ASSESSMENT OF HEALTH INFORMATICS COMPETENCIES IN TRAINING OF UNDERGRADUATE HEALTHCARE PROFESSIONALS IN RWANDA

Case of University of Rwanda College of Medicine and Health Sciences

NISHIMWE AURORE

College of Medicine and Health Sciences
School of Public Health
Master of Health Informatics

2014

ASSESSMENT OF HEALTH INFORMATICS COMPETENCIES IN TRAINING OF UNDERGRADUATE HEALTHCARE PROFESSIONALS IN RWANDA

Case of University of Rwanda College of Medicine and Health Sciences

NISHIMWE AURORE

College of Medicine and Health Sciences

School of Public Health

Master of Health Informatics

2014

ASSESSMENT OF HEALTH INFORMATICS COMPETENCIES IN TRAINING OF UNDERGRADUATE HEALTHCARE PROFESSIONALS IN RWANDA

Case of University of Rwanda College of Medicine and Health Sciences

By

NISHIMWE AURORE

12/PS/3974

A dissertation submitted in partial fulfilment of the requirements for the degree of

MASTER OF HEALTH INFORMATICS

In the College of Medicine and Health Sciences

Supervisor: Prof Marc NYSSEN

Co-Supervisor: NGENZI Joseph Lune

December,2014

DECLARATION

I declare that this Dissertation contains my own work except where specifically acknowledged.

NISHIMWE AURORE

12/PS/3974

Signed……..

Date……..

DEDICATION

To my husband, KANIMBA Philbert;

To my sons, SHIMWA KANIMBA Onesta Davy and HIRWA KANIMBA Angel Darly,

To my parents, my Sisters and my Brothers,

For your love, support, encouragement, and patience,

This dissertation is tenderly dedicated.

ACKNOWLEDGEMENT

Firstly, I thank God for guiding me throughout this research.

The completion of this dissertation would not have been possible without the contribution of a number of people.

My heart-felt gratitude goes to the Government of Rwanda, to UR, College of Medecine and Health sciences for kindly accepting to sponsor my masters program.

I am particularly indebted to my supervisor and co-supervisor, Professor Marc NYSSEN and Mr. NGENZI Joseph Lune respectively, for their excellent supervision. Their encouragement and constructive comments were invaluable.

May my special thanks also go to Prof Kato NJUNWA, Mme MURENZI Joyce and Mr. MBARUSHIMANA Valens for their kind assistance throughout this research process.

To all of you who contributed to this project but whom I may have forgotten to mention I say, "Thank you and May God bless you".

ABSTRACT

Introduction: The concept "health informatics" is a discipline that is as old as healthcare itself. It was born the day a clinician first wrote down some impressions about a patient's illness, and used these to learn how to treat the next patient. Healthcare professionals often lack knowledge of systematically processing data and information which affects the decision-making process. Furthermore, in order to enhance their practices through better use of information resources, healthcare professionals are often asked to use information technologies for which they have poor appreciation and limited skills. Nevertheless, as more health information technologies become part of the health care environment, the need for healthcare professionals with health informatics competencies is growing.

Aim: The aim of the current study is to assess health informatics competencies in existing curricula for training undergraduate health care professionals in Rwanda.

Methods: A descriptive cross – sectional study with a review of document approach was conducted. Using a census method, the study assessed thirty curricula designed for training undergraduate health care professionals in University of Rwanda, College of Medecine and Health Sciences during the academic year 2013 - 2014. Data collection was carried out using a standardized questionnaire designed to assess health informatics competencies in four level of clinical practice. The tool was adapted to local context to include advanced diploma level. Data collection began after the study was granted an explicit authorization from the College Principal's Office. SPSS 21 was used for data coding, processing and analysis. Frequency tables where used to summarize categorical variables. Descriptive statistics were used to describe numerical variables. One-way ANOVA was used to compare means differences across schools and undergraduate programmes.

Results: only 11 out of 23 competences (47.8%) had a score of presence greater than 50% in the assessed curricula. Use of personal application software for documentation, ability to use personal computers, Ability to communicate electronically and basic informatics terminology were the most frequent competencies in curricula and each one accounted for 70% (n=21). Socio-organizational and socio-technical issues and methods of project management and change management were totally

absent from the assessed curricula. Other competencies weakly represented included the methods for decision support and their application to patient management (3.3%), the principles of medical decision-making (6.7%), and the need for systematic information processing in healthcare (10%). The remaining competencies had a presence score between 10 and 50%. Health informatics competencies in Curricula from the School of Medicine Pharmacy were significantly higher than others ($p<0.001$) and the Bridging program was less likely to contain assessed health informatics competencies ($p<0.05$).

Conclusion: There is a low presence of health informatics competencies in the studied curricula. To insure that healthcare professionals have the knowledge, skills, and attitudes to effectively and efficiently interact with today's health information technologies, more health informatics competencies need to be included and assessed in all undergraduate curricula leading to a healthcare professionals` qualification.

TABLE OF CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

AAMC: Association of American Medical Colleges

ANOVA: Analysis of Variance

BMHI: Biomedical and Health Informatics

CBPR: Computer Based Patient Record

CBR: Case Based Reasoning

CDSS: Clinical Decision Support System

EBM: Evidence Based Medecine

EHR: Electronic Health Record

GOR: Government of Rwanda

HI: Health Informatics

HMSS: Health Management Support System

ICT: Information, Communication and Technology

IMIA: International Medical Informatics Association

MCV: Medical College of Virginia Campus

NICQ: Nursing Informatics Competencies Questionnaire

PDA: Personal Digital Assistant

SD: Standard Deviation

SPSS: Statistical Package for Social Sciences

UR: University of Rwanda

VCU: Virginia Commonwealth University

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

CHAPTER 1: INTRODUCTION

1.1 DEFINITIONS OF KEY TERMS

1.1.1 Health informatics

Health (or Medical) informatics is the rapidly developing scientific field that deals with the resources, devices and formalized methods for optimizing the storage, retrieval and management of biomedical information for problem solving and decision making. It is an interdisciplinary field based on computer science, information science, the cognitive and decision sciences, epidemiology and telecommunication, among others, and is used to enhance healthcare, medical research and education (Vanbemmel et al 1998). In the present study, health informatics refers to an introduction to essential Clinical Informatics Skills which are Health information systems, Clinical or diagnostic decision support systems (CDSS), Computer based patient records (CBPR) Evidence based medicine (EBM) and Case based reasoning (CBR).

1.1.2 Health informatics competencies

It is the ability to pursue the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving and decision making, motivated by efforts to improve human health. The shared core informatics competencies of Biomedical informatics draw on the practical experience of many specific informatics sub-disciplines(Mantas et al. 2010).In the present study health informatics competencies refers to the first framework of the current International Medical Informatics Association (IMIA) recommendations which involves professionals in health care (e.g. general practitioners, nurses, dentists, ophthalmologists, BMHI professionals,..).

1.1.3 Undergraduate education/training

Undergraduate education is the post-secondary education previous to the postgraduate education. It includes all the academic programs up to the level of a bachelor's degree(Sarbadhikari et al,2008). In the current study, undergraduate education in the field of health refer to educational program directed to the general public that attempts to improve, maintain, and safeguard the health care of the community which include all undergraduate degrees in medecine and health sciences available in University of Rwanda, College of Medicine and Health Sciences.

1.1.4 Health care

According to Byrne(2012)health care is the maintaining and restoration of health by the treatment and prevention of disease especially by trained and licensed professionals (as in medicine, dentistry, clinical psychology, and public health, etc.).In this context we mean all the clinical practice fields performed by the graduates from UR, College of Medicine and Health Sciences.

1.1.5 Health care professional

A person who by education, training, certification, or licensure is qualified to and is engaged in providing health care(Sarbadhikari et al, 2008). In this context, Health care professionals are the advanced diploma holders and the bachelor`s degree holders, graduated from University of Rwanda, college of medecine and health sciences.

1.1.6 Need assessment

A need assessment is a systematic process for determining and addressing needs, or "gaps" between current conditions and desired conditions or "wants". The discrepancy between the current condition and wanted condition must be measured to appropriately identify the need. The need can be a desire to improve current performance or to correct a deficiency. It is a part of planning processes, often used for improvement in individuals, education/training, organizations, or communities. It can refine and improve a product such as training or service a client receives. It can be an effective tool to clarify problems and identify appropriate interventions or solutions (Schwartz et al,2011).In this study need assessment refer to the need that Medical schools should designate an academic unit for institutional leadership in the application of information sciences and computer technology to the general professional education of health workers and promote their effective use.

1.1.7 Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics

The IMIA recommendations centre on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology. The educational needs are described as a three-dimensional framework. The dimensions are: 1) professionals in health care (e.g. physicians, nurses, dentists, ophthalmologists, BMHI

professionals), 2) type of specialisation in BMHI (IT users, BMHI specialists), and 3) stage of career progression (bachelor, master, doctorate).Learning outcomes are defined in terms of knowledge and practical skills for health care professionals in their role as IT user and as BMHI specialist. Recommendations are given for courses/course tracks in BMHI as part of educational programs in medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and informatics/computer science as well as for dedicated programs in BMHI (with bachelor, master or doctor degree)(Mantas et al. 2010). In this study we will only focus on the first framework of professionals in health care (e.g. physicians, nurses, dentists, ophthalmologists, BMHI professionals).

1.2 BACKGROUND

Effective and appropriate use of information and communication technologies is an essential competency for all health care professionals, to achieve this goal, healthcare professionals must receive the requisite training during basic and advanced educational programs (Desjardins et al. 2005).Edward Shortliffe describes health informatics as the rapidly developing scientific field that deals with the storage, retrieval, and optimal use of biomedical information, data, and knowledge for problem solving and decision making (Staggers et al. 2002). It accordingly touches on all basic and applied fields in medical science and is closely tied to modern information technologies, notably in the areas of computing and communications (Burnette et al. 2012).

Although the name “health informatics” only came into use around 1973, it is a discipline that is as old as healthcare itself. It was born the day a clinician first wrote down some impressions about a patient’s illness, and used these to learn how to treat the next patient.(Vedel et al. 2012)Health care professionals often lack knowledge of the possibilities and limitations of systematically processing data, information and knowledge with the resulting impact on quality decision-making. in order to enhance their practices through better use of information resources healthcare professionals are often asked to use information technologies of which they have limited appreciation,. However, for systematically processing data, information and knowledge in medicine and in healthcare, health care professionals who are well-trained in health informatics are needed(Haux et al, 1998).

There is evidence that Information technology has the potential to facilitate patient care delivery by increasing time spent in direct patient care, improving decision making, reducing duplicate

work, decreasing error, and minimizing time spent on documentation (Chang et al. 2011).Also, Health information technology, especially electronic health records, has the potential to improve the efficiency and effectiveness of health care providers and the use of health information technology should lead to more efficient, safer, and higher-quality care (Georgiou et al., 2014).

In addition, the importance of incorporating health informatics into the education of medical students and medical practitioners is being increasingly recognized. (De Gagne et al, 2012).The extensive introduction of electronic health information systems into hospitals and clinics and at the enterprise level in Rwanda and elsewhere is driving a demand for health professionals who have at least basic skills in and appreciation of the use of these technologies(Anderson et al ,2007).In our days the employers are usually obliged to invest in the development of health informatics skills of their staff, so that they can cover the gaps and help them increase their productivity through on job training courses which is a time consuming and a costing process; Without forgetting the resistance to change often remarquable. Otherwise a good way to fight a resistance to change is through communication and education.

In the same vein, The essential clinical informatics skills have been identified and should be incorporated into the undergraduate medical curriculum (Anderson et al, 2007). It is recommended that these be introduced in stages and integrated into existing programmes rather than taught as a separate module. At the same time, medical schools should support the integration of health informatics in the educational process in view of the numerous potential benefits (De Gagne et al. 2012). In Brisbone, Australia, researchers such as Georgiou, Andrew Lymer, Sharyn Forster, Megan Strachan &Michael Graham (2014) in their research called "Lessons learned from the introduction of an electronic safety net to enhance test result management in an Australian mothers' hospital". There were 27 354 inpatient test results (679 for imaging and 26 675 for laboratory) relating to 6855 patients (involving 7647 episodes of care) across the August 2011 to August 2012 period. The findings showed that all results in the hospital had been acknowledged, with 60% of laboratory tests (n=24 458; 95% CI 59% to 61%) and 44% of imaging tests (n=586; 95% CI 40% to 48%) acknowledged within 24 h (Georgiou et al. 2014).

In a study carried out by Espino & Levine (1998) it was revealed that the idea that medical schools should incorporate topics in information management is not new. In 1984 a panel on the

General Professional Education of the Physician (Association of American Medical Colleges) specifically identified health informatics, including computer applications, as an area in which new educational opportunities needed to be developed so that physicians and clinicians would be better prepared for the practice of medicine (Espino et al,1998).The challenges faced by medicine today are enormous. With the present climate, it is desirable for clinicians to graduate with a minimum set of management skills so that they can practice in this new changing environment. The efficient use of medical information is a major part of this skill set(Espino et al, 1998).

