School of Business, Economics and IT
Division of Informatics

IPV600 - Informatics influencing our lives

Role of Health Informatics in digitalization of Health care systems
- Focus on European Union

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Assignment, 7.5 HE credits
Autumn term 2021

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Abstract

Informatics is a stream of discipline that tends to how we live with information. Informatics is generally perceived to include loads of data handling and governance of the same typically upheld by technology.At the core of informatics lies the art and science of information that characterizes and shapes this digital world.The various themes of informatics are everyday activities that have been evolved throughout history and across various cultures.All the Information and communication tools empower more data to be processed, handled and venture new possibilities.Design standards can be applied to a wide range of products to establish proper communication.Informatics can be visualized as inter-collaboration of people,process and technology that gives a fruitful outcome. Informatics has its own specific scope of learning and these zones are appropriate to various orders of study.It is therefore motivated to dive deep into the ocean of Informatics.This scientific paper gives an overview of Informatics,evolution and role of Health Informatics in digitalization of Health Care systems with a focus on European Union.Adoption of Electronic Health Record system in the past,present and future is presented.Furthermore,the theories relevant to Health Informatics and the author's perspective on theories are discussed.Lastly, it was concluded that there is a great scope and utilization in digitalization of Health care systems.

Keywords: Informatics,Health Informatics,Evolution of theories,Information Science, EHR,Telemedicine,Information Systems

Contents

List of Abbreviations

AI Artificial Intelligence

CPOE Computerised Physician Order Entry

DiCoT Distributed Cognition Theory

EC European Commission

EHR Electronic Health Record

EU European Union

mHealth mobile health - medical solutions based on the use of mobile devices

ML Machine Learning

PD Parkinson's disease

TAM Technology Acceptance Model

1 Introduction

The following section provides a theoretical background about Health Informatics and how Informatics has been playing a key role by promoting efficiency and productivity of health care systems.This information is necessary to follow the later presented and discussed digital solutions along with the theories involved in the developmental phase which leads to successful product launch and ongoing research activities.Finally, the aims and limitations of the study are declared.

1.1 Background

Health Informatics is a part of Informatics and can be defined as an interdisciplinary field of Computer,Information Science, cognitive as well as social science to improve human health and assist with the management of healthcare systems.Thanks to the revolutionary technological advancements which created a remarkable difference between the 20^{th} and 21^{st} century in the field of medicine. Although it is nearly impossible to imagine a world free of Diabetics, Parkinson's Disease, Asthma, Alzheimer's or be it for any other Neurodegenerative disorder,these diseases could be prevented by detecting at the earliest onset of symptoms or at the least providing a feasible recovery solution with timely updates and progression of the disease.We live in a digital era flooded with infinite data floating around us giving way to Machine Learning(ML) and Data analytics techniques on a wider perspective.This is just one example of how Informatics has changed the face of healthcare systems and Health Informatics being a common denominator with endless initiatives making the world a better place to live.

1.2 Aims

The overall aim of this paper is to provide a good understanding of how Informatics acts as a benevolent factor in the development of several digital solutions aimed to facilitate everyday life for healthy subjects as well as non-healthy subjects.Here,digital solutions refers to the digitalization of Health care systems and it's adoption of the same.

1.3 Limitations

Health Informatics is a well studied phenomena but there is a lot that is not yet understood. Thus, there is much information available on the subject and some limitations for this study has therefore been formulated. First of all, only a brief description of Informatics and its role in health care applications is presented since there are many reviews and sources including this information already available. Further,already developed digital solutions especially in the developed countries that has been in consistent use among individuals has been considered. This is partly to enable a sufficient analysis, partly since many state-of-the-art digital solutions has been successfully implemented.In addition to this, the term *'Health Informatics'* can be used in general context through this paper, because Health Informatics comprises of numerous sub-disciplines like Nursing Informatics, Bioinformatics, Medical Informatics and so on.Thus, this study is focused more on digitalization and adoption of health care systems.

