing issues related to patients. But there can be many challenges like security and confidentiality (Omary, Lupiana, Mtenzi and Wu, 2010).

Table 3: Issues, Challenges and its Suggested Solution

Issues and Challenges	Proposed Solution
Lack of patient's unique Identifiers	Using Birth Certificates Numbers which are uniquely enumerated
Lack of funds	Using FOSS such as Linux and open EHR to reduce cost
Lack of standards	Using e-healthcare standards adopted by other developing countries such as HL7
Manpower issues	Short term and long term training strategies
ICT challenges	Adopt systems that can work in hostile environments, government control over access cost, customization of the systems into local languages

Some of the challenges related with data management are described below.

Table 4: challenges of conventional data management

Challenges	Findings
Misdiagnosis and missing Data	• 44,000 to 98,000 preventable deaths occur each year due to medical errors and most of them are happened in order to misdiagnosis.(Kohn et. al.,2000) • reduce the quality of medical care lead to missed outbreak recognition and defective population health assessment and planning.
Pervasiveness and accessibility	• 80% of world population was within a mobile network by 2008. • The probable health informatics systems in a developing country are developing a system wherein cell phones are used to access a central knowledge base and diagnostic engine. (Heckerman,1991) • Diverse and region specific nature of the diseases and medical conditions. Whereas a solution the rule based expert systems have to be reengineered and customized completely according to the region's condition. (Heckerman,1991)
Data availability	• Data can also be limited regionally by organizations, providers and pharmaceutical companies. • Importing, managing and exporting data via public data sets allow many stake holders to share the same interactive de-identified (private preserving) global database while maintaining control of proprietary and protected data. .(Kohn et. al.,2000)
Analyze the patient's records to come to conclusions	• Clinical decision support systems allow the interaction with the clinician to use his knowledge and the knowledge based system to analyze the patient's records and come to conclusions. Developing this kind of system is one of the ongoing challenges. (Keepanasseril,2011)
Knowledge transition(KT) to right hands	• KT is defined as a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge to improve the health. • It is a challenging task to make sure that the right information is passed along to the right people at the most appropriate time. • Clinicians need to be updated about relevant practice guidelines and recent trends in medical literature. • Patients also need to be provided with right information. • It is a significant challenge for the health profession to device, implement and modify effective KT tools. ('Canadian Institute of Health Research 2011)
Adapting unified medical terminology	• There is a puzzling variety of terms used by clinicians across different systems to represent the same condition. • Ongoing efforts have necessitated the adoption of a 'common language' to bridge the gap between various health providers. • The existing systems have largely been successful to a very limited extent due to lack of ease of use and paucity of adequate effort from clinicians and administrators. • But it is unanimously agreed that adoption of a unified medical terminology system is a prerequisite for seamless healthcare and this remains a challenge for healthcare profession as a whole.
Appropriate data representation	• Data analysis and interpretation represent a major bottleneck in healthcare sector. • Comparison, sharing and exchange of data between different laboratories and platforms across the world would have been extremely difficult due to various differences in data analysis and processing and IP (Intellectual Property) issues. • The implementation of mass spectrometric standard data formats such as mzXM, choice of search engines such as Sequest, Mascot,

	Comet and Tandem and implementations of guidelines for database searching by defining processing parameters were few of the early steps to overcome this problem.
Efficient data Management	• The large volumes of data generated are stored in databases like Global Proteome Machine Database. • Meta data for various disease related studies in health informatics level enhance the chances of uncovering unfamiliar avenues, which may lead to discovery of new biomarkers. • Meta data sharing helps statistically validating a data contributed by several people in the world, and putting the pieces of work from individual scientific groups together to see the emerging picture of a disease holistically. • TCGA(The Cancer Genome Atlas) is a classic example of bodies encouraging data sharing and efficient data management.

Sri Lankan health informatics challenges and opportunities.

District Hospital, Dompe was an ordinary government hospital. The hospital was disorganized, overcrowded and there were unnecessary delays that compromised total patient care. The hospital administration and the hospital staff wanted to change the situation and make the hospital more efficient.

As a result of that a program has been launched to provide efficient health care in Dompe District hospital. The program included attitude changing, improving moral, building team spirit and obtaining optimal use of the abilities of staff. In addition re-arrangement of the hospital setting, provision of specific accesses to each service points especially emergency access and improving the quality of care provided have also been included into the program. A new patient registration desk, Queue Management Centre, and a reception desk were established and 5s concepts were introduced. In addition, an uninterrupted power supply solution was installed with the assistance of donors in the community (Kulathilaka, 2013).

As it was believed that, an information technology solution would help make the hospital more efficient they approached the Information and Communication Technology Agency of Sri Lanka (ICTA) for support.

Dompe General Hospital has experienced these advantages and opportunities with the implementation of health informatics.