In addition,(Byrne et al ,.(2010) demonstrated that a Clinical Decision Support System (CDSS) which is an interactive computer software designed to assist health professionals with decision making tasks, such as preventing adverse drug events at the point of care with an objective to deliver the "right knowledge to the right people in the right form at the right time is very helpful to assist in the clinicians' work ,still they are reluctant to adopt CDSS because of unfamiliarity of the system. One way to address these problems is through medical education on CDSS within the undergraduate medical curriculum and the health informatics courses in specific (Byrne et al, 2010).

In another study conducted by Jha et al.(2009) it was found that Electronic medical records are supposed to improve clinicians' workflow and to offer a better overview on patient's history. The authors believe that this innovation should improve safety and reduce costs with good data quality and reliability, the study surveyed data from stratified random sample of all medical practices in Massachusetts in 2005, they determined rates of EHR adoption, perceived barriers to adoption, and satisfaction with EHR systems, its results revealed that health care professionals identified educational , financial and other barriers to implementing EHR systems at similar rates, although these clinicians were less likely to be concerned with privacy and security concerns of EHRs (47.1% vs. 64.4%, $P = 0.01$). Finally, health care professionals had similar perceptions about the positive impact of EHRs on quality (73.7% vs. 76.6%, $P = 0.43$) and costs (46.9% vs. 51.5%, $P = 0.17$) of care(Jha et al. 2009).

A number of recent studies(Lu, Xiao, Sears, & Jacko,.(2005) suggest that fragmented and inaccessible clinical information adversely affects both the cost and quality of health care as well as compromises patient safety.(Lu et al. 2005) Information technology has been proposed as an essential tool in solving these problems and promoting better health care. Information

technologies (IT) such as electronic health records, e-prescribing, decision support systems, electronic management of chronic disease, and bar coding of drugs and biological products have been shown to reduce health care costs and medical errors.(Neuner et al. 2014) For example, several studies(Anderson et al(2007); Bakken et al. (2004); Belar et al (2004); Blumenthal et al. (2005); Burnette et al. (2012) have shown that an electronic medical record that facilitates computerized physician order entry can significantly prevent serious medication errors. Electronic prescribing has been shown to reduce prescription errors and improve compliance with managed care formularies. Point-of-care decision support tools can provide providers with alerts for contraindicated medications(Magrabi et al. 2007).

However, implementation of these information technologies has lagged in most European nations as well as the U.S. The Harvard School of Public Health and the Commonwealth Fund's International Symposium survey of primary care clinicians found that the proportions of primary care clinicians in the following countries who were using electronic medical records were: U.S. (17%), Canada (14%), Australia (25%), New Zealand (52%), and the U.K. (59%). The survey also found that use of electronic prescribing by primary care physicians was: U.S. (9%), Canada (8%), Australia (44%), New Zealand (52%), and the U.K. (87%). A key barrier to implementation is the complexity of EMRs and clinical IT applications. Surveys have found that clinicians cite the time and effort involved in learning at work to use these technologies as a significant barrier(Anderson et al,2007).

At the international level, the International Medical Informatics Association has defined and promulgated a set of recommendations that emphasizes inclusion of content in all health care professional undergraduate curricula that enables health care professionals to ‘‘efficiently and responsibly use information processing methodology and information and communication technology(Desjardins et al. 2005).

According to IMIA recommendations, In order to provide good quality health care, training and education in biomedical and medical informatics is needed, every profession in health care even at an early stage needs some core BMHI knowledge. They specify the Learning outcomes for all health care professionals in their role as IT users: Enabling health care professionals to efficiently and responsibly use information and knowledge processing methodology and information and communication technology. These learning outcomes need to be included in all

undergraduate curricula, leading to a health care professional qualification(Mantas et al. 2010). Different levels of education, respectively stages of career progression, (bachelor, master, and doctor) have different BMHI education needs according to experience, professional role and responsibility. A Junior professional uses information differently compared to a senior professional(Mantas et al. 2010).The IMIA recommendations center on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology. The educational needs are described as a three-dimensional framework. The dimensions are: professionals in health care (e.g. physicians, nurses, BMHI professionals), type of specialization in BMHI (IT users, BMHI specialists), and stage of career progression (bachelor, master, doctorate). Learning outcomes are defined in terms of knowledge and practical skills for health care professionals in their role a) as IT user and b) as BMHI specialist (Mantas et al. 2010).

In Brooklyn, State University of New York, Espino & Levine (1998) carried out a survey called "An Overview of the Medical Informatics Curriculum in Medical Schools" Its results revealed that Of the 26 medical schools responding only 1 school reported no informatics subjects in the curriculum. 2 schools reported informal teaching of health informatics within existing courses. 9 schools had formal health informatics objectives in the curriculum longer than one year. 8 schools reported the formalization of objectives for this or next year. 6 schools reported an elective only curriculum for health informatics. Most medical schools have an interest in a health informatics curriculum. In the most recent profile of medical school curriculum from the AAMC(American Association of Medical Colleges)Curriculum Directory, 1996-1997, 116 schools out of 127 (93%) reported incorporation of health informatics subjects. They concluded by a remark saying that ideally, health informatics should be incorporated into all four years of medical school. The data from this survey reflects this desire(Espino et al, 1998).

In Africa , form a report of IST- Africa consortium titled "Guide to ICT Initiatives and Research Capacity in IST-Africa Partner Countries Version 1.1" they document the current state of ICT and Innovation related policy making, infrastructure, initiatives, national ICT research priorities, research focus within Higher Education Institutions, across the 18 IST-Africa partner countries in North Africa (Egypt, Tunisia), West Africa (Senegal, Ghana), East Africa (Burundi, Ethiopia, Kenya, Tanzania, Uganda), Central Africa (Cameroon) and Southern Africa (Botswana, Lesotho,

Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland) and they emphasize on Ict incorporated in health sector as a priority of all African countries.(www.ist africa.org 2014)

Finally, In Rwanda Health information technology is a quickly growing industry with many committed stakeholders, including the Government of Rwanda (GoR), several nongovernmental organizations (NGOs), and private sector partners. Particularly in the areas of electronic health records and national reporting system, Rwanda has been a pioneer in national initiatives to integrate technology into its expanding health care system. Where the private market has not emerged, the GoR has provided significant support to help these fledging industries. As a result, GoR is significantly involved in all major initiatives and emerging technologies. There are six significant entities in health information technology in Rwanda to date. These programs are:

OpenMRS – An open-source Medical Records System that tracks patient-level data ; TracPlus and TRACnet – Monthly monitoring of infectious diseases including HIV/AIDS, TB, and Malaria, CAMERWA – Drug and medical supply management system ; Telemedicine – Information and communication technology (ICT) used to deliver health and healthcare services, information and education to geographically separate parties ; Health Management Information Systems (HMIS) – systems that integrate data collection processing, reporting, and use of the information for programmatic decision-making ; E-Learning – use of ICT in instruction of A2-level nurses for promotion to A1 (Frasier et al. 2008).

Also the Rwandan National Information and Communication Integration (NICI) document committed the Government of Rwanda to an integrated ICT-led socio-economic policy and plan. In line with this plan, the Ministry of Health together with the Ministry of education are committed to the deployment of ICT in order to contribute to this social development taking into consideration also the country's vision 2020.

1.3 PROBLEM STATEMENT

Within the next decade, a large majority of hospitals and health care centers in developed nations and many in developing nations will have electronic health records and other forms of health information technology. Healthcare professionals will be expected to use these tools to improve patient safety, enhance the quality of care, and reduce costs. This expectation requires that healthcare professionals be trained, not as medical informaticians but as knowledgeable users of the health technology tools.

Research from other parts of the world has revealed that in this millennium, every health-related discipline can benefit from the knowledge of informatics and appreciation of the advances occurring in the healthcare system .Vedel (2012) .maintained that health professionals educators must integrate the available knowledge base and skill training into the curriculum so students can develop and maintain competence related to professional responsibilities(De Gagne et al. 2012). The IMIA recommendations(2010) argued that new graduates, regardless of their specialty or practice setting, are expected to possess technology literacy and fluency along with health information management skills(Mantas et al. 2010).

In the lines above, we have seen that health informatics education is an essential component of the undergraduate curriculum, as far as health care professionals are concerned. So far, however, we have been talking about health informatics in countries other than Rwanda. Thus, one may wonder whether Rwanda as well is confronted with the same argument that health informatics should be a central feature of the medical curriculum like in other countries.

To date, no research appears to have been carried out in Rwanda to assess health informatics competencies in training of undergraduate health care professionals, and I have noticed missing health informatics skills in existing curricula thus the need for the current study. The results thereof may help policy-makers in the field of education to better plan for education so as to achieve effective and quality health care.

1.4 OBJECTIVES

1.4.1 MAIN OBJECTIVE

The purpose of this study is to assess health informatics competencies in existing curricula for training undergraduate healthcare professionals in Rwanda.

1.4.2 SPECIFIC OBJECTIVES

The specific objectives of this study are to:

- Find out health informatics competencies outlined in existing curricula for training undergraduate health care professionals in college of Medecine and health sciences.

- Provide guidance and future directions for integrating health informatics competencies in training of undergraduate healthcare professionals.

1.5 RESEARCH QUESTIONS

The research questions are:

- What are the health informatics competencies outlined in undergraduate curricula of the College of Medicine and Health Sciences?

- What are the guidelines for integrating health informatics in undergraduate health care professionals' curricula?

1.6 SIGNIFICANCE OF THE STUDY

So far, to the best of our knowledge, no research has been carried out to assess health informatics competencies in training of undergraduate health care professionals in Rwanda. This does not mean that the reasons identified in other countries are not likely to be found in Rwanda as far as this field is concerned. The results of the current study may enrich the field of health care practice in Rwanda, it may contribute to a better understanding of health informatics by raising the appropriate use of information as information is a crucial resource of health care activity and health informatics is particularly interested in application of automated information systems in the field of health care activity.

In education, this study may demonstrate the need for medical schools to include health informatics in the curriculum particularly if the research discovers gaps in the current curricula. The current study may also contribute to the limited body of studies that are related to health informatics in Rwanda.

1.7 SUBDIVISION OF THE PROJECT

This project is subdivided in 6 main parts, the first chapter ; introduction comprise the following sections: Operational definitions of key terms, Background to the Study, Problem Statement, Objectives ,Research Questions , Significance of the study and the Subdivision of the Project.

The second chapter which is the Literature review describes the literature (i.e. books, journal articles, etc) about the various researches previously done in relation to health informatics and the conceptual framework of the study. While the third chapter; Methodology describes the research methodology which will be used. It includes Study area, study design, study population, study sample and sampling strategy, data collection methods and procedures used data analysis, problems and limitations of the study, instruments used including the ethical issues which were taken into account, and the validity and reliability of the research tool. The fourth chapter; Results describes the findings of the study, the fifth chapter Discussion discuss the results by comparing them with currently used standards and with similar studies done in the same place or elsewhere and state the implications of the outcome of the comparison of the results with the established standards or earlier findings on the system studied. Finally the sixth chapter; Conclusion and Recommendations State categorically the main findings of the study based on the objectives and research questions and give a final conclusion and then it makes overall recommendations based on the conclusions and Point out areas for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Health Informatics represents the intersection of medicine and information science. At its most basic level, health Informatics deals with individual patient data and how clinicians interpret and use that data. As such, it involves the technology used to store and retrieve patient data, and the skills to use such technology both proficiently and critically (Vedel et al. 2012).

Beyond its use in clinical care, health Informatics also supports research, teaching and health services administration (Vedel et al. 2012). health Informatics embraces the electronic patient record, data-capturing tools, analytic tools operating on patient and population levels, clinical practice guidelines and clinical decision support, using various information resources such as MEDLINE, e-learning modalities, epidemiology and public health decision-making, communication systems, practice management tools, and other technologies(Vedel et al. 2012).

Researchers such as Hart et al. (2010); Haux et al(1998); Häyrinen et al. (2008),Sarbadhikari (2008) contend that health Informatics is the science and art of processing medical information and in this age of "Information Explosion" choosing the useful one is rather difficult, and there lies the scope of electronic database management. However, still many outstanding personnel related to the healthcare sector take pride in being "computer illiterate" while The onus of the best use lies on the end-user health care providers only Haux et al(1998).According to(Sarbadhikari ,2008) ,in the next century, the study of informatics will become as fundamental to the practice of medicine as anatomy has been to the last; The last few years have seen rapid advances in communication and information technology, and the pervasion of the worldwide web into everyday life has important implications for education(Sarbadhikari ,2008).

Most medical schools provide extensive computer networks for their students, and these are increasingly becoming a central component of the learning and teaching environment. Such advances bring new opportunities and challenges in medical education, and are having an impact on the way we teach and on the way students learn, and on the very design and delivery of the quality health care services(Hart et al. 2010; Haux et al ,1998; Häyrinen et al. 2008,Mantas et al. 2010,Sarbadhikari (2008)).

Although, the challenges faced by medicine today are enormous. With the present climate, it is desirable for clinicians to graduate with a minimum set of management skills so that they can practice in this new changing environment and the efficient use of medical information is a major part of this skill set(Desjardins et al. 2005).

In spite of a growing body of evidence assessing health informatics competencies in health care professionals internationally, there is still relatively little or no research in the clinical context of Rwanda, therefore the aim of this literature review was to obtain all important information related to the topic and to enable the researcher to determine what was already known about the topic in order to form the basis of comparison and support for the research study(Haux 2010). The discussion and organization of this literature review has been guided by the research questions and theoretical framework of this study.