2 Study selection process

In order to fulfill the aims presented in section 1.2 a literature study was performed. Initially, a general search through various scientific databases, namely *Science Direct, PubMed,research gate, Google Scholar,sematic scholar* through *University West* Library was made. In this search of phase1, the search terms were a combination of *'Health Informatics'* and at least one of the following keywords: *'eHealth'*, *'digital solutions'*, *'telemedicine'*, *'EHR'*, *'mHealth'* and/or *'Information systems'*. This resulted in a large amount of articles, which were critically analyzed to enable a careful selection of studies to investigate further. The selected texts provided an introductory understanding of the theories involved and the current state-of-the-art innovative solutions in this area.

To further fulfill the study from section 1.2 the knowledge gained from the above procedure was used to make a more specific search through the previously mentioned databases.During this phase, keywords such as *'Role of Informatics'*, *'Theories in Health Informatics'*, *'Development of eHealth solutions'*,*'adoption of EHR'* and *'Current research in Health Informatics'* were used. Since eHealth has been a fast developing technology during the last two decades studies from the year 2000 were included in the selection of potentially interesting articles. Following the limitation regarding only presenting successfully implemented digital solutions as presented in section 1.3, studies describing methods and technologies of future digital products and health care applications that are still in the developmental phase were excluded. For a better understanding, a simple flowchart of the article selection process is given in figure 1

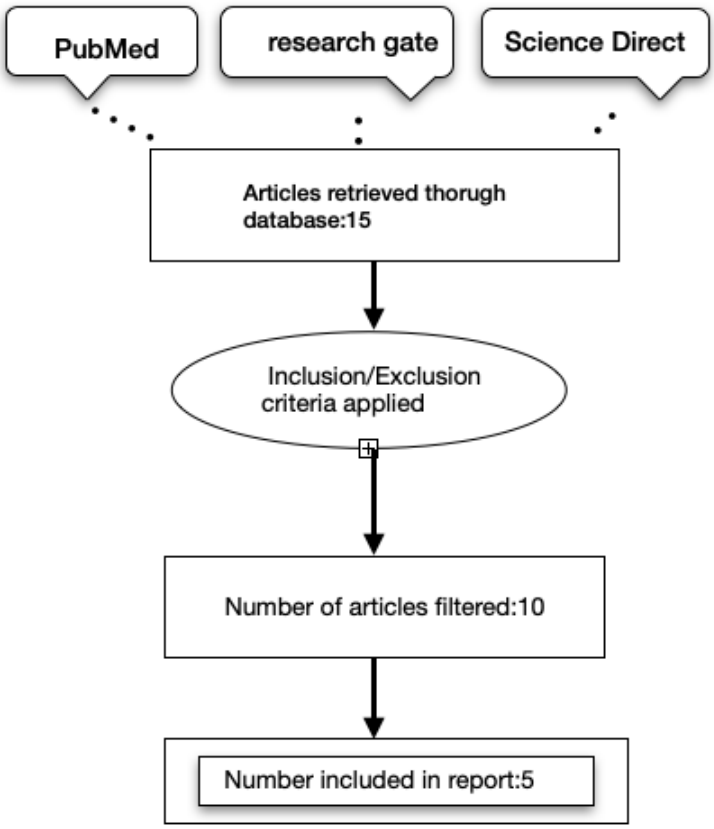


Figure 1: Overview of the selection process of the articles.

3 History of Informatics

The author uses Dahlbom's *'Scandinavian Journal of Information Systems'* as a reference material to detect greater historical awareness on the transition of *'Information Technology use'* to *'Informatics'*.Dahlbom(1996) compares and contrasts the evolution of computers with technologies and it's impact on people and society.This article clearly defines *'Informatics'* as a new discipline with underlying theories and demarcates the boundary between *'natural'* human and *'Artificial'* environment.The transition of *'Information Technology use'* to *'Informatics'* was crystal clear to bring out the difference between *administrative data processing* and *data analytics*.While the former term relates to more of data usage in databases or just word processors,the latter was used in a wider context of Information Science.

3.1 History and Development of Theories

An intuitive timeline on the evolution of theories is shown below in figure 2.Theories only more close to this study has been considered.