Table 5: Opportunities of implementing health informatics at Dompe General Hospital

Opportunities	Description
Patients are easily managed in hospitals.	• Queue management system, and the system generated daily report benefited OPD staff. • The patients have faith in the system.
Improved accuracy of medications	• Availability of drugs immediately. • Accurate, past histories with medication, investigations and demographic data • Plan the patient's management and easily retrieve lab reports. • Doctors can make a more accurate diagnosis. • Rational use of drugs by doctors. • Doctors can also make sure that the ordered

	procedure was performed correctly at the relevant unit. • The doctors can have a look at statistics for their personal interest (eg. the number of patients treated by him/her).
Receiving clear orders from doctors	• Nurses get clear orders from doctors in advance of the patients' arrival, which help them to get ready for treatment. • The pharmacists /dispensers are able to get legible prescriptions with automatic calculation of the number of tablets, making their duty easier. • The Medical Laboratory Technicians receive properly labeled samples.
Utilize man power optimally	• The admin monitors the whole process sitting in his/her room. • Obtaining statistical data is made easy by the system and it helps to utilize labor optimally.
Password protected system	• Hospital staff has limited access to the system so they cannot misuse the laboratory reports • They cannot enter or alter patient's complains. • They cannot misuse prescriptions to the pharmacy

Jayawardena (2014) describes about the relevance of business process reengineering with the experience of Electronic Hospital Information system implementation at District General Hospital Trincomalee. He further states that there are three stages for this re-engineering process as pre-implementation, implementation and post implementation. In order to achieve the objectives through computerization of the hospital functions at the District General Hospital Trincomalee, each unit was studied and then radical changes were brought about by re-engineering the processes with the newly set up of computerization.

Some of the re-engineering processes and benefits of them are described below.

Table 6: Re engineering processes and their benefits

Re engineering Process/Result	Benefits
Issue a Patient Identification number to patients	Easy tracking of patients on their second visits/No duplication of attendance
Record history, examination findings of every patient	Easy retrieval of records
Minimize the use of sheets to request laboratory investigations	Improve medical officers' productivity
Laboratory test results stored, consolidate in one sheet, print only when necessary	No duplication of test on same patient, reduce patient waiting time, eliminate wastage of stationary
Radiological images store in the computer	Easy retrieval of reports, minimize duplication of same film, reduce cost for X-ray filming
On-line theatre time booking	Reduce patient waiting time
Generation of IMMR, Out patient records, notification record, etc.	Accuracy and timeliness of data

Many changes in the clinical process have been occurred with many modules such as clinic visit module, quick patient search module and Laboratory test results information module. It is a main drawback in hospital information in Sri Lanka that OPD statistics are not available. This was one of the main problems occurred during the post tsunami period. But after the implementation of Electronic Hospital Implementation System it is said that it has provided all the details of OPD statistics as mentioned above, which is the best and major advantage of this system.

Generally it can be concluded mainly the quality of care has been improved with automated entry of patient records, laboratory results and the ability to cross check reports as they reduce human error and identify clinical problems quickly. It is stated that automated medication reports and prescriptions improve the safety of drug administration and also multiparty expert consultations can be conducted online, and all the pertinent data are readily accessible by all parties.

The username and password given for the system has improved the security and confidentiality of the data they handle.
Jayawardena (2014) has described the challenges they have to face in each step of the process namely pre implementation, implementation and post implementation. In the pre implementation period, they had to go through the challenge of changing minds of staff from conventional procedure to new system. The Medical Superintendent (MS) had organized several discussions repeatedly for several months to change their minds. Most of the staff also initially did not participate for the training program. At the implementation stage, again getting away from the papers has also become a major challenge because most of the staff was very much familiar with the papers. They were reluctant to use the computer instead of papers. Once they were familiar with the system, they accepted the new system and now it is said that they have accepted it almost completely.

Training and Education Challenges
Most of the obstacles faced by the HI education on a national and international level are identified as intercultural communication, lack of staff with the proper knowledge and skills to stand academic relationship and absence of ideal level of education and most important competencies (Asiri, 2014).

Asiri (2014) recommends all the Arabic HI education institutes to be brought under one unified body such as SAHI. He further says that Saudi informaticians should focus on specialization in different areas in informatics such as bio informatics, public health informatics and clinical research informatics.

Some of the identified challenges related to HI education are described below.

- Unclear Criteria of Ideal Education
  As it is identified this happens due to the unknown educational needs of informaticians and "lack of known best practices for their optimal deployment" (Hersh, 2008). Hersh also mentions the absence of "a clear view of the ideal levels of education and most important competencies to teach such individuals". The fact that "competences of individual informatics educational programs are less well developed, but were recently analyzed and determined to be quite diverse".
  Equally important, Hersh pointed out some of the recommendations of both the American Medical Informatics Association (AMIA), and American Health

Information Management Association (AHIMA) in his paper. These recommendations included "establishing industry-wide advocacy for workforce training and development, utilizing innovative learning environments to train the workforce, developing formal educational programs and promoting their value, disseminating tools and best practices for these new professionals to succeed".

- Intercultural Communication

"Health informatics education itself is becoming increasingly internationalized, requiring professors with cross-cultural teaching skills" (Brillinger & Kagolovsky 2008). They suggest some solutions such as providing courses, as the ones they already provide in their program, in "Intercultural Communication Skills" and "Cultural Diversity in the Workplace".