2.2 Conceptual Framework

For a comprehensive assessment of health informatics competencies, this study uses a model derived from Staggers et al's theory of Information Management framework (**Figure2.1**). The model is based on informatics competencies as the key concept of the framework. Staggers' model relies on Informatics competencies along with human information processing skills which comprise the overall construct of information management competencies. Three components of informatics competencies (computer skills, informatics knowledge, and informatics skills useful in health care) are interdependent and of equal importance. The highlighted elements are the focus in this study.

During recent years The identification of specific informatics competencies for health professionals has been a topic of keen interest(Chang et al. 2011, Staggers et al. 2002).Health professionals must exploit information technology, especially clinical technology, to function in contemporary health care settings worldwide thus Information technology has the potential to facilitate health care delivery by increasing time spent in direct patient care, improving decision making, reducing duplicate work, decreasing error, and minimizing time spent on documentation(Chang et al. 2011). Even if the theory was developed in the nursing context and health profession of Taiwan, the relationships between education and scientific knowledge differences are understood and accepted by many in different clinical domains that include but are not limited to medical profession and other clinical health workers.

In the same line, Staggers' model assumes that in the process of developing global health informatics education , a common understanding of educational outcomes is required(Garde et al. 2005). This reflects the need to be able to characterise health informatics (HI) professionals by their graduate attributes. An educational framework for health informatics professionals as proposed in IMIA recommendations can provide clarity about the relative position of different qualifications(Mantas et al. 2010). This framework then supports decision-making regarding the progression between various educational sectors, including countries and providers. Such a framework would assist with program accreditation, positioning the results of any recognition of prior learning exercise, and the administration of credit-transfers(Lu et al. 2005,Staggers et al. 2002).As a consequence, such frameworks provide a desirable infrastructure for supporting student mobility, trans-national and borderless education. It is highly desirable to establish such a framework for health informatics education as this would assist with the identified need to be able to characterize health informatics professionals by their graduate attributes(Garde et al. 2005).

In addition, recent publications identified unintended consequences of applications such as provider order entry and the lack of sufficient cognitive support in existing clinical systems (Garde et al. 2005).Nevertheless, information technology will increase its penetration into health care settings even with current drawbacks, the fact is that health professionals in all specialties and roles must have the knowledge and skills to use information technology (Lu et al. 2005). Informatics competencies are a global imperative for health professionals (Mantas et al. 2010).

Regardless of the level of education, health informatics competencies are critically necessary in health care delivery systems (Garde et al. 2005). Several studies have connoted the impact information technology has had on the health profession and health education(Mantas et al. 2010,Lu et al. 2005,Staggers et al. 2002). In the U.S., informatics is becoming an integral part of medical curricula at both the baccalaureate and graduate level as health professionals educators work to meet the requirements of the health care delivery systems in which clinicians provide care (Staggers et al. 2002,Garde et al. 2005).

In the context of the present study, it is presumed that health Informatics is the science and art of processing medical information (where information is the processed data).

Medical science is advancing very rapidly, especially with the unexpected progress of technology, both related and unrelated to the healthcare delivery field directly. Definitely the need has now arisen for a formal training in health Informatics to grasp the essential concepts of basic medical informatics sciences (computer skills, information knowledge, information Management competencies and informatics skills applied in health sector) (**Figure2. 1**).

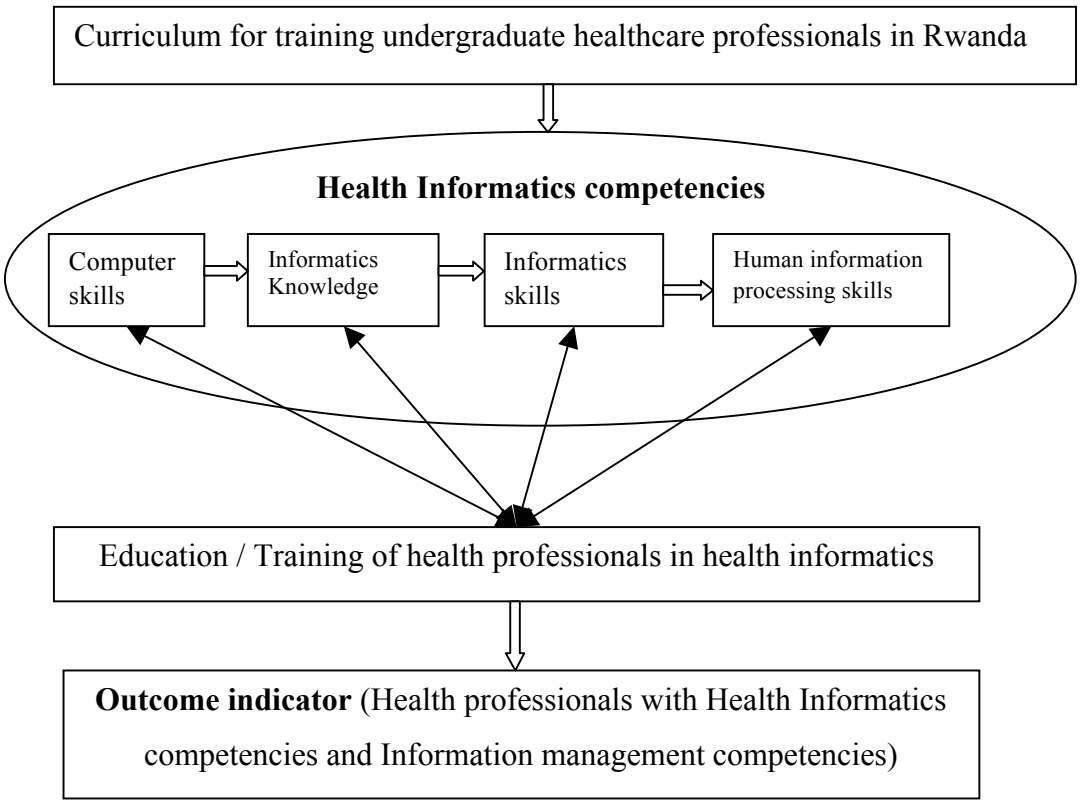

Figure 2. 1: Schematic representation of the conceptual framework (Adapted From Staggers et al.2002)

2.3. Health informatics education: an overview

Health informatics has been the first science that connects all traditional medical disciplines, thanking to common information needs and requirements of these disciplines(Masic 1998).Its goal is incorporating of information technology into medical praxis, getting medical professionals in touch with capabilities of computer technology and preparing the professionals for the future that belongs to more and more powerful computer technologies(Masic 1998).

Information as a 'crucial' component of medicine is in the focus of each investigation; Therefore

the uses of new and emerging technologies are being considered key to decreasing medical errors and easing the burden of paperwork for the health care professional(Masters 2008).As healthcare increasingly focuses on timely information to drive decision-making and to support the electronic health record, the use of informatics to support practice must be integrated into clinical education program curricula to prepare graduates for the workforce of which informatics is increasingly an integral part(Masters 2008).

Although there are references to the field of informatics dating back to the 19th century, it was in 1949 that the term informatik was used in Germany to describe the first professional organization for informatics(De Gagne et al. 2012). Across Europe and Asia, countries such as the Soviet Union, France, Holland, and Belgium subsequently began to use a version of this term (Collen, 1995). Medical informatics as the term Informatique Médicale was used in France during the 1960s to describe the study of the application of information technology to medical science, During the late 1960s and early 1970s, a transition from manual to electronic methods began to take place in the medical informatics community in the form of mainframes, data processing systems, and laboratory systems (Protti, 2004). However, it was not until 1976 that the English language formally defined the general field of informatics in the Supplement to the Oxford English Dictionary (Collen, 1995). During that period of time, the advent of hospital information systems to provide more efficient processing of patients and lab specimens took place (Protti, 2004). During the 1980s, early telemedicine defined as “the practice of medical care using audio, visual, and data communications” emerged to provide “healthcare delivery, diagnosis, consultation, treatment, education, and the transfer of related data” (Mandil, 2005).Health informatics became more widely known with the independent establishment of the International Medical Informatics Association (IMIA) in 1979 and the renaming of Healthcare Information and Management Systems Society (HIMSS) in 1986 (Protti, 2004). The 1990s and early 2000s were times in which Health informatics evolved into an electronic health record (EHR) orientation with the use of more integrated decision support systems, clinical data repositories, and networks (Protti,2004). Recently, HI has continued to prove integral to healthcare providers and researchers so they can more effectively adopt HIT to provide better patient care. HIT involves the use of computer hardware and software in the retrieval and sharing of patient information with providers, patients, and insurers, as well as for the integration with other

healthcare information systems (Blumenthal, 2009). Reducing health errors, improving care quality and access, and minimizing healthcare costs are three priorities of HIT (Fetter, 2009).

Several studies (Seago et al., 2007; Blumenthal et al.,2005; Burnette et al.,2012; Espino, Levine 1998; Schwartz et al, 2011)examining health Informatics For Medical Students And Medical Practitioners were reviewed .these studies revealed that Basic Medical Education and Research lays the foundation for advancing and applying proper healthcare delivery systems. Consequently there is no doubt that deep knowledge of anatomy is mandatory for successful surgery. Also, comprehensive knowledge of physiology is essential for grasping the principles of pathology and Pharmacology adequately, to avoid incorrect and inadequate practice of medicine. Similarly, health informatics is not just a subject to be learnt and forgotten after the first professional examination. The final aim of every student should not only be to become a good user but also an expert for advancing medical knowledge base through medical informatics(Seago et al. 2007; Blumenthal et al. 2005; Burnette et al. 2012; Espino & Levine 1998; Schwartz et al,2011).

In North Carolina,USA De Gagne et al.(2012)in their study called "Integrating health informatics into the BSN curriculum" it was revealed that approximately half of BSN programs were teaching information literacy skills and required word-processing (51%) and e-mail (47%) skills as a prerequisite. In summary, skills most often identified as potential prerequisites to a BSN program were word-processing, e-mail, internet navigation, presentation, spreadsheet, statistical software, and online literature search skills(De Gagne et al. 2012). They determined that incorporating informatics into BSN curricula has produced positive findings regarding patient care. (De Gagne et al. 2012).

In Bosnia ,at university of Sarajevo, Masic,(1998) in his research called " Education of health informatics in Bosnia and Herzegowina" The authors have investigated 400 students of Medical Faculty and Higher Medical School and it was revealed that Students (95.3%) need more lectures on expert systems and Internet in practice. About 92.6% students want more theoretical lectures on health informatics. Finally, all students would like to have more practical lessons(Masic 1998).

In china, Hu et al. (2013) in their research called “An overview of medical informatics education in China” a total of 55 program offerings for undergraduate education, 27 for master's-level education, and 5 for PhD-level education in medical informatics were identified and assessed in China. The results indicate that health informatics education, a specialty rooted in medical library and information science education in China, the objectives and curriculum design of health informatics education differ from one university to another and also from those of foreign universities or colleges(Hu et al ,2013). It is recommended that China treat health informatics as a priority “must-have” discipline to build in China we can see that, before 2000, there were only 4 universities that offered a specialty in medical library and information science (now known as information management and information systems and health informatics), At present, there are 55 programs at which the specialty is offered in Chinese universities or colleges. Thus, health informatics education in China has developed significantly over the past 10 years. Of the 55 programs, 45 (81.82%) offer information management and information systems; 5 offer medical informatics engineering, The other 5 offer medical informatics and related specialties: 3 of them medical informatics, 1 information and computer science (health informatics), and 1 electronic information science and technology (medical information)(Hu et al. 2013).

In Virginia, USA, The School of Medicine at the Medical College of Virginia Campus of Virginia Commonwealth University examined the 2005/2006 medical school curriculum to ensure that students were prepared to meet the informatics objectives put forward by the AAMC Medical School Objectives Project published in 1998. The AAMC Medical Informatics Objectives Survey, issued in 2005, led the VCU School of Medicine to investigate the points of integration between informatics objectives and course syllabi for the first three years of the medical school curriculum ,A review of all first through third-year courses was completed, and results were compiled on the tracking tool. All clerkship directors (and their educational coordinators) on the MCV and Inova campuses were contacted to review the findings and to ensure the scope of the project was comprehensive (Seago et al. 2007).This outreach resulted in the identification of additional informatics objectives incorporated in the third-year clerkships. Overall, project findings show that the VCU School of Medicine has integrated more than 74% of the AAMC informatics objectives into the first three years of the curriculum (46 of 62 courses). Nearly 89% (16 of 18) Role 1 objectives, 92.3% (12 of 13) of Role 2 objectives, 85.7%

(6 of 7) of Role 3 objectives, 30.8% (4 of 13) of Role 4 objectives, and 72.7% (8 of 11) of Role 5 objectives are integrated into the School of Medicine Curriculum. Also,14.5% of all the objectives are integrated into the curriculum infrastructure(Seago et al. 2007).

2.4. Recommendations for Learning Outcomes in Biomedical and Health Informatics

The International Medical Informatics Association (IMIA) endorsed a set of recommendations on education in health and medical informatics' in 1999 and a scientific map was developed in 2002 (http://www.imia.org/endorsed.html).

The IMIA recommendations centre on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology as it is needed and used in medicine and health care. The educational needs are described as a three- dimensional framework with dimensions 'professional in health care', 'type of specialisation in BMHI' and 'stage of career progression'(Mantas et al. 2010).