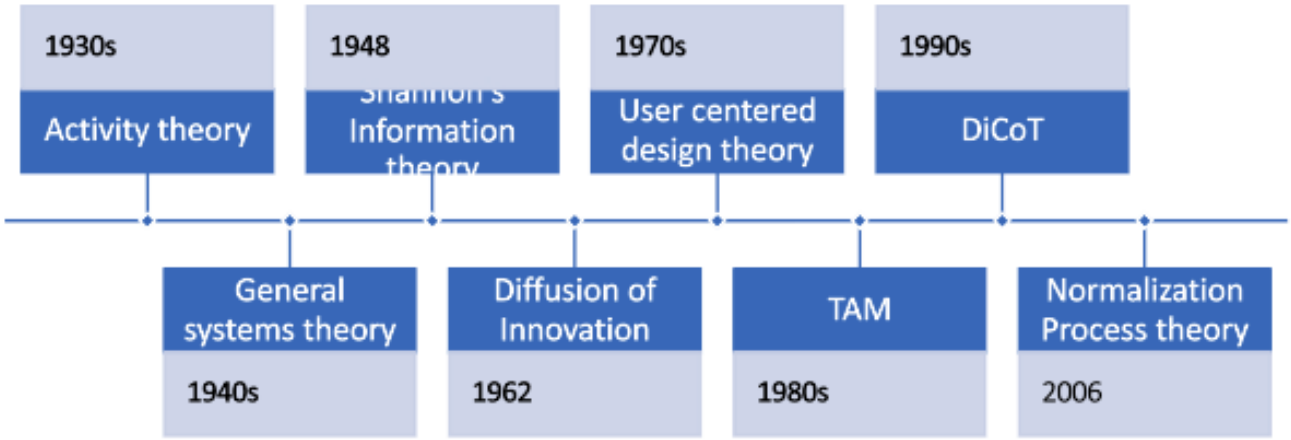


Figure 2: Timeline of the Theories in Informatics.

4 Theories in Health Informatics

The author shows that as an applied topic of research, Health Informatics integrates theories from information science, computer science, and cognitive science, as well as a wide range of sciences used in health care delivery.Several theories are based upon *concepts* that acts as a building block for each theory,As a result, Health Informatics professionals use different approach of theories to guide their work((Scott, Keizer and Georgiou(2019);Nelson, R., lerms-cont'd, K. (2010)).After a careful study of both the articles mentioned in this section,the author concentrates on a few key theories from many disciplines that are relevant to health informatics. These theories are essential for comprehending and managing issues that health informatics professionals confront.As the reader goes through this section, there is a possibility that grasping the selected ideas may pose some difficulties as they analyze them.

4.1 Study 1

Scott, Keizer and Georgiou(2019) has used a vehement approach to broadly classify all the theories under two major subject areas from multiple authors throughout the book.The book itself contains multiple theories analyzed by multiple authors.These theories have been tested in the field of Health Informatics with mixed results.Given below is a list of theories covered under a main theory as it's parent.

- **Information Science and Technology Theories**
    1. General System Theory
    2. Shannon's Information Theory
    3. Technology Acceptance Model
    4. User Centred Design and Activity Theory
- **Social and Psychological Theories**
    1. Distributed cognition theory
    2. Normalization process theory

Table 1: Scope and Utilization of theories

Scope	**Utilization**
General System Theory	
The application of big data analytics to the development of better, more integrated, and personalized pathways in patient care.	Learning health systems
Shannon's Information Theory	
Decision-making based on medical information	Assisting with the selection of diagnostic tests in a clinical environment; identifying redundancy in clinical testing.
Technology Acceptance Model	
A guide to digital health,including its benefits and how to achieve it.	Efficacy and ease of use of EHRs among nurses; acceptance of home telehealth among senior citizens.
User Centred Design and Activity Theory	
User complexity and their interaction with computer systems.	The design and evaluation of a mHealth application for community health workers to improve healthcare delivery.
Distributed cognition theory	
How Human agency and technology are involved in shaping social structures in a recursive process.	Awareness of situations in cardiac surgery,handling of emergencies in psychiatry,knowledge of infection control,safety,and pharmacy.
Normalization process theory	
Why do new technologies and working practices succeed in some environments but not others!	Analyzing the effectiveness of a digital health intervention for type 2 diabetes with a preoperative information within a surgery preassessment clinic.