- Lack of staff with the proper knowledge and skills
Furthermore, In the UK (United Kingdom) between 2000 and 2002, an educational provider national survey was carried out to investigate the level of "education, training, and development (ETD) are being provided in health informatics". In addition, it will investigate to which degree the "provision confirms to the standards specified" in a national consensus document of the gold standards of HI education called "Learning to Manage Health Information". The survey targeted three groups; physicians, nurses and NHS (National Health Services) managers. The results showed that several factors impeded the progress of health informatics ETD in the UK with the factor of lack of staff with the proper knowledge and skills to stand as academic leadership as the most important factor. (Murphy et.al, 2004)

In Saudi Arabia health informatics, health information management and technology and health information systems specialties are only covered in a bachelor and master degrees. The different levels of the available health informatics programs, i.e., bachelor and master, do not cover all requirements and needs of the education sector such as the need for specialists on a PhD level.

This issue also included,

- Lack of understanding of HI among health science educators
- Lack of champions within clinical schools (an absence of trained qualified staff to promote HI and to teach it)
- Crowded curricula which makes it difficult to find time to innovate or experiment
- Too many competing directives, checklists and gold standards which leads to 'let us wait and see what happens' attitude
- Confusion and uncertainty as to who is ultimately responsible for overseeing HI

- Lack of communication and co-ordination
When it comes to the case of Saudi Arabia, different matters represent some serious problems in this sector. To begin with, there is a lack of communication, cooperation and coordination between the health information technology colleges across the country. In addition, there is no coordination between the workplace needs and the numbers of graduates every year. In addition, the low number of

workforce in each discipline does not go well with the demands of the market needs. (Asiri, 2014)

In a nutshell, (Asiri, 2014) states that current health information technology education fails to support an interdisciplinary and synchronous work and communication between all the HIT (Health Information Technology) colleges in the country.

- Health informatics program's curriculum development challenges

In health informatics, curricula development should combine courses from computer science and health sciences. The question that always pops in is; should health informatics curricula be comprised primarily of more health science or computer science? Many programs try to find some sort of harmony between these two disciplines.

A Pakistanis experience reviewed in 2007 the curricula of an already offered health informatics programs in twelve UK and New Zealand universities in order to help develop a curriculum for a training master degree program in health informatics at COMSATS (Commission on Science and Technology for Sustainable Development in South) Institute of Information Technology in Islamabad, Pakistan. The review showed that, in the examined twelve universities, health informatics program curricular were dominated by the health science courses as compared with computer science. Such findings are consistent with the International Medical Informatics Association's (IMIA) recommendations on education (2000) which indicates that out of 60 credits, 40 should be dedicated to "the processing of data, information and knowledge in medicine and healthcare" while 15 credits should focus on the knowledge and skills in computer science. (Malik & Kahn 2007)

Nevertheless, the review identifies some limitations in the courses of HI such as the disagreement in the core modules across these twelve programs as well as the courses' scope variations that would inevitably result in a form of discrepancy in some of the particular skills and knowledge competencies that students would acquire throughout their educational journey. To better prepare students for their future profession, Malik and Khan (2007) suggest that the core competencies of HI courses should be identified and employed by "monitoring bodies and institutions involved in the field".

Sri Lankan Health Informatics Training and Education
Sisira et al. (2005) in his study of medical students, a self-administered survey questionnaire has been distributed to assess the knowledge, attitudes and the level of use of e-learning modalities of medical students. The survey was distributed to all final year students (n=136) studying at the Faculty of Medicine, University of Sri Jayewardenepura (SJU), Sri Lanka. Questions were divided into sections such as demographic details, knowledge and perceptions in e learning, the use of computers and the Internet, the access to e-learning education and barriers for usage. It has been analyzed that only 69% of the students are comfortable using computers, 51% are comfortable with internet, and only 69% have had a formal computer education/training. Although majority of the students are more comfortable and capable with computer usage still there is a significant percentage of students who are not familiar with computers.

Keeping in line with the vision of the Sri Lanka Medical Association (SLMA) for 2012 a series of symposiums on e-Health were held together with the regional conferences of the SLMA in 2012. As Clive C.J (2012) explains the symposium was divided into three main areas. The first focused on introducing e-Health and the process of streamlining its implementation in the health sector of Sri Lanka. The second included e-Health initiatives already undertaken in the Sri Lankan health sector. The third focused on hands on training on some of the e-Health applications already initiated. Medical officers and mid wives have been educated mainly in these sessions on above aspects.

It is said that several examples of e-Health failures around the world which occur due to the lack of coordination were discussed and it was stressed that Sri Lanka should learn from such mistakes and take necessary action so that they do not occur in future.
 In developing human resource capacity of health informatics it is essential to improve the health informatics education sector. Vajira (2010) in his study he has analyzed the contribution of some organizations to this factor.

As Vajira mentioned, it is with the need of developing human resource capacity that the Health Informatics Society of Sri Lanka (HISSL) was launched. HISSL had as its objective the promotion and education of key benefits of e Health such as access to health records at point of care, improved reliability and sharing of records, rapid access to key patient data, timely and supported decision making, improved clinician productivity, reduced errors in diagnosis and treatment, and improved outcomes together with transparency of the health system.

HISSL considers in addressing some identified main e Health challenges that Sri Lanka facing Sri Lanka such as inadequate information, inadequate human resources and infrastructure quality and security of data, legal issues and financial and sustainability issues. Addressing the issue of human resource development also gave rise to the birth of the MSc in Biomedical Informatics at the Postgraduate Institute of Medicine in the University of Colombo. As the study mentions advances made in the field of genomics and systems biology are finding their way from bench to bedside faster than ever before and transforming medicine in the process. Broadening the scope of the course to include biology has been done to introduce and prepare the graduates of the course for the prevailing challenges of introducing and incorporating the above advances of to the systems. It is hoped that they would take leadership in developing future.