If one is studying a certain discipline (e.g. medicine, dentistry, physiotherapy,… to receive a bachelor degree), then the IMIA recommendations suggest that in their study, all these students should get a minimum of education in BMHI, so that they are able to efficiently use information and communication technology (IT users). On the other side, candidates may want to prepare for careers as BMHI specialists. The study of BMHI for these specialists is somewhat different (Mantas et al. 2010).

For education in BMHI two kinds of major learning outcomes can be identified. They specify the

1. Learning outcomes for all health care professionals in their role as IT users: Enabling health care professionals to efficiently and responsibly use information and knowledge processing methodology and information and communication technology(Mantas et al. 2010). These learning outcomes need to be included in all undergraduate curricula, leading to a health care professional qualification. On the other hand there are:

2. Learning outcomes for BMHI specialists: Preparing graduates for careers in BMHI in academic, health care (e.g. hospital, primary care), government or industrial settings. These learning outcomes need to be included in all curricula, leading to a qualification as specialist in BMHI.(Mantas et al. 2010) But in our context we will focus on learning outcomes for all undergraduate health care professionals in their role as IT users. And the IMIA suggested that

All health care professional graduates should, in their role as IT users, have the levels of knowledge and skills mentioned for IT users.(Mantas et al. 2010)

Table2. 1 contains the list of learning outcomes, recommended by IMIA. The knowledge and Skill levels are classified into three domain areas:

1. BMHI core knowledge and skills,
2. Medicine, health and biosciences, health system organisation
3. informatics/computer science, mathematics, biometry,

Table 2. 1: Recommended and optional learning outcomes in terms of levels of knowledge and skills for professionals in health care in their role as IT users.

Knowledge/Skill – Domain	**Level IT user**
(1) Biomedical and Health Informatics Core Knowledge and Skills	
1.1 **Evolution of informatics** as a discipline and as a profession	+
1.2 **Need for systematic information processing** in health care, benefits and constraints of information technology in health care	++
1.3 Efficient and responsible **use of information processing tools**, to support health care professionals' practice and their decision making	++
1.4 **Use of personal application software** for documentation, personal communication including Internet access, for publication and basic statistics	++
1.5 **Information literacy**: library classification and systematic health related terminologies and their coding, literature retrieval methods, research methods and research paradigms	+
1.6 Characteristics, functionalities and examples of **information systems in health care** (e.g. clinical information systems, primary care information systems, etc.)	+
1.7 **Management of information systems** in health care (health information management, strategic and tactic information management, IT governance, IT service management, legal and regulatory issues)	+
1.8 Methods and approaches to **regional networking and shared care** (eHealth, health telematics applications and inter-organizational information exchange)	+
1.9 Appropriate documentation and **health data management principles** including	+

ability to use health and medical coding systems, construction of health and medical coding systems	
1.10 Structure, design and analysis principles of the **health record** including notions of data quality, minimum data sets, architecture and general applications of the electronic patient record/electronic health record	+
1.11 **Socio-organizational and socio-technical issues**, including workflow/process modelling and reorganization	+
1.14 **Ethical and security issues** including accountability of health care providers and managers and BMHI specialists and the confidentiality, privacy and security of patient data	+
(2) Medicine, Health and Biosciences, Health System Organisation	
2.1 Fundamentals of **human functioning** and biosciences (anatomy, physiology, microbiology, genomics, and clinical disciplines such as internal medicine, surgery etc.)	+
2.2 Fundamentals of **what constitutes health**, from physiological, sociological, psychological, nutritional, emotional, environmental, cultural, spiritual perspectives and its assessment	+
2.3 Principles of **medical decision making** and diagnostic and therapeutic strategies	+
2.4 **Organisation of health institutions** and of the overall health system, interorganizational aspects, shared care	+
2.5 Principles of **evidence-based medicine** and evidence-based nursing	
(3) Informatics/Computer Science, Mathematics, Biometry	
3.1 **Basic informatics terminology** like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management	+
3.2 **Ability to use personal computers**, text processing and spread sheet software, easy-to-use database management systems	++
3.3 **Ability to communicate electronically**, including electronic data exchange, with other health care professionals, internet/intranet use	++
3.4 Handling of the **information system life cycle**: analysis, requirement	+

specification, implementation and/or selection of information systems, risk management, user training	
3.5 Methods of **project management and change management** (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies)	+
3.6 Methods for **decision support** and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines	+

Recommended level of knowledge and skills: + =introductory. ++ =intermediate.

Source: (Mantas et al. 2010)

2.5. The Benefits of health informatics in health care

If physiology literally means "the logic of life", and pathology is "the logic of disease", then health informatics is "the logic of healthcare"(Ganjalikhani et al, 2010) .In fact, Health informatics, Healthcare informatics or Medical informatics is the intersection of information science, computer science, and health care. Medical informatics develops and assesses methods and systems for the acquisition, processing, and interpretation of patient data with the help of knowledge that is obtained in scientific research(Hasman, 1998). Overall, it is the science of information management in healthcare, and its application to support clinical practice, decision making and research(Vedel et al. 2012).

Numerous studies showed that health informatics systems have valuable Benefits. These benefits include offering clinicians mobility, help in decision making, providing real-time access to data and information, reducing medical errors, saving time, supporting evidence-based practice, enhancing productivity and quality of care, and providing a tool for communication.(Ganjalikhani & Babaei 2010; Garde et al. 2005; Hasman 1998)

Rothschild et al. (2002) examined the clinical contributions of a handheld drug database in March 2000. They found that Clinicians reported the database saved time during information retrieval, could be incorporated easily into their workflow, and improved drug-related decision making (Rothschild et al.2002). D'Hemecourt (2001) also reported positive outcomes (from an average 33-day reimbursement time to 1 day) after PDA technology were used for billing and

reimbursement: reimbursement time was reduced from an average of 33 days to 1 day (d'Hemecourt, 2001).

Silva et al. (2003) reported using PDAs to document the services offered by pharmacists to physicians (such as providing drug information and pharmacotherapy consultation). The cost reduction associated with electronic documentation totalled $662,335 during a 6-month period for the four pharmacists and four residents who participated in the study (Silva et al.2003).

Leung et al. (2003) evaluated the use of a clinical decision support system to assess its educational effectiveness on learning evidence-based medicine and reported improvement in participants educational experience Most health care professionals perceived that CDSS are useful tools that can enhance their practice by offering the needed information at exact time (Leung et al. 2003).

On the other hand, Grasso et al. (2002) examined whether using PDAs to create discharge order lists instead of transcribing the lists manually would reduce errors. They documented a decrease in errors from 22% to 8% at 4 months after implementation (Grasso et al. 2002).

Finally, in a study of Lee et al (2002) this study evaluated the clinical contribution of a drug database developed for PDAs. Clinicians reported that the system saved time during information retrieval (40.6% saved 0—30 s per encounter; 29.8% saved 30—60 s; 20.8% saved 1—3 min); improved practice efficiency(86.3% for outpatient and 87.1% for inpatient practice); increased self-reported drug knowledge (78.9%); improved drug-related decisions (80.3%); and improved patient care (83% reported better able to inform patients; 54% reported more patients satisfaction and 63.1% reported reduced potential adverse drug effects) (Lee et al ,2002)

From the discussions of this literature review, it is obvious that different research studies showed the importance of integration of health informatics competencies in training of health professionals at an international level. Rwanda was not presented because of scarcity or unavailability of research study in Rwanda clinical areas related to health informatics. The current research questions strive to address this deficit.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology which was used. It includes Study area, study design, study population, study sample and sampling strategy, data collection methods and procedures, data analysis, problems and limitations of the study, instruments used including the ethical issues which were taken into account, and the validity and reliability of the research tool.

3.2 Study Area

This study was conducted in University of Rwanda, college of Medecine and health Sciences. This college is a merger of the former Kigali Health Institute, the Faculty of Medicine and the School of Public Health of the former National University of Rwanda and the Public Midwifery and Nursing schools across the country. The College of Medicine and Health Sciences is based at Nyarugenge, but also with programmes taught at Nyamishaba, Kicukiro, Huye, Nyagatare, Byumba, Kibungo, Rwamagana and Kabgayi Campuses.

The selected college is mandated to train health care professionals in different fields. it is composed of 5 schools: the school of medicine and pharmacy, the School of Health Sciences, the school of dentistry, the school of nursing and midwifery and then the school of community health development ; they all offer programs leading to the award of Advanced Diplomas, Bachelor's Degrees, Bachelor's Degrees with honours and bridging programs in the relevant disciplines as listed below :Bachelor of sciences in medecine, Bachelor of Science in pharmacy , Bachelor of science in clinical psychology; Bachelor's Degree with honours in Environmental Health Sciences; Bachelor of Science in Human Nutrition and Dietetics; Bachelor of Science in Clinical Medicine and Community Health ,Bachelor's degree with honours in nursing, Bachelor of Science in Biomedical Laboratory Sciences; Bachelor of Science in Physiotherapy; Bachelor of Science in Dentistry***;*** Bridging Program of Anaesthesia; Bridging Program of Physiotherapy, Advanced Diploma in Anaesthesia; Advanced Diploma in Ophthalmology; Advanced Diploma in Medical Imaging Sciences; Advanced Diploma in Orthopaedic Technology ,Advanced diploma in mental health , Advanced diploma in nursing and Advanced diploma in midwifery.
The college has been chosen because it is the only public healthcare professional training facility in the whole country of Rwanda.

3.3 Study design

To achieve our research objectives, a descriptive cross - sectional study was conducted with the aim of Assessing health informatics competencies in existing curricula for training undergraduate health care professionals in Rwanda. This design was considered suitable, given that this study focuses on health informatics competencies available in existing curricula. In fact, according to Wallen and Frankel (1991), surveys best suit studies like the current one where the intent is to obtain a sizeable amount of information about the characteristics of a particular sample. It is also Loiselle *et al*. (2007)'s contention that a descriptive study creates an opportunity for researchers to describe a phenomena.

3.4 Study population

The population in this study is comprised of all curricula currently used in training of undergraduate health care professionals in University of Rwanda, College of Medicine and Health Sciences for the academic year 2013 - 2014. The total number of curricula is 30.

3.5 Study Sample

The sample size of the present research is 30 curricula currently used in teaching and learning in College of Medicine and Health Sciences for undergraduate healthcare professionals.

3.6 Sampling strategy

To overcome the problem of a limited number of curricula, all curricula for undergraduate in University of Rwanda, College of Medicine and Health Sciences for the academic year 2013 - 2014 by the time of data collection were recruited to the study. All those curricula were reviewed. The census method was therefore used.

3.7 Data collection procedures

3.7.1 Data collection tool

The instrument used in this study, the health Informatics Competencies Questionnaire, was developed from the nursing informatics competencies for four levels of undergraduate nursing identified by Staggers et al. (2002)

The questionnaire was designed according to Recommendations of the International Medical Informatics Association (IMIA) on Education for health care professionals obtained from Mantas et al(2010), we reviewed documents(curricula for undergraduate training in College of

Medicine and Health Sciences) and Compared available health informatics competencies with the ones provided by the Recommendations of the International Medical Informatics Association (IMIA) on Education for health care professionals.

A document review approach was used to assess the curricula of undergraduate health care professionals regarding health informatics competencies based on IMIA recommendations on education in biomedical and health informatics. Further, Document review is the process whereby each party to a case sorts through and analyzes the documents and data they possess (and later the documents and data supplied by their opponents through discovery) to determine which are sensitive or otherwise relevant to the case. (Mackay, 2013)

3.7.2 Validity and reliability

This study used instruments which had been used previously in similar studies. The content of the tool that is used in the present study .was derived from the original questionnaire developed by Staggers, Gassert and Curran (2002) which included health informatics competencies based on IMIA recommendations. After a review of the literature from 1998 to 2004, these competencies were assigned to one of three major classifications: computer skills, informatics knowledge, informatics skills into four levels of nursing practice. In addition, two new subcategories of informatics knowledge (evidence-based and information literacy) were added (Staggers et al, 2002).

To make sure that the tool is measuring what it is supposed to measure, the questionnaire was adapted to the local context. A pilot study involving 4 curricula was conducted. The purpose of the pilot study is to check whether the tool is well designed in a way that would allow measurement of what is supposed to be measured. In addition, the aim of conducting the pilot study is to estimate the time required for reviewing a document. Approximately twenty five to thirty minutes were required for the researcher to review one document.

3.8 Data Analysis

An electronic database was established prior to the use of questionnaire. Once the data were collected, the Statistical Package for the Social Sciences (SPSS version 21) was used for data coding and processing, whereas frequency and mean summary statistics were performed to describe the study population characteristics. Data were analyzed, presented and grouped. Tables were used to present the results for easy interpretation.

To check whether the availability of health informatics competencies in curricula varies according to different schools and/or different undergraduate programmes or not; a one way ANOVA with an alpha level of 0.05 was conducted to compare schools and to compare undergraduate programmes.

To determine which school or undergraduate programme is different from the others, we conducted a PostHoc pair-wise difference was performed.