METHODOLOGY
The objective of this study is mainly to find the current state of health informatics education in Sri Lanka and find out the applicability of the implemented solutions in other countries to Sri Lankan context.

The research will be started with a literature survey to find out the approaches, gaps and applicability of existing available literature with health informatics education. Then research questions will be formulated.

- What are the gaps and the needs coming from the healthcare sector?.
- What are the prevailing challenges and opportunities in Sri Lankan health informatics education?

- What can be done to minimize the challenges in healthcare education in Sri Lanka?
- What can be done to minimize the gaps in healthcare sector through proper education process?

The literature survey has been done to answer the above research questions using the key words health informatics, clinical health informatics, health informatics education, gap analysis, needs, challenges and opportunities.

DATA ANALYSIS

Literature relevant to above mentioned questions have been reviewed as the secondary data source for the analysis.

Through the literature review, the, aspects and issues given below have been found as the needs of health informatics implementation. The users of health informatics have stated these aspects as some of the requirements of the health information systems as well as processes.

Table 7: Identified Needs of Health Informatics users in clinical process

Objectives	Key Findings
Business process re-engineering	Pre-implementation Implementation Post implementation
Competency	A competent doctor should be able to enter details of a patient in several minutes. A competent nurse should be able to enter the details within a period of 1-2 minutes. An attendant who is familiar with the system can enter demographic details of a patient with in 40-45 seconds.
Change management	Most of the staff members thought it is easy to use paper records than computers. The staff can be reluctant to accept the new system. The change management is one of the important things to be concerned to familiarize the staff with the new system.
Quality of patient care	Increased time doctors, nurses spend with patients • Easy access to information • Improved quality of documentation • Improved quality of patient care • Increased nursing productivity •Improved communications • Reduced errors of omission • Reduced medication errors
Advantages of the password protected system,	1. Hospital staff has limited access to the system so they cannot misuse the laboratory reports 2. They cannot enter or alter patient's complains 3. They cannot misuse prescriptions to the pharmacy
Automated process	1. Automated entry of patient records, laboratory results . 2. Ability to cross-check reports means that human error is reduced. 3. Clinical problems can be identified more quickly.

	4. Automated medication reports and prescriptions improve the safety of drug administration. 5. Multiparty expert consultations can be conducted online. 6. All the pertinent data are readily accessible by all parties.
Security and Confidentiality	Electronic health information systems are potentially vulnerable to authorized or unauthorised access and to misuse of sensitive information. Authorised users may access information with their legitimate authority but with no valid reason for the access, often it may be due to personal interest regarding a relative or a friend or to divulge sensitive information to outsiders who cannot access such information.
Legal Acceptability	The legal acceptance of an electronic patient record by the Sri Lankan judiciary/courts is still an issue which is not covered by Sri Lankan law. Therefore how much effort is taken to eliminate paper work from hospital information system, it is still a requirement to maintain a manual BHT specifically in a case of legal interest.
Cost Containment	The initial cost for the introduction of the system in the Trincomalee General Hospital with hardware, software and the network system was roughly Rs. 10 million (about $US 80,000). The project implementation was funded by the Australian/Swiss Red Cross from 2006-2009 then handed over to the government. The maintenance cost was roughly around Rs. 0.5 million
Data summarization	Provides computationally efficient, interactive data summarizing capability.

These issues can be classified in to main categories as Process, People and Technology. For a better clinical health informatics implementation, these issues have to be better addressed by a proper education and awareness. Specially users of the clinical process have to be given a special training and education based on these aspects.

Many issues can be arisen during the education programs such as poor knowledge and attitudes towards IT.
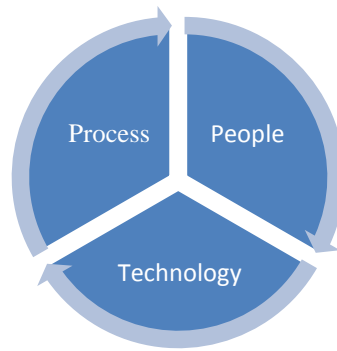
Figure 3: Needs classification

When comparing these areas against with the provided course content of MSc in bio medical science and training specifications of HISSL , it can be seen course areas such as Management of Information in Healthcare Organizations, Ethics in biomedical informatics and clinical decision support systems are aiming these areas. But, when it comes to clinical health informatics, MSc in bio medical science is not explicitly focusing on CHI. So it is recommended to benchmark the content provided by AMIA when improving clinical informatics area.
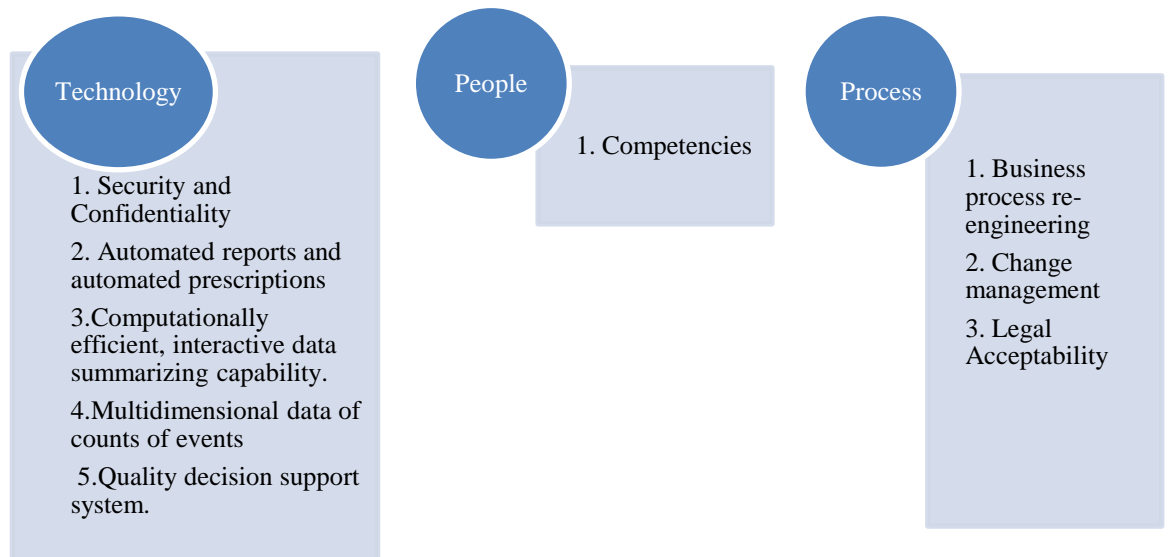

Figure 4: Needs classification with sub areas

It is identified that the only structured post graduate degree on bio medical science was the MSc. in Biomedical Informatics at the Postgraduate Institute of Medicine University of Colombo.

The content of the course is summarized below.

Table 8: Summarized course contents of M.Sc. in Bio Medical Science

Main section	Contents
Computers and Information and Communication Technology	• Historical Developments in Computer and Information Technology. • Basic maths and computational logic • Computer Hardware • Computer Operating systems and Application packages • Data communication and networking • Systems analysis and design • Database Systems • Programming • Object oriented systems development • Internet and the World Wide Web • Web Development Techniques • Tools for online communication • Mobile programming concepts • Research Methods and Basic Medical Statistics
Themes in Biomedical Informatics	• Biomedical data – their acquisition, storage and use • Biomedical decision making – probabilistic clinical reasoning • Cognitive science and biomedical informatics • Essential concepts for biomedical computing • Systems design and engineering in heath care • Standards in biomedical informatics • Natural language and text processing in bioinformatics • Imaging and structural Informatics • Ethics in biomedical informatics • Evaluation and Technology Assessment
Biomedical Informatics Applications	• Electronic Health Record Systems and data exchange • Management of Information in Healthcare Organizations • Consumer health Informatics and Tele-Health • Patient care systems • Patient monitoring systems • Imaging systems in Radiology • Information retrieval and digital libraries • Clinical decisions support systems • Healthcare financing and information technology • Telemedicine • Bioinformatics • Public Health Informatics • Informatics in Medical and Health Professional Education

As it was discovered in a previous survey on medical students, it is mentioned that only 69% of the students are comfortable using computers, 51% are comfortable with internet, and only 69% have had a formal computer education/training. Although, majority of the students are more comfortable and capable with computer usage still a significant percentage of students are not familiar with computers. This could be a future challenge of health informatics as this would create future circumstances of less knowledgeable professionals and more training needs.

HISSL's main contributions for health informatics education by conducting sessions are as follows.

Lack of communication and coordination and Health informatics program's curriculum development challenges are some of the major drawbacks emphasized in most of the literature.

Mostly the opportunities of health informatics in both Sri Lankan and international contexts include the improvement of quality of care and efficiency. Mainly accuracy, timeliness and productivity of data management are considered under quality of care. As challenges, the literature emphasizes changing minds of the staff and training needs and non-familiarity for using the systems.
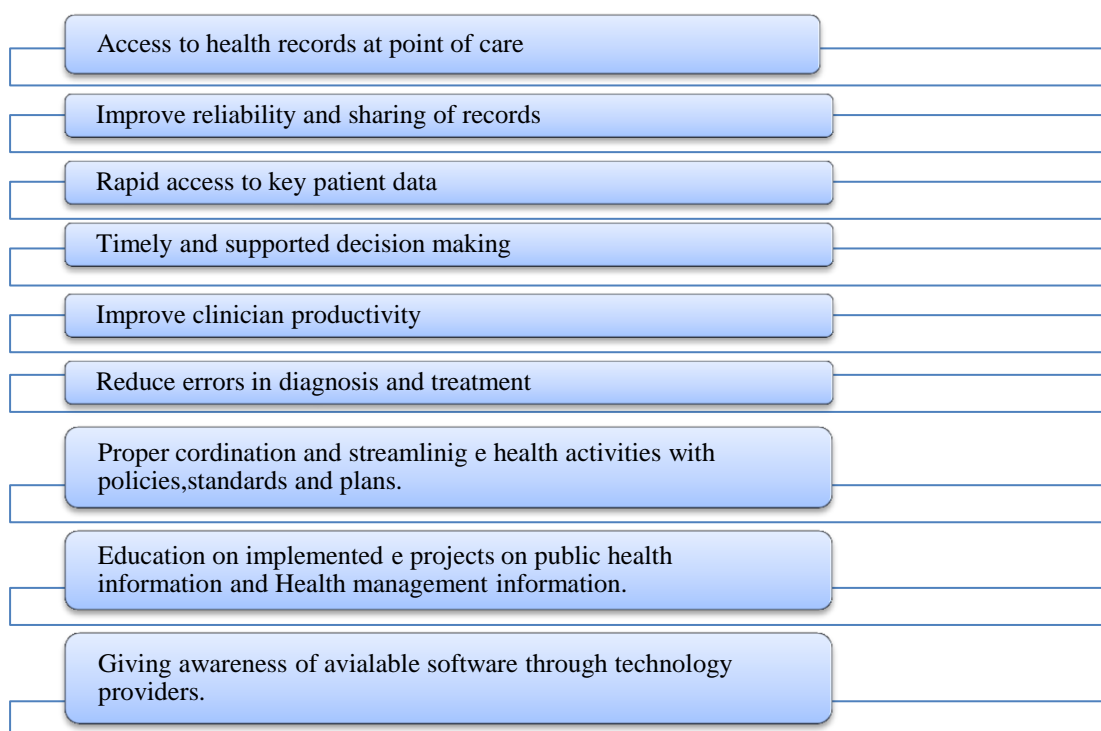
Access to health records at point of care