3.9 Ethical consideration

Before embarking on this study, the researcher presented a research proposal to the University of Rwanda, college of medecine and health sciences Research Committee for approval. In addition, before the data collection process start, the researcher sought and obtained permission from the Schools Research Ethics Committees. The information obtained was kept anonymous and confidential at all times and was used only for the purpose of the current study. Numbers were used to protect the school's identity, meaning that no data could be traced back to an individual. When it comes to data management, data was kept in a secure place to which only the researcher and her supervisors had access. It will be kept for a period of five years after which it will be destroyed.

3.10 Limitations of the study

The researcher may have limited Access to official documents (curricula) for whatever reason; access may be denied or otherwise limited.

In the same line the researcher may encounter a problem of a small Sample size because of the available curricula to be analyzed.

CHAPTER 4: RESULTS

This chapter describes the findings relevant to an assessment of health informatics competencies in training of undergraduate healthcare professionals in Rwanda. The study was conducted on 30 undergraduate curricula of 5 schools of the College of Medicine and Health Sciences, University of Rwanda. Using a standardized data collection tool, a review of curricula was done to check the availability of health informatics competencies. The data collection phase lasted for one month, from August to September, 2014. All potential curricula were collected and assessed, which represents a response rate of 100%. Data were entered and analyzed using Microsoft SPSS 21.

The presentation of the research findings is structured according to the sections of the data collection tool.

4.1. Presentation of the results

4.1.1. Undergraduate curricula by school

Information regarding the undergraduate curricula available in different schools of college of medicine and health sciences is presented in Table 4.1**.**The findings reveal that out of 30 curricula, the School of Health sciences accounted for the majority of them (43.3%) while the whole college has five schools.

Table 4. 1: Number of assessed undergraduate curricula by school

School	Frequency	Percent
Medicine and Pharmacy	3	10.0
Health Sciences	13	43.3
Nursing and Midwifery	6	20.0
Dentistry	3	10.0
Community Health Development	5	16.7
Total	30	100.0

Note: The School of Community Health Development has been transferred to the School of Public Health**.**

4.1.2. Presentation of undergraduate curricula by Department

Table 4.2 displays the distribution of undergraduate curricula according to different departments of the College of Medicine and Health Sciences. Some departments have more than one curriculum because they have either the bachelor`s degree program or the advanced diploma program or even the bridging program; one department may have all the above mentioned programs or two of them at the same time.

Table 4. 2: Presentation of undergraduate curricula by Department

Department	Frequency	Percent
Anaesthesia	2	6.7
Biomedical Laboratory Sciences	2	6.7
Clinical Medecine and Community Health	2	6.7
Clinical Psychology	1	3.3
Dental Surgery	1	3.3
Dental Therapy	2	6.7
Environmental Health Sciences	2	6.7
General Medicine	1	3.3
General Nursing(Former KHI)	1	3.3
General Nursing (Rwamagana, Kibungo, Kabgayi, Byumba, Nyagatare)*	1	3.3
Human Nutrition and Dietetics	1	3.3
Medical Imaging Sciences	3	10.0
Medical Imaging Sciences(Diagnostic Ultrasound)	1	3.3
Mental Health Nursing	1	3.3
Midwifery(Former KHI)	2	6.7
Midwifery (Rwamagana, Kibungo, Kabgayi, Byumba, Nyagatare)*	1	3.3
Occupational Therapy	1	3.3
Ophthalmology	1	3.3
Pharmacy	1	3.3
Physiotherapy	2	6.7
Prosthetics and Orthotics	1	3.3
Total	30	100.0

Note*: The 5 nursing and midwifery schools across the country have only 2 similar curricula for their departments even if they are located in different areas.

4.1.3. Undergraduate curricula by programme

Table 4.3 illustrates the number of curriculum according to their respective undergraduate teaching programmes. All programmes had nearly the same number of assessed curricula.

Table 4. 3: Undergraduate curricula by programme

Undergraduate Programme	Frequency	Percent
Advanced Diploma	8	26.7
Bachelor`s Degree	7	23.3
Bachelor`s Degree with honours	7	23.3
Bridging Program	8	26.7
Total	30	100.0

4.1.4. Existence of Health informatics competencies in different Curricula

The availability of health informatics competencies was assessed using a tool consisting of a set of recommendations which describes ways that curricula should outline specific items related to health informatics. Each recommendation was to be rated using a yes-or-no option, reflecting respectively the presence or absence of the concerned health informatics competency in the curriculum. Results are presented according to the educational needs for health informatics competencies as classified as a three-domain area by The International Medical Informatics Association (IMIA). These domain areas include Biomedical and Health Informatics Core Knowledge and Skills; Medicine, Health and Biosciences and Health System Organisation; and Informatics/Computer Science, Mathematics and Biometry. Related results for each domain area are presented in Tables 4.4, 4.5 and 4.6.

Table 4.4 provides the frequency of availability of competencies relating to the area of Biomedical and Health Informatics Core Knowledge and Skills. The findings reveal that one competency was completely missing (n=0.0%) in all curricula. That competency is socio-organizational and socio-technical issues, including workflow/process modelling and reorganization. Other competencies were available at different levels.

Table 4. 4: Frequency of Biomedical and Health Informatics Core Knowledge and Skills

Competencies n = 30	Yes n (%)	No n (%)
1.1.Evolution of informatics as a discipline and as a profession	19 (63.3)	11 (36.7)
1.2.Need for systematic information processing in health care, benefits and constraints of information technology in health care	3 (10)	27 (90)
1.3.Efficient and responsible use of information processing tools, to support health care professionals' practice and their decision making	20 (66.7)	10 (33.3)
1.4.Use of personal application software for documentation, personal communication including Internet access, for publication and basic statistics	21 (70%)	9 (30%)
1.5.Information literacy: library classification and systematic health related terminologies and their coding, literature retrieval methods, research methods and research paradigms	4 (13.3)	26 (86.7)
1.6. Characteristics, functionalities and examples of information systems in health care (e.g. clinical information systems, primary care information systems, etc.)	18 (60)	12 (40)
1.7.Management of information systems in health care (health information management, strategic and tactic information management, IT governance, IT service management, legal and regulatory issues)	18 (60)	12 (40)
1.8.Methods and approaches to regional networking and shared care (eHealth, health telematics applications and inter-organizational information exchange)	14 (46.7)	16 (53.3)
1.9.Appropriate documentation and health data management principles including ability to use health and medical coding systems, construction of health and medical coding systems	5 (16.7)	25 (83.3)
1.10.Structure, design and analysis principles of the health record including notions of data quality, minimum data sets, architecture and general applications of the electronic patient record/electronic health record	17 (56.7)	13 (43.3)
1.11.Socio-organizational and socio-technical issues, including workflow/process modelling and reorganization	0 (0)	30 (100)
1.12.Ethical and security issues including accountability of health care providers and managers and BMHI specialists and the confidentiality, privacy and security of patient data	18 (60)	12 (40)

Table 4.5 presents the availability of health informatics competencies for the area of Medicine, Health and Biosciences and Health System Organisation. The results indicate that competencies for this second domain area are missing in most curricula, the maximum availability rate appear for the item 2.5, related to principles of evidence-based medicine and evidence-based nursing (60%), while the minimum availability rate is shown by the item 2.3, related to principles of medical decision making and diagnostic and therapeutic strategies (6.7%).

Table 4. 5: Frequency of Medicine, Health and Biosciences and Health System Organisation competencies

Competencies (n = 30)	**Yes n (%)**	**No n (%)**
2.1. Fundamentals of human functioning and biosciences (anatomy, physiology, microbiology, genomics, and clinical disciplines such as internal medicine, surgery etc.)	4 (13.3)	26 (86.7)
2.2.Fundamentals of what constitutes health, from physiological, sociological, psychological, nutritional, emotional, environmental, cultural, spiritual perspectives and its assessment	4 (13.3)	26 (86.7)
2.3.Principles of medical decision making and diagnostic and therapeutic strategies	2 (6.7)	28 (93.3)
2.4.Organisation of health institutions and of the overall health system, interorganizational aspects, shared care	5 (16.7)	25 (83.3)
2.5.Principles of evidence-based medicine and evidence-based nursing	18 (60)	12 (40)

Table 4.6 illustrates the frequency of existence of competencies related to Informatics/Computer Science, Mathematics and Biometry competencies. The findings indicate that for this third domain area, three competencies are highly available in curricula. These competencies include basic informatics terminology such as data, information, knowledge, hardware, software, computer, networks, information systems, information systems management (n=21, 70%); ability to use personal computers, text processing and spreadsheet software, easy-to-use database management systems (n=21, 70%); and ability to communicate electronically, including electronic data exchange with other healthcare professionals, internet/intranet use (n=21, 70%).

Another competency of methods for decision support and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines was available at a lower percentage (3%). there was also for this domain area a missing competency in all curricula (n=0 , 0%)which is related to methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies).

Table 4. 6: Frequency of Informatics/Computer Science, Mathematics and Biometry competencies

Competencies **n = 30**	**Yes** **n (%)**	**No** **n (%)**
3.1.Basic informatics terminology like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management	21 (70)	9 (30)
3.2.Ability to use personal computers, text processing and spread sheet software, easy-to-use database management systems	21 (70)	9 (30)
3.3.Ability to communicate electronically, including electronic data exchange, with other health care professionals, internet/intranet use	21 (70)	9 (30)
3.4.Handling of the information system life cycle: analysis, requirement specification, implementation and/or selection of information systems, risk management, user training	4 (13.3)	26 (86.7)
3.5.Methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies)	0 (0)	30 (100)
3.6.Methods for decision support and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines	1 (3.3)	29 (96.7)

4.1.5. Descriptive statistics of Health informatics competencies in Curricula

In order to assess the overall degree of availability of each specific item in the curricula, we computed the means and standard deviations of every competency after recoding data from binary scale to numerical scale. A yes-option was equivalent to one (1), while a no-option was equivalent to zero on the new scale.

The corresponding results are illustrated in tables 4.7, 4.8 and 4.9. These tables indicate the means and standard deviations for every single competency taking into consideration the 3 domain areas of health informatics.

When the mean value of a specific item/competency is far from 0, this means that the competency is present, and when the mean value is closer to 0, the competency is absent from the assessed curriculum.

Table 4.7 lists the mean value and standard deviation for the overall degree of availability in curricula for Biomedical and Health Informatics Core Knowledge and Skills.

Table4 .7 Biomedical and Health Informatics Core Knowledge and Skills Means and standard deviations

Biomedical and Health Informatics Core Knowledge and Skills	Mean	Standard Deviation
1.1.Evolution of informatics as a discipline and as a profession	0.63	0.490
1.2.Need for systematic information processing in health care, benefits and constraints of information technology in health care	0.10	0.305
1.3.Efficient and responsible use of information processing tools, to support health care professionals' practice and their decision making	0.67	0.479
1.4.Use of personal application software for documentation, personal communication including Internet access, for publication and basic statistics	0.70	0.466
1.5.Information literacy: library classification and systematic health related terminologies and their coding, literature retrieval methods, research methods and research paradigms	0.13	0.346
1.6. Characteristics, functionalities and examples of information systems in health care (e.g. clinical information systems, primary care information systems, etc.)	0.60	0.498
1.7.Management of information systems in health care (health information management, strategic and tactic information management, IT governance, IT service management, legal and regulatory issues)	0.60	0.498
1.8.Methods and approaches to regional networking and shared care (eHealth, health telematics applications and inter-organizational information exchange)	0.47	0.507
1.9.Appropriate documentation and health data management principles including ability to use health and medical coding systems, construction of health and medical coding systems	0.17	0.379
1.10.Structure, design and analysis principles of the health record including notions of data quality, minimum data sets, architecture and general applications of the electronic patient record/electronic health record	0.57	0.504
1.11.Socio-organizational and socio-technical issues, including workflow/process modelling and reorganization	0.00	0.000
1.12.Ethical and security issues including accountability of health care providers and managers and BMHI specialists and the confidentiality, privacy and security of patient data	0.60	0.498

Table 4.8 lists the mean value and standard deviation for the overall degree of availability in curricula for Medicine, Health and Biosciences and Health System Organisation competencies

Table 4. 8: Medicine, Health and Biosciences and Health System Organisation competencies Means and standard deviations

Medicine, Health and Biosciences and Health System Organisation competencies	Mean	Standard Deviation
2.1. Fundamentals of human functioning and biosciences (anatomy, physiology, microbiology, genomics, and clinical disciplines such as internal medicine, surgery etc.)	0.13	0.346
2.2.Fundamentals of what constitutes health, from physiological, sociological, psychological, nutritional, emotional, environmental, cultural, spiritual perspectives and its assessment	0.13	0.346
2.3.Principles of medical decision making and diagnostic and therapeutic strategies	0.07	0.254
2.4.Organisation of health institutions and of the overall health system, interorganizational aspects, shared care	0.17	0.379
2.5.Principles of evidence-based medicine and evidence-based nursing	0.60	0.498

Table 4.9 lists the mean value and standard deviation for the overall degree of availability in curricula for Informatics/Computer Science, Mathematics and Biometry competencies

Table 4. 9. Informatics/Computer Science, Mathematics and Biometry competencies Means and standard deviations

Informatics/Computer Science, Mathematics and Biometry competencies	Mean	Standard Deviation
3.1.Basic informatics terminology like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management	0.70	0.466
3.2.Ability to use personal computers, text processing and spread sheet software, easy-to-use database management systems	0.70	0.466
3.3.Ability to communicate electronically, including electronic data exchange, with other health care professionals, internet/intranet use	0.70	0.466
3.4.Handling of the information system life cycle: analysis, requirement specification, implementation and/or selection of information systems, risk management, user training	0.13	0.346
3.5.Methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies)	0.00	0.000
3.6.Methods for decision support and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines	0.03	0.183

4.1.6 Comparison between schools of the College of Medicine and Health Sciences in relation to health informatics competencies availability in their curricula

To identify whether the availability of health informatics competencies in curricula varies across schools, one-way ANOVA was performed to make multiple comparisons between mean scores. Alpha value was set to 0.05. The results are summarized in Table 4.10.