Improve reliability and sharing of records

Rapid access to key patient data

Timely and supported decision making

Improve clinician productivity

Reduce errors in diagnosis and treatment

Proper cordination and streamlinig e health activities with policies,standards and plans.

Education on implemented e projects on public health information and Health management information.

Giving awareness of avialable software through technology providers.

Figure 5: HISSL's main contributions for health informatics education

Solutions

Many solutions have been identified from the literature as well. Best worker competitions, out bound trainings can be arranged for staff with the view to changing their attitudes. %s programs and productivity programs (green productivity) can be arranged and they that would support the health informatics processes and change the culture and attitudes of the health professionals.

Workforce development

In analyzing main needs of health informatics these questions have to be asked (Hersh et.al, 2014).

What are the basic health literacy skills of citizens and patients?

- How will people use technology to improve health and interact with healthcare and public health systems?
- How will healthcare and public health professionals use informatics to improve care, interact with citizens or patients, and obtain education?
- How will informatics professionals develop and implement technology and evaluate its accomplishments in improving health care and public health?
- What will local leaders and policy makers need to make the best decisions about using and investing in information technology?

To answer the questions on how best to implement and use in health informatics can be done related with three categories (Hersh et.al, 2014).
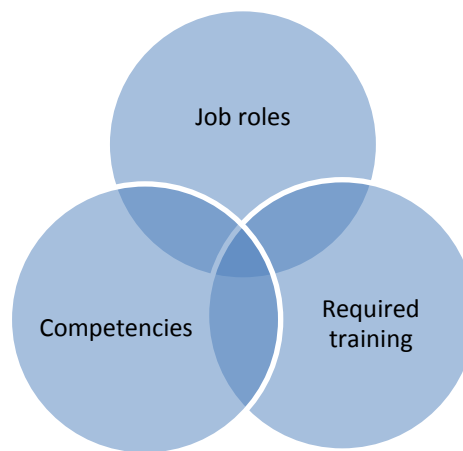
Figure 6: The categories considered in developing the workforce

Foy et.al, (1994) in their study has done a need analysis in two phases. Those are, Content Analysis and Survey of student interest and knowledge.The informal interviews consisted of discussions with both information systems and health care professionals about the educational needs for undergraduates who will enter the field. These discussions targeted this undergraduate population and not dual training in information systems and a health care specialty such as nursing or medicine. The broad results of these interviews are categorized below: (Foy et.al, 1994).

- Balance technical and organizational issues
- Practical training in CO-OP s
- Keep the curriculum broad
- IT applications

Some workforce studies have focused on the needs concerning specific HIT applications. For example, a recent analysis looked at the workforce estimated to deploy a Nationwide Health Information Network (NHIN) in the US.

It is emphasized as a variety of educational and health care systems exist all over the world, programs, courses and course tracks in BMHI may vary in different countries. In spite of this variability, basic similarities in BMHI education can be identified and