Table 4. 10: Comparison of availability of health informatics competencies according to schools of the College of Medicine and Health Sciences

Domain-areas	Schools	Mean	SD	F	Significance
Biomedical and Health Informatics Core Knowledge and Skills	Medicine and Pharmacy	8.0	0.0	0.8	0.563
	Health Sciences	4.4	4.2		
	Nursing and Midwifery	5.7	3.7		
	Dentistry	3.7	4.0		
	Community Health Development	6.2	3.9		
	Total	5.2	3.8		
Medicine, Health and Biosciences, Health System Organisation	Medicine and Pharmacy	4.0	1.7	12.0	0.000
	Health Sciences	0.5	0.5		
	Nursing and Midwifery	1.3	0.8		
	Dentistry	0.7	0.6		
	Community Health Development	0.8	0.8		
	Total	1.1	1.3		
Informatics/ Computer Science, Mathematics, Biometry	Medicine and Pharmacy	3.7	0.6	1.6	0.206
	Health Sciences	1.6	1.6		
	Nursing and Midwifery	2.5	1.2		
	Dentistry	2.0	1.7		
	Community Health Development	3.0	1.9		
	Total	2.3	1.6		
All domains	Medicine and Pharmacy	15.7	2.3	1.7	0.176
	Health Sciences	6.5	6.3		
	Nursing and Midwifery	9.5	5.2		
	Dentistry	6.3	6.0		
	Community Health Development	10.0	6.3		
	Total	8.6	6.1		

Table 4.10 depicts F test results and indicates that considering the availability of the 3 health informatics competencies domain areas in curricula, there was statistically significant differences

between schools for the second domain-area as determined by one-way ANOVA ($F_{4,25}$=11.957, $p < 0.001$). For the remaining two domain-areas, differences between mean scores were not statistically significant.

To identify which school has a significantly different mean score from the others for that second domain area, a Post Hoc test (Bonferonni) was run and the significance levels are depicted in Table 4.11. And from this table, it can be seen that the mean score of the school of Medicine and Pharmacy was significantly higher than others ($p<0.001$).

Table 4. 11: Significance analysis of results for the area of Medicine, Health and Biosciences, Health System Organisation

Schools	Medicine and Pharmacy	Nursing and Midwifery	Dentistry	Community Health Development	Health Sciences
Medicine and Pharmacy	1.000	0.001*	0.000*	0.000*	0.000*
Nursing and Midwifery	0.001*	1.000	1.000	1.000	0.552
Dentistry	0.000*	1.000	1.000	1.000	1.000
Community Health Development	0.000*	1.000	1.000	1.000	1.000
Health Sciences	0.000*	0.552	1.000	1.000	1.000

*. The mean difference is significant at the 0.05 level.

It can be seen that there were significant differences considering the availability of health informatics competencies in curricula between the School of Medicine and Pharmacy and the School of Health Sciences ($p = 0.000$), between the School of Medicine and Pharmacy and the school of Nursing and Midwifery ($p = 0.001$), between the School of Medicine and Pharmacy and the school of Dentistry ($p = 0.000$), as well as between the School of Medicine and Pharmacy and the School of Community Health Development ($p = 0.000$). In summary, the mean score of the school of Medicine and Pharmacy statistically differs from others. However, there were no differences between the mean scores of the remaining four schools ($p > 0.05$).

4.1.7 Comparison between undergraduate programmes of the College of Medicine and Health Sciences in relation to health informatics competencies availability in their curricula

To assess the availability of health informatics competencies in curricula across different undergraduate programmes, mean scores were analysed using one-way ANOVA. Post Hoc test (Bonferonni) was used to systematically compare differences between mean scores of two programs. The significance level was set to 0.05. The results are summarized in table 4.12.

Table4.12:One-way ANOVA analysis of health informatics competencies by undergraduate programmes

Domain-areas	Programs	Mean	SD	F	Significance
Biomedical and Health Informatics Core Knowledge and Skills	Bachelor`s Degree	7.1	2.0	11.0	.000
	Bachelor`s Degree with honours	7.3	1.9		
	Advanced Diploma	6.3	4.4		
	Bridging Program	0.6	1.8		
	Total	5.2	3.8		
Medicine, Health and Biosciences, Health System Organisation	Bachelor`s Degree	1.3	0.5	6.4	.002
	Bachelor`s Degree with honours	2.3	1.9		
	Advanced Diploma	1.0	0.8		
	Bridging Program	0.0	0.0		
	Total	1.1	1.3		
Informatics/ Computer Science, Mathematics, Biometry	Bachelor`s Degree	3.0	0.0	9.1	.000
	Bachelor`s Degree with honours	3.3	0.5		
	Advanced Diploma	2.4	1.8		
	Bridging Program	0.5	1.4		
	Total	2.3	1.6		
All domains	Bachelor`s Degree	11.4	1.5	12.6	.000
	Bachelor`s Degree with honours	12.9	3.4		
	Advanced Diploma	9.7	6.9		
	Bridging Program	1.1	3.2		
	Total	8.6	6.1		

For all the 3 domain areas, there were statistically significant differences between mean scores of programmes as determined by one-way ANOVA results: first domain area ($F_{3, 26} = 11.008$, $p = .000$); second domain area ($F_{3, 26} = 6.363$, $p = .002$); third domain area ($F_{3, 26} = 9.057$, $p = .000$).

To perform inter-program comparisons, a Post Hoc (Bonferonni) test was used and results for different significance levels (p-value) are shown in Table 4.13.

It can be seen that the Brigding program was less likely to have the studied health informatics competencies in its curricula.

Table 4. 13: Significance of differences between means for different programs

Domain-areas		Advanced Diploma	Bachelor `s Degree	Bachelor`s Degree with honours	Bridging Program
Biomedical and Health Informatics core knowledge and skills	Advanced Diploma	1.000	1.000	1.000	0.000*
	Bachelor`s Degree	1.000	1.000	1.000	0.000*
	Bachelor`s Degree with honours	1.000	1.000	1.000	0.002*
	Bridging Program	0.000*	0.000*	0.002*	1.000
Medicine, Health and Biosciences and Health Systems organizations	Advanced Diploma	1.000	0.360	1.000	0.126
	Bachelor`s Degree	0.360	1.000	0.155	0.001*
	Bachelor`s Degree with honours	1.000	0.155	1.000	0.413
	Bridging Program	0.126	0.001*	0.413	1.000
Informatics/Computer science, mathematics and Biometry	Advanced Diploma	1.000	1.000	1.000	0.001*
	Bachelor`s Degree	1.000	1.000	1.000	0.001*
	Bachelor`s Degree with honours	1.000	1.000	1.000	0.021*
	Bridging Program	0.001*	0.001*	0.021*	1.000

*. The mean difference is significant at the 0.05 level.

From the results in table 4.12, it is already known that there are significant differences between mean scores of the undergraduate programmes. In Table 4.13, multiple comparisons show which undergraduate programme was different from each other. It can be seen that there was a significant difference considering the availability of health informatics competencies in curricula between the Bridging program and the advanced diploma program (p = 0.001), between the Bridging program and the bachelor`s degree program ($p$ = 0.001) as well as between the Bridging program and the bachelor`s degree with honours program (p = 0.021). However, there were no differences between mean scores of the remaining undergraduate programs (p >0.05).

4.1.8 Guidance and future directions for integrating health informatics competencies in training of undergraduate health care professionals.

It was identified by the Institute of Medicine (IOM) report in 2001 that a transformation in healthcare was needed. This report made a call for the use of health information technology (IT) to enhance the quality, safety, and efficiency of healthcare. The IOM's transformation suggested improving communication between providers and patients, automating clinical information, reducing errors, and promoting evidence based practice (Ehnfors & Grobe 2004).

The importance of incorporating health (or medical) informatics into the education of medical students and practitioners is increasingly being recognized. The advances in information and communication technology and the pervasion of the Internet into everyday life have important implications for healthcare services and medical education (Haux 1998).Students and practitioners should learn to make good use of biomedical information for problem solving and decision making, the essential clinical informatics skills have been identified and should be incorporated into the undergraduate medical curriculum.

There are many opportunities worldwide for obtaining education in the field of health informatics. In some countries, there are extensive educational components in biomedical and health informatics (BMHI) at different levels of education and for the different health care professions (Mantas et al. 2010). However it is recommended that these be introduced in stages and integrated into existing training programmes rather than taught as a separate course. At the same time, medical schools should support the integration of e-learning in the educational process in view of the numerous potential benefits (Mantas et al. 2010). The detailed health informatics competencies for undergraduate level in healthcare professionals` education are shown in Table 2.1. These recommendations remain valid and useful for the Rwanda Health System. In addition, there are different eHealth information technology systems which are operational in different health institutions of Rwanda. Some of these systems include OpenEMRS (Rwinkwavu, Kirehe and Butaro District Hospitals), Drug and Medical Supply Management Systems (CAMERWA), Telemedicine, HMIS (Ministry of Health), OpenClinic softwares (CHUK), and E-Learning in five nursing schools. So there is a need to integrate health informatics competencies in the training of healthcare professionals for better usage and management of the existing eHealth information technology systems. Furthermore, on-job

trainings are necessary for those health professionals who have already completed their academic training.

CHAPTER 5: DISCUSSION

5.1. Existence of health informatics competencies in undergraduate curricula

Having consulted many researches about health informatics for health care professionals, and having realized that a comprehensive health informatics education framework is needed to enable health professionals to function optimally. Our concern was to try to find out health informatics competencies outlined in existing curricula for training undergraduate healthcare professionals in Rwanda. The study population was comprised of all curricula currently used in training of undergraduate health care professionals in University of Rwanda, College of Medicine and Health Sciences for the academic year 2013 – 2014 in all the 5 schools of the college.

The total number of undergraduate curricula which participated in this study was 30.the assessed health informatics competencies in each curriculum were 23 competencies under 3 domain areas of health informatics competencies as stipulated in the existing international recommendations in health informatics /medical informatics education by the International Medical Informatics Association (IMIA).These recommendations provide a sound foundation for a more comprehensive and detailed health informatics education framework and were used as a basis for the development of our survey (Herbert et al,2010).

The results from the current study reveal that out of 30 undergraduate curricula of the College of Medicine and Health Sciences, the majority belong to the school of health sciences 13(43%),the school of medicine and Pharmacy has 3(10%) and the school of dentistry has 3(10%), 5(17%) are for the school of community health development while 6(20%) belong to the school of nursing and midwifery. with regard to several department , the total number of departments is 21 that may host 1 or more different undergraduate programs; Bachelor`s degree(7 curricula) , Bachelor`s degree with honours(7 curricula) , Bridging program(8 curricula) and Advanced diploma(8 curricula).

The assessment of health informatics competencies was done using a tool measuring the availability of them in curricula; the tool was composed with a set of recommendations which describes ways that curricula should outline specific items related to health informatics. Each recommendation was to be rated using a yes-or-no option, reflecting respectively the presence or absence of the concerned health informatics competency in the curriculum. As the educational

needs are described as a three domain area by The International Medical Informatics Association (IMIA), the results for each domain area were analyzed categorically.

Findings from the current study show that in the first domain area which is Biomedical and Health Informatics Core Knowledge and Skills, the higher rate of items` presence is 70% (n=21) and the lower rate is 0%(n=0); there were a competency missing completely in all curricula which is item 1.9 relating to socio-organizational and socio-technical issues, including workflow/process modelling and reorganization.

With regard to the domain area, Medicine, Health and Biosciences and Health System Organisation, the study reveals that the higher rate of items` presence is 60%(n=18) and the lower rate is 7%(n=2); whereas the study findings reflect that for the third domain area which is Informatics/Computer Science, Mathematics and Biometry competencies; the higher rate of items` presence is 70%(n=21) and the lower rate is 0%(n=0) ;for this domain area , there were also a competency missing completely in all curricula which is item 3.5.Methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies).

When considering each specific item/competency availability in curricula, we computed a mean and a standard deviation for each, which reflects statistically the presence or the absence of the competency in curricula(Mean value far from 0 , the competency is present ; Mean value closer to 0,the competency is missing),there were 4items/Competencies most present in curricula(Mean score= 0.70) which are: Use of personal application software for documentation, personal communication including Internet access, for publication and basic statistics ; Basic informatics terminology like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management ; Ability to use personal computers, text processing and spread sheet software, easy-to-use database management systems and Ability to communicate electronically, including electronic data exchange, with other health care professionals, internet/intranet use. while two competencies were completely missed in all curricula(Mean score=0.00) they refer to Socio-organizational and socio-technical issues, including workflow/process modelling and reorganization; and Methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies).