used as a framework for recommendation. These recommendations are also necessary for enabling an international exchange of students and teachers and for establishing international programs (Mantas et.al, 2010]. Some subfields of healthcare-related informatics (eg, nursing informatics) have always been more practice-oriented, offering degrees at the master's rather than the doctoral level. Technological advances, developments in genomics, and the move from curative to preventive patient care have broadened the scope of BMHI education, which now includes preparation for a wider range of informatician roles in health and biomedicine (Kampov-Polevoi et.al, 2011). It is noted that many programs provide their qualifications in "base discipline" such as clinical epidemiology and biostatistics rather than health informatics directly (Covvey et.al, 2010). Triola et.al stress the importance of incorporating biomedical informatics education and training within the curricula of medical school. This include knowing and understanding health information systems such as electronic medical records and computerized provider order entry systems; uses and limitations of clinical data in warehouses; system interoperability; and why clinical information systems can fail (Triola et.al, 2010).
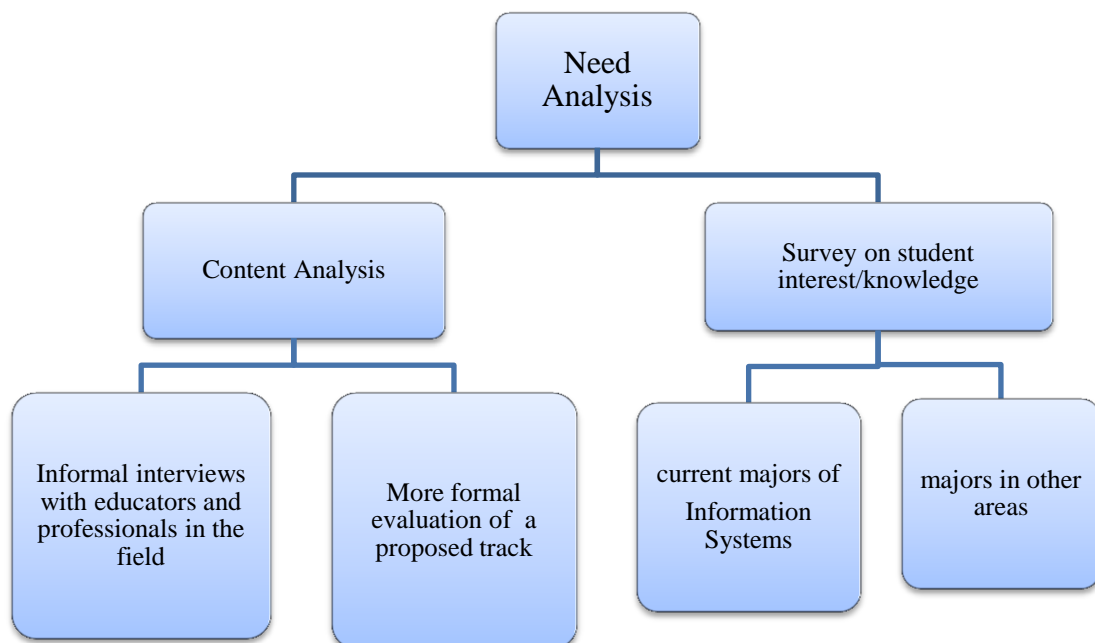

Figure 7: Phases of need analysis

Source: Foy et al. (1994)

Key principles of the IMIA recommendations to provide good quality healthcare, training and education in bio medical and health informatics are stated as follows.

- Health care Professionals
- Different modes of Education
- Different and Alternate types of specialization in BMHI
- Various Levels of education, corresponding to respective stages of career progression
- Qualified Teachers to provide BMHI courses
- Recognized qualifications for biomedical and Health informatics positions.

Source: Mantas et.al, 2010

Below list contains the list of learning outcomes, recommended by IMIA. The knowledge and skill levels are classified into the domain areas:

1. BMHI core knowledge and skills
2. Medicine, health and biosciences, health system organization
3. Informatics/computer science, mathematics, biometry
4. Optional modules in BMHI and from related fields

In order to achieve the learning outcomes mentioned above, their educational components should be considered for inclusion into the respective educational programs. Source: (Mantas et.al, 2010).

Recommendation for core content of clinical health informatics sub specialty
The Core Content for Clinical Informatics defines the boundaries of the discipline and informs the Program Requirements for Fellowship Education in Clinical Informatics. The Core Content includes four major categories: fundamentals, clinical decision making and care process improvement, health information systems, and leadership and management of change. The AMIA Board of Directors approved the Core Content for Clinical Informatics in November 2008.

This framework of core content can be used in developing the course content provided by relevant education providers in Sri Lanka. Currently the Postgraduate institute of Medicine is concerning bio medical informatics in general. Therefore, it is essential to focus more on clinical health informatics as it is one of the main areas of health informatics in Sri Lanka. The below framework can be utilized when developing the current course content.
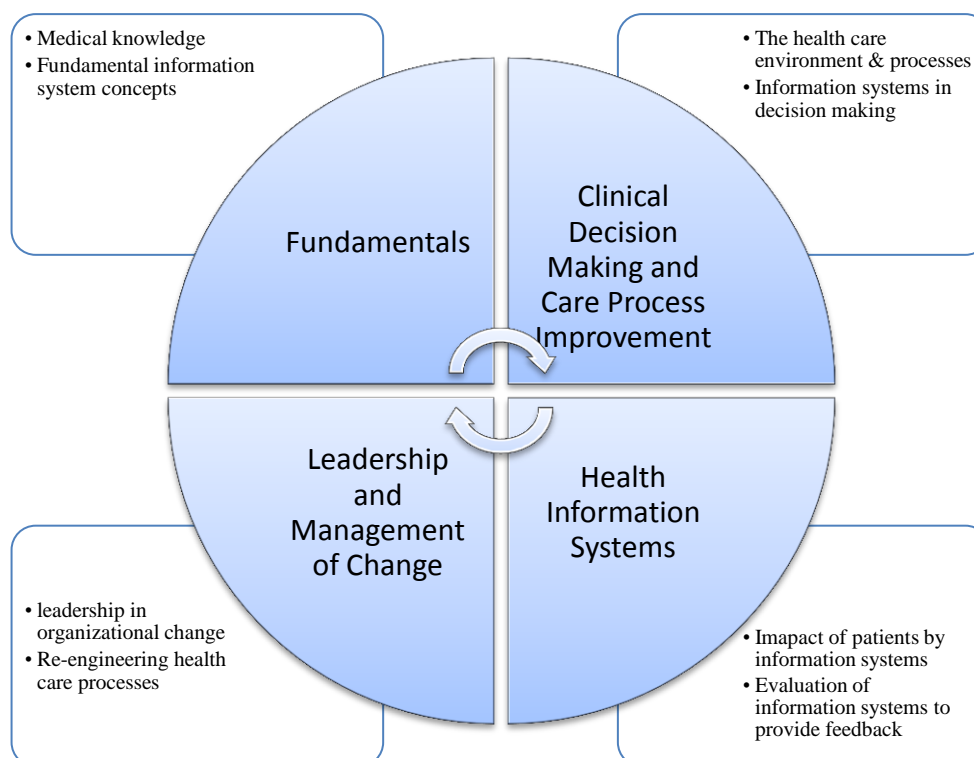