As far as health informatics education is concerned, the results of the present study are similar to those we find in the literature related to the field of health/medical informatics, where it is reported that even though health informatics education is an essential component of the undergraduate health care professional curriculum, it remains controversial with no clear consensus on which knowledge and skills should be integrated in a baccalaureate healthcare professional program. The literature argued that basic medical science education must include health/medical informatics(De Gagne et al. 2012).

In their study untitled "Integrating informatics into the BSN curriculum: A review of the literature" Using the aforementioned inclusion and exclusion criteria, 19 original reports on HI education in the field of nursing were included in the literature review (De Gagne et al. 2012). Studies involved over 2400 subjects, including students, faculty, nurses, schools, and healthcare organizations. Of the 19 studies published between 2000 and 2010, 14 were undertaken in the U.S. and the others in 5 different countries, which were Canada, Greece, Sweden, Taiwan, and Turkey. The most frequently used research method was a non-experimental design that included surveys, case studies, and mixed-methods studies. From the critical reading and synthesis of the 19 studies emerged that in summary, they determined that approximately half of BSN programs were teaching information literacy skills and required word-processing (51%) and e-mail (47%) skills as a prerequisite. skills most often identified as potential to a BSN program were word-processing, e-mail, internet navigation, presentation, spreadsheet, statistical software, and online literature search skills. Competencies to obtain upon completion of a BSN program most often included knowledge of simulation software, networks, telecommunication, databases, security/backup, ethics/legal issues, and healthcare information systems including EHRs, and definitions of informatics and its history (De Gagne et al. 2012).

5.1.1 Comparison between schools of the College of Medicine and Health Sciences in relation to health informatics competencies availability in their curricula

To identify whether the availability of health informatics competencies in curricula varies according to different schools or not, we examined the answers that were provided by our tool which reviewed curricula and we computed a mean score. It was this mean score that was used to make a comparison within and between groups. One Way Analysis of the Variance (ANOVA) model was used and the alpha value was 0.05. The results indicate that for the first domain area

(Biomedical and Health Informatics Core Knowledge and Skills) and the third domain area (Informatics/Computer Science, Mathematics and Biometry competencies) there were no significant differences between schools. while for the second domain area which is Medicine, Health and Biosciences and Health System Organisation competencies, there was a statistically significant difference between schools as determined by one-way ANOVA ($F_{4,25} = 11.957$, p = .000).

In the same line, to identify which school is different from the others for that second domain area, we conducted a PostHoc (Bonferonni) Test and the results show that the school of medicine and pharmacy differ from all other 4 schools($p < 0.05$), However, there were no differences between the other remaining 4 schools($p > 0.05$). And from our research findings, it can be seen that A Bonferonni post-hoc test revealed that the school of medicine and pharmacy was statistically significantly higher.

The findings above are similar to those of another survey that was conducted and which involved 17 Canadian medical schools. In this survey, it was revealed that although Medical/health Informatics tools and technologies have an ever-growing influence on healthcare and multiple organizations have published Medical Informatics learning objectives or competencies for clinicians including Health Canada, AAMC, IMIA, UME-21 and the HealNET National Centre of Excellence Initiative. Despite these efforts, the uptake of Medical/health Informatics into undergraduate medical education has been poor and as medical schools incorporate medical informatics into their curriculum the problems of implementation arise, medical schools are implementing the subjects in various ways. A survey was undertaken to amass an overview of the medical informatics curriculum nationally. Of the responding schools, most have aspects of health informatics incorporated into current courses and utilize existing faculty. Literature searching, clinical decision-making, and Internet are the basic topics in the current curricula (Espino & Levine 1998).

Furthermore, The results from this study are comparable to the findings published by Hu et al. (2013) in their research called “An overview of health informatics education in China” a total of 55 program offerings for undergraduate education, 27 for master's-level education, and 5 for PhD-level education in health informatics were identified and assessed in China. The results indicate that health informatics education, a specialty rooted in medical library and information

science education in China, the objectives and curriculum design of health informatics education differ from one university to another and also from those of foreign universities or colleges. And it was recommended that China treat health informatics as a priority "must-have" discipline to build in China, as they realized that, before 2000, there were only 4 universities that offered a specialty in medical library and information science (now known as information management and information systems and health informatics). At present, there are 55 programs at which the specialty is offered in Chinese universities or college (Hu et al. 2013).

Our results are different from those of a study conducted by (Blumenthal et al. 2005) where In a 2007-2008 survey, 108 of 126 US medical schools (86%) reported that informatics was included as a required course. However, according to a survey conducted in 2006, only a few medical schools taught health informatics learning objectives.

In fact from published literature, we observed international examples of health Informatics curricula initiatives; the University Of Arizona College Of Medicine has partnered with the Department of Biomedical Informatics at Arizona State University to launch an integrated informatics curriculum that spans the four years of undergraduate medicine and includes 90 hours of instruction. The curriculum includes information literacy, mobile computing skills, decision analysis and decision support(Hu et al. 2013). And according to a recent survey of five medical schools in Bosnia and Herzegovina it revealed significant challenges in teaching health informatics. For example, lack of multimedia equipment, high-speed internet and computer access interfere with students' ability to utilize electronic resources. However, the University of Sarajevo emerged as a leader having introduced health Informatics to the curriculum in 1992-93, they planned to teach the following "basic principles" to undergraduate students: Medical terminology, Medical linguistics, International classification of diseases (ICD), Hospital information systems, Practical application of computing in medicine (Hu et al. 2013).

5.1.2 Comparison between undergraduate programmes of the College of Medicine and Health Sciences in relation to health informatics competencies availability in their curricula

To identify whether the availability of health informatics competencies in curricula varies according to different undergraduate programmes or not, we examined the answers that were

provided by our tool which reviewed curricula for different undergraduate programmers of the College of Medicine and Health Sciences and computed a mean score. It was this mean score that was used to make a comparison within and between undergraduate programmes. One Way Analysis of the Variance (ANOVA) model was used and the alpha value was 0.05,for all the 3 domain areas, There was a statistically significant difference between programmes as determined by one-way ANOVA first domain area ($F_{3,26}$ = 11.008, p = .000); second domain area ($F_{3,26}$ = 6.363, p =.002); domain area ($F_{3,26}$ = 9.057, p = .000).

And from our research findings, it can be seen that A Bonferonni post-hoc test revealed that the bridging program was statistically significantly lower.

The results from this study are comparable to the findings published by (Hu et al. 2013), which reported a significant difference between undergraduate programs (advanced diploma program versus bachelor`s degree program)($F=3.58$, $p < 0.01$).

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1. CONCLUSION

The present study has assessed the availability of health informatics competencies in training of undergraduate healthcare professionals. It was conducted in University of Rwanda, College of Medicine and Health Sciences. The overall results show that in 30 undergraduate curricula of the College of Medicine and Health Sciences assessed the higher rate of items` presence is 70%(n=21) and the lower rate is 0%(n=0) ;there were 2 items/competencies missing completely in all curricula as far as the 3 main health informatics domain areas are concerned. A comparison was made between the schools and between the undergraduate programmes. It was found that the availability of health informatics competencies in curricula varies according to different schools and different undergraduate programmes ($p<0.05$). More specifically, one school (school of medicine and pharmacy) was outstanding compared to the others and one programme (Bridging program) was outstanding compared to the others. In fact, all the schools did not have fully health informatics competencies outlined in their undergraduate curricula as recommended by the international medical informatics association (IMIA).

From the findings presented above, it can be concluded that the college of medecine and health sciences' schools have insufficient health informatics competencies outlined in their undergraduate curricula. For this reason, new policies should be designed and implemented to insure that health care professionals have the knowledge, skills, and attitudes to effectively and efficiently interact with today's health information technologies, therefore health informatics competencies need to be included in all undergraduate curricula, leading to a health care professional qualification in Rwanda.

6.2 RECOMMENDATIONS

6.2.1 Recommendations for undergraduate healthcare professionals' education

The present study has pointed out that curricula for undergraduate healthcare professionals' education in Rwanda are not fully equipped with adequate knowledge about health informatics. This is a problem that has been pointed out also internationally by previous studies as well. Therefore, there is an urgent need to increase the level of undergraduate healthcare professionals‟ knowledge about health informatics. The integration of health informatics competencies in curricula for training undergraduate healthcare professionals would help them to

increase their level of making good use of biomedical information for problem solving and decision making. Furthermore, the establishment of continuous on-the-job training in health informatics for those who are already practicing is also required. At the same time, medical schools should support the integration of e-learning in the educational process in view of the numerous potential benefits.

6.2.2 Recommendations for clinical practice

This study has identified areas of knowledge deficit in health informatics competencies outlined in undergraduate curricula as far as healthcare professionals are concerned. Despite the fact that the aim was not to investigate whether health professionals` knowledge about health informatics affects the clinical practice, the results of this study can be used to improve clinical practice in the field of health informatics considering that in these days the advances in information and communication technology have important implications for healthcare services therefore the use of health information technology to enhance the quality, safety and efficiency of healthcare is needed.

6.2.3 Areas for future research

This study used a limited sample and was conducted in University of Rwanda, College of Medicine and Health Sciences. In addition, The College has been chosen because it is the only public healthcare professional training facility in the whole country of Rwanda but they are also in the country non public training facilities. Therefore, the results cannot be generalized to non public training facilities. Consequently, further research in this field would be more than welcome. For instance, a study using a larger number of participants with the specific aim to explore whether the level of health informatics` knowledge for health professionals affects practice would be interesting as improved knowledge would probably lead to the improvement of practice.

REFERENCES

Anderson, J.G., 2007. Social, ethical and legal barriers to e-health. *International journal of medical informatics*, 76(5-6), pp.480–3. Available at: http://www.sciencedirect.com/science/article/pii/S1386505606002218 [Accessed March 25, 2014].

Anthony, D.L. & Campos-Castillo, C., 2013. Do health care users think electronic health records are important for themselves and their providers?: exploring group differences in a national survey. *AMIA ... Annual Symposium proceedings / AMIA Symposium. AMIA Symposium*, 2013, pp.42–9. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3900121&tool=pmcentrez&rendertype=abstract [Accessed March 13, 2014].

Bakken, S. et al., 2004. Promoting patient safety through informatics-based nursing education. *International journal of medical informatics*, 73(7-8), pp.581–9. Available at: http://www.sciencedirect.com/science/article/pii/S1386505604000887 [Accessed April 17, 2014].

Belar, C.D., 2004. The Future of Education and Training in Academic Health Centers. *Journal of Clinical Psychology in Medical Settings*, 11(2), pp.77–82. Available at: http://link.springer.com/10.1023/B:JOCS.0000025718.34590.2b [Accessed April 17, 2014].

Blumenthal, J.L. et al., 2005. Defining and assessing medical informatics competencies. *Medical reference services quarterly*, 24(2), pp.95–102. Available at: http://hinarilogin.research4life.org/uniquesigwww.tandfonline.com/uniquesig0/doi/abs/10.1300/J115v24n02_08#.U0UFSSgyQ8M [Accessed April 9, 2014].

Burnette, M.H., De Groote, S.L. & Dorsch, J.L., 2012. Medical informatics in the curriculum: development and delivery of an online elective. *Journal of the Medical Library Association : JMLA*, 100(1), pp.61–3. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3257474&tool=pmcentrez&rendertype=abstract [Accessed April 9, 2014].

Byrne, M.D., 2012. Informatics competence in the EHR era. *Journal of perianesthesia nursing : official journal of the American Society of PeriAnesthesia Nurses / American Society of PeriAnesthesia Nurses*, 27(1), pp.42–5. Available at: http://www.sciencedirect.com/science/article/pii/S1089947211005156 [Accessed April 17, 2014].

Byrne, M.D., 2010. Nursing informatics and ASPAN: clinical decision support through the perianesthesia data elements. *Journal of perianesthesia nursing : official journal of the American Society of PeriAnesthesia Nurses / American Society of PeriAnesthesia Nurses*, 25(2), pp.108–11. Available at: http://www.sciencedirect.com/science/article/pii/S1089947210000456 [Accessed April 17, 2014].

Chang, J. et al., 2011. Nursing informatics competencies required of nurses in Taiwan. *International journal of medical informatics*, 80(5), pp.332–40. Available at: http://www.sciencedirect.com/science/article/pii/S1386505611000347 [Accessed April 8, 2014].

Desjardins, K.S. et al., 2005. Effect of an informatics for evidence-based practice curriculum on nursing informatics competencies. *International journal of medical informatics*, 74(11-12), pp.1012–20. Available at: http://www.sciencedirect.com/science/article/pii/S138650560500105X [Accessed April 17, 2014].

Ehnfors, M. & Grobe, S.J., 2004. Nursing curriculum and continuing education: future directions. *International journal of medical informatics*, 73(7-8), pp.591–8. Available at: http://www.sciencedirect.com/science/article/pii/S1386505604000826 [Accessed April 17, 2014].

Espino, J.U. & Levine, M.G., 1998. An overview of the medical informatics curriculum in medical schools. *Proceedings / AMIA ... Annual Symposium. AMIA Symposium*, pp.467–71. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2232057&tool=pmcentrez&rendertype=abstract [Accessed April 9, 2014].