Figure 8: Competencies for health informaticians

Source: Gardner et.al., 2009

DISCUSSION

It can be seen that the need for health informatics in Sri Lankan context is more focused on clinical and public health informatics when considering the technological solutions implemented to the current moment. Many challenges and opportunities of Sri Lankan health informatics that have been found from literature are also mostly related with the clinical process. However, when we come to the above summarized course content of MSc in Bio Medical informatics, it gives the impression that course is more focused on bio informatics rather than clinical and public informatics. This has to be analyzed in depth in further research, investigating the relevance of each course unit with the needs of the healthcare process. In addition, it can be concluded that it will be benefited if the course providers can focus more on educating the business process reengineering relevance with the health informatics implementation.

It can be seen that HISSL has contributed in minimizing the challenges in healthcare process by educating relevant bodies under aspects such as coordinating health activities with policies and educating the healthcare providers. But as mentioned in the data analysis it can be seen that the significant percentage of future doctors would not be that familiar with health informatics processes. It would be reasonable if HISSL can also focus more on educating the medical students on basic health informatics applications.

FUTURE WORK

This study is merely done based on the literature survey relevant with the research topic. This study can be extended with further practical investigations on above-mentioned areas. Furthermore, this study can be utilized for implementing a framework that can address the opportunities and challenges in health informatics education sector.

CONCLUSION

Due to the increasing demand on healthcare institutions and systems to deliver better quality services for patients, health informatics has evolved to bridge the gap between health care providers and healthcare consumers. However, as a developing country Sri Lanka has to face for many issues while implementing as well as educating the health informatics practices.

It is hoped that the analysis of loopholes related with health informatics education would help to identify the gaps of the educational programs and the importance of rectifying them. This will ultimately help to improve the quality of the programs. The identified opportunities can be related with the practices of health informatics in order to optimize the quality of the healthcare processes. Furthermore, the study will focus on matching the needs of the health informatics practices with the educational aspect.

REFERENCES

Asiri, A. (2014). "Challenges of the Health Informatics Education in the Kingdom of Saudi Arabia: What Stands in Our Way?". *Journal of Health Informatics in Developing Countries*, vol8, 123-126.

Bhuyan, D. (2010). *Multiple Career Choices*. 2nd ed. Okhla, New Delhi: Pustak Mahal

Becker SJ, Blank EC, Martin R, Skeels M. (2001). *Public Health Laboratory Administration*. In: Novick LF and Mays GP, eds. Public Health Administration. Gaithersburg, MD: Aspen Publishers; 623-645.

Covvey, D., A. Kushniruk, and S. Fenton, The State of Health Informatics Education in Canada.

Gardner RM, Overhage JM, Steen EB, et al. (2009). AMIA board white paper: core content for the subspecialty of clinical informatics. J Am Med Inform Assoc 16:153–7.

Foy D Canfield K Schwartz, J, 1994. Undergraduate health care informatics education: a needs analysis and proposed curriculum. *Symposium on Computer Applications in Medical Care*, 02, 367-370

James, C.(2012). Symposia on e-Health – Opportunities and Challenges. *Sri Lanka Journal of Bio-Medical Informatics*, 3(4), 123-126.

Jayawardena AS (2014) The Electronic Hospital Information System Implemented at the District General Hospital Trincomalee-An Experience of Business Process Re-engineering. J Community Med Health Educ S2: 001. doi:10.4172/2161-0711.S2-001

Keepanasseril, A, (2011). *Top Ten Challenges Facing* Healthcare in Informatics Domain: An Opinion Paper. *Philica*, 285, 33-55.

Kulathilaka, S. (2013). "eHospital - Dompe" project – the story of the transformation of a district hospital in Sri Lanka. *Sri Lanka Journal of Bio-Medical Informatics*, 4(2), 40-43.

Lewis, D. Chang, B. and Friedman, C (2005). *Consumer Health Informatics*. Pitssburg: American Medical Informatics Association. p1-8.

Malik, M. A., & Khan, S. (2007). Health informatics training at the postgraduate level: a curriculum development exercise in Pakistan [Electronic Version]. Journal of Health Informatics in Developing Countries, 1(1), 16-18. Retrieved 5thof March from http://www.jhidc.org/index.php/jhidc/article/view/3

Mantas; Ammenwerth; Demiris; Hasman; Haux; Hersh; Hovenga; Lun; Marin; Martin-Sanchez; Wright, 2010. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. *IMIA*, 49, 1:16.