Frasier, H., May, M.A. & Wanchoo, R., 2008. Microsoft Word - ICT Rwada case final _2_.doc - Rwanda + Appendices.pdf. Available at: http://www.ehealth-connection.org/files/resources/Rwanda + Appendices.pdf [Accessed December 5, 2014].

De Gagne, J.C. et al., 2012. Integrating informatics into the BSN curriculum: a review of the literature. *Nurse education today*, 32(6), pp.675–82. Available at: http://www.sciencedirect.com/science/article/pii/S0260691711002243 [Accessed March 27, 2014].

Ganjalikhani, M. & Babaei, M., 2010. Medical informatics on an ongoing road to final destination. *Sri Lanka Journal of Bio-Medical Informatics*, 1(3), pp.186–190. Available at: http://www.sljol.info/index.php/SLJBMI/article/view/1985 [Accessed April 29, 2014].

Garde, S., Harrison, D. & Hovenga, E., 2005. Skill needs for nurses in their role as health informatics professionals: a survey in the context of global health informatics education. *International journal of medical informatics*, 74(11-12), pp.899–907. Available at: http://www.sciencedirect.com/science/article/pii/S1386505605001188 [Accessed April 14, 2014].

Georgiou, A. et al., 2014. Lessons learned from the introduction of an electronic safety net to enhance test result management in an Australian mothers' hospital. *Journal of the American Medical Informatics Association : JAMIA*. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24598829 [Accessed March 11, 2014].

Hart, J.K., Newton, B.W. & Boone, S.E., 2010. University of Arkansas for Medical Sciences electronic health record and medical informatics training for undergraduate health professionals. *Journal of the Medical Library Association : JMLA*, 98(3), pp.212–6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2900996&tool=pmcentrez&rendertype=abstract [Accessed March 24, 2014].

Hasman, A., 1998. Education and health informatics. *International Journal of Medical Informatics*, 52(1-3), pp.209–216. Available at: http://www.sciencedirect.com/science/article/pii/S1386505698901333 [Accessed April 25, 2014].

Haux, R., 1998. Health and medical informatics education: perspectives for the next decade. *International Journal of Medical Informatics*, 50(1-3), pp.7–19. Available at: http://www.sciencedirect.com/science/article/pii/S138650569800046X [Accessed March 31, 2014].

Haux, R., 2010. Medical informatics: past, present, future. *International journal of medical informatics*, 79(9), pp.599–610. Available at: http://www.sciencedirect.com/science/article/pii/S1386505610001140 [Accessed March 19, 2014].

Häyrinen, K., Saranto, K. & Nykänen, P., 2008. Definition, structure, content, use and impacts of electronic health records: a review of the research literature. *International journal of medical informatics*, 77(5), pp.291–304. Available at: http://www.sciencedirect.com/science/article/pii/S1386505607001682 [Accessed January 23, 2014].

Herbert E. Longenecker, S. Matt Campbell, Jeffrey P. Landry, Harold Pardue, R.J.D., 2010. EBSCOhost | 49718836 | Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. *IMIA Recommendations*, p.48. Available at: http://web.a.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=03538109&AN=49718836&h=0gwPZiRHA/vmGRqCghtJaBt1YUsfoKKzCFEhxwFu57q3tOR2oMITeVkj5tsRqvJetRGWYP0Rcc91rbzBjYl2QQ==&crl=c [Accessed March 24, 2014].

Hu, D., Sun, Z. & Li, H., 2013. An overview of medical informatics education in China. *International journal of medical informatics*, 82(5), pp.448–66. Available at: http://www.sciencedirect.com/science/article/pii/S138650561200086X [Accessed April 1, 2014].

Jha, A.K. et al., 2009. Electronic health records: use, barriers and satisfaction among physicians who care for black and Hispanic patients. *Journal of evaluation in clinical practice*, 15(1), pp.158–63. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18759752 [Accessed April 23, 2014].

Lu, Y.-C. et al., 2005. A review and a framework of handheld computer adoption in healthcare. *International journal of medical informatics*, 74(5), pp.409–22. Available at: http://www.sciencedirect.com/science/article/pii/S1386505605000201 [Accessed March 26, 2014].

Mackay, S., 2013. *Auto-Classification Review Technologies: What Every Attorney Needs to Know*, The National Law Review. Available at: http://www.natlawreview.com/article/auto-classification-review-technologies-what-every-attorney-needs-to-know [Accessed April 29, 2014].

Magrabi, F., Westbrook, J.I. & Coiera, E.W., 2007. What factors are associated with the integration of evidence retrieval technology into routine general practice settings? *International journal of medical informatics*, 76(10), pp.701–9. Available at: http://www.sciencedirect.com/science/article/pii/S1386505606001717 [Accessed April 17, 2014].

Mantas, J. et al., 2010. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision. *Methods of information in medicine*, 49(2), pp.105–120. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20054502 [Accessed March 25, 2014].

MASIC, I., 1998. Education of medical informatics in Bosnia and Herzegowina. *International Journal of Medical Informatics*, 50(1-3), pp.95–101. Available at: http://www.sciencedirect.com/science/article/pii/S1386505698000562 [Accessed April 9, 2014].

Masters, K., 2008. Access to and use of the Internet by South African general practitioners. *International journal of medical informatics*, 77(11), pp.778–86. Available at: http://www.sciencedirect.com/science/article/pii/S138650560800083X [Accessed March 28, 2014].

Neuner, J. et al., 2014. Meaningful Use and the Patient Portal: Patient Enrollment, Use, and Satisfaction With Patient Portals at a Later-Adopting Center. *American journal of medical quality : the official journal of the American College of Medical Quality*. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24563085 [Accessed February 25, 2014].

Sarbadhikari, S.N. et al, 2008. REVIEW ARTICLE BASIC MEDICAL SCIENCE EDUCATION MUST INCLUDE MEDICAL INFORMATICS. *Basic medical science*, 2(1), p.54. Available at: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.117.502 [Accessed March 27, 2014].

Schwartz, B., 2011. The introduction of a medical informatics course into a medical school curriculum. *Medical reference services quarterly*, 30(1), pp.74–82. Available at: http://hinarilogin.research4life.org/uniquesigwww.tandfonline.com/uniquesig0/doi/abs/10.1080/02763869.2011.540216#.U0UKBigyQ8M [Accessed April 9, 2014].

Seago, B.L., Gyore, R. & Williams, S., 2007. Assessment of the integration of AAMC Medical Informatics Objectives into the medical school curriculum. *Medical reference services quarterly*, 26(2), pp.1–14. Available at: http://hinarilogin.research4life.org/uniquesigwww.tandfonline.com/uniquesig0/doi/abs/10.1300/J115v26n02_01?src=recsys#.U0UISygyQ8M [Accessed April 9, 2014].

Staggers, N., Gassert, C.A. & Curran, C., 2002. A Delphi study to determine informatics competencies for nurses at four levels of practice. *Nursing research*, 51(6), pp.383–90. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12464758 [Accessed May 1, 2014].

VANBEMMEL, J. & DUISTERHOUT, J., 1998. Education and training of medical informatics in the medical curriculum. *International Journal of Medical Informatics*, 50(1-3), pp.49–58. Available at: http://www.sciencedirect.com/science/article/pii/S1386505698000501 [Accessed March 31, 2014].

Vedel, I. et al., 2012. Healthcare professionals' adoption and use of a clinical information system (CIS) in primary care: insights from the Da Vinci study. *International journal of medical informatics*, 81(2), pp.73–87. Available at: http://www.sciencedirect.com/science/article/pii/S1386505611002358 [Accessed April 17, 2014].

www.ist africa.org, 2014. IST-Africa_ICTInitiatives_ResearchCapacity_v1.1_310114.pdf - IST-Africa_ICTInitiatives_ResearchCapacity_310114.pdf. *Ist africa journal*, pp.55–63. Available at: http://www.ist-africa.org/home/files/IST-Africa_ICTInitiatives_ResearchCapacity_310114.pdf [Accessed April 25, 2014].

APPENDICES

APPENDIX I. STUDY TOOL
HEALTH INFORMATICS COMPETENCIES ASSESSMENT

ASSESSMENT OF HEALTH PROFESSIONALS UNDERGRADUATE CURRICULA BASED ON IMIA RECOMMENDATIONS

Directions:

This set of recommendations describes ways that curricula should outline specific items related to health informatics.

Each recommendation is to be rated using a yes-or-no option, reflecting respectively the presence or absence of the concerned health informatics competency in the curriculum.

IMIA Recommendations and guidelines for health informatics. Competencies(Learning outcomes)	**Health informatics competencies items availability in the Current curriculum**	
	Yes	**No**
LEARNING OUTCOMES / COMPETENCIES		
(1) **Biomedical and Health Informatics Core Knowledge and Skills**		
1.1.Evolution of informatics as a discipline and as a profession		
1.2.Need for systematic information processing in health care, benefits and constraints of information technology in health care		
1.3. Efficient and responsible **use of information processing tools**, to support health care professionals' practice and their decision making		
1.4.Use of personal application software for documentation, personal communication including Internet access, for publication and basic statistics		

1.5.Information literacy: library classification and systematic health related terminologies and their coding, literature retrieval methods, research methods and research paradigms		
1.6. Characteristics, functionalities and examples of **information systems in health care** (e.g. clinical information systems, primary care information systems, etc.)		
1.7.Management of information systems in health care (health information management, strategic and tactic information management, IT governance, IT service management, legal and regulatory issues)		
1.8. Methods and approaches to **regional networking and shared care** (eHealth, health telematics applications and inter-organizational information exchange)		
1.9. Appropriate documentation and **health data management principles** including ability to use health and medical coding systems, construction of health and medical coding systems		
1.10. Structure, design and analysis principles of the **health record** including notions of data quality, minimum data sets, architecture and general applications of the electronic patient record/electronic health record		
1.11.Socio-organizational and socio-technical issues, including workflow/process modelling and reorganization		
1.12.Ethical and security issues including accountability of health care providers and managers and BMHI specialists and the confidentiality, privacy and security of patient data		
(2) Medicine, Health and Biosciences, Health System Organisation		
2.1. Fundamentals of **human functioning** and biosciences (anatomy, physiology, microbiology, genomics, and clinical disciplines such as internal medicine, surgery etc.)		
2.2. Fundamentals of **what constitutes health**, from physiological, sociological, psychological, nutritional, emotional, environmental, cultural, spiritual perspectives and its assessment		

2.3. Principles of **medical decision making** and diagnostic and therapeutic strategies		
2.4.Organisation of health institutions and of the overall health system, interorganizational aspects, shared care		
2.5. Principles of **evidence-based medicine** and evidence-based nursing		
(3) Informatics/Computer Science, Mathematics, Biometry		
3.1.Basic informatics terminology like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management		
3.2.Ability to use personal computers, text processing and spread sheet software, easy-to-use database management systems		
3.3.Ability to communicate electronically, including electronic data exchange, with other health care professionals, internet/intranet use		
3.4. Handling of the **information system life cycle**: analysis, requirement specification, implementation and/or selection of information systems, risk management, user training		
3.5. Methods of **project management and change management** (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies)		
3.6.Methods for **decision support** and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines		

APPENDIX II: PARTICIPANT INSTITUTION INFORMATION FORM

Dear Sir/Madam,

My name is NISHIMWE Aurore, I am currently registered with the University of Rwanda, College of Medicine and Health Sciences for a master's degree in health informatics and I am conducting research on:
"Assessment of health informatics competencies in training of undergraduate health care professionals in Rwanda". The purpose of this study is to assess health informatics competencies in existing curricula for training of undergraduate health care professionals in Rwanda.

I would be grateful if you could avail the official curriculum you are using for teaching and learning. Participation in this research project is voluntary. The information you will provide will be kept confidential and you will remain anonymous. Please be also assured that the information you will provide will be used for the sole purpose of the current study.
If you have any questions regarding the research project as a whole, please feel free to ask. I can be reached through my cellular phone (0788814121) or my email: auroreshimwa@yahoo.fr.

Thank you in advance.

Kind regards,
NISHIMWE Aurore

Research Supervisor: Prof. Marc NYSSEN

APPENDIX III: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF RWANDA
COLLEGE OF MEDICINE AND HEALTH SCIENCES

Research Centre

June 10th, 2014

Ref: UR/RECC/154/2014

Dear

NISHIMWE Aurore

Master of Health Informatics Program

RE: ETHICAL CLEARANCE CERTIFICATE & APPROVAL FOR DATA COLLECTION

With reference to the application for Research and Ethical clearance; and approval for data collection for the study entitled " **Assessment of Medical Informatics Competencies in Training of Undergraduate Healthcare Professionals in Rwanda.**

Case of UR, College of Medecine and Health Sciences"

Following the review of your research proposal by Research, Ethics and Consultancy Committee in accordance with the authority granted to it; the reviewers recommended that your study be granted a Research and ethical certificate. It is on this note that the Directorate of Research, Ethics and Consultancy also grants approval for data collection. You will be required to submit the progress report and any major changes made in the proposal during the implementation stage. Also at the end of the study, the Directorate of Research, Ethics and Consultancy shall need to be given the final report of the study.

I wish you success in your study.

Mr. KANYONI Maurice

Chairperson of Research Ethics and Consultancy Committee

Cc:

- Principal, College of Medicine and Health Sciences
- Director of Postgraduate studies
- Director of Research Centre