Table 1 shows an overview of the theories that has been widely used as an interdisciplinary approach in the field of health care along with it's scope and area of utilization.The author has filtered out few theories during the selection process,one reason is that few theories are still in it's infancy stage, and the other reason being it's rare usage and due lack of consistence in the field of Health Informatics.

4.2 Study 2

Nelson, R.,&lerms-cont'd, K.(2010) writes that *'Concepts'* are the building blocks of a theory and provide structure to a theory.These concepts can either be abstract,such as freedom or concrete,such as an ice-cream.The author also agrees with the four-stage process as given below which has helped in the development of most of the theories.

1. Observation of a specific ***phenomenon***.
2. Proposal of ***idea*** to develop the phenomenon.
3. Development of ***model*** to explain the operation of phenomenon.Identification of key concepts related to the phenomenon and the process of concepts interaction is described.
4. Development of a ***theory*** as supporting evidence accumulates on testing the model.

Nelson, R.,&lerms-cont'd, K.(2010) has included a list of theories that has been widely used in Health Informatics.The author has tried to pick only those concepts, phenomenon,model and example scenarios related to healthcare systems.These theories have been extremely useful to explain and predict important phenomena to health care practitioners.One of the inarguable fact is that these theories also serve as a support system to encounter challenges and analyze problems when using automation for delivery of quality and reliable health care.

4.2.1 Systems Theory

A System can be classified as an open system, closed system, living or non-living. *Concepts* from systems theory helps to understand how people work with computers in a health care organization. These concepts give a glimpse of the total picture of system interaction and also analyze individual elements, such as software.

Figure 3 illustrates an open system interaction with the environment.Open systems take input from the environment, process the input, and then returns output to the environment.The output then becomes feedback to the system.
Based on this perspective,a real time scenario of health care systems with each characteristics of the system is discussed below.

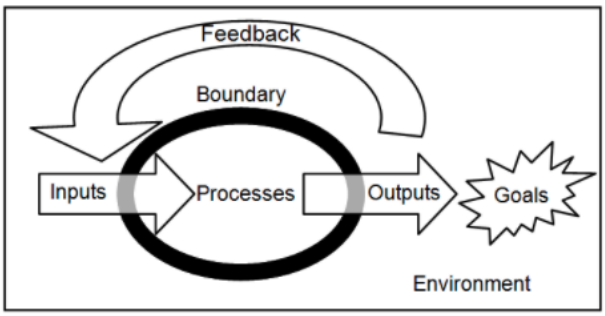


Figure 3: Open System Interaction

Function - A clinical data framework might accomplish the interdepartmental communication by email program, just as a program for record entry and reporting results. Each time a request is placed into the system, it reaches the concerned department. Each time a department has to report the result, they are reverted to respective healthcare provider or clinical unit.

Purpose- One purpose of a health care information system is to provide interdepartmental communication while another purpose is to maintain a census that can be used to bill patients for offered services.Whatsoever the case, the purpose is to provide patient care.

Structure - Health care teams organizational structure varies with the purpose and the functions that are to be performed.The staff is structured in an orderly manner to ensure that the functions necessary for nursing care are completed. The organization of a nursing staff can use the concept of team nursing, primary nursing, or case management.

Systems and the Change Process: Any system is prone to change and this is a constant process.There are six concepts which is helpful in understanding the change process.It is as follows.

1. **Dynamic Homeostasis** - process used by a system to maintain equilibrium.
2. **Entropy** - tendency of all systems to break down into their simplest parts.
3. **Neg-entropy** - opposite of entropy,tendency of living systems to grow and become more complex.
4. **Differentiation and specialization** - As systems grow and become more complex, they divide into subsystems and then sub subsystems.
5. **Reverberation** - Change within any part of the system will be reflected across the total system. Reverberation is reflected in the intended and unintended consequences of system change.
6. **Equifinality** - ability of open systems to reach the same end state by starting at different initial states and by using different means.

4.2.2 Information Theories

This section discusses two theoretical models of information theories.

- **Shannon and Weaver's information-communication model:** Concepts in this model can be well understood by figure 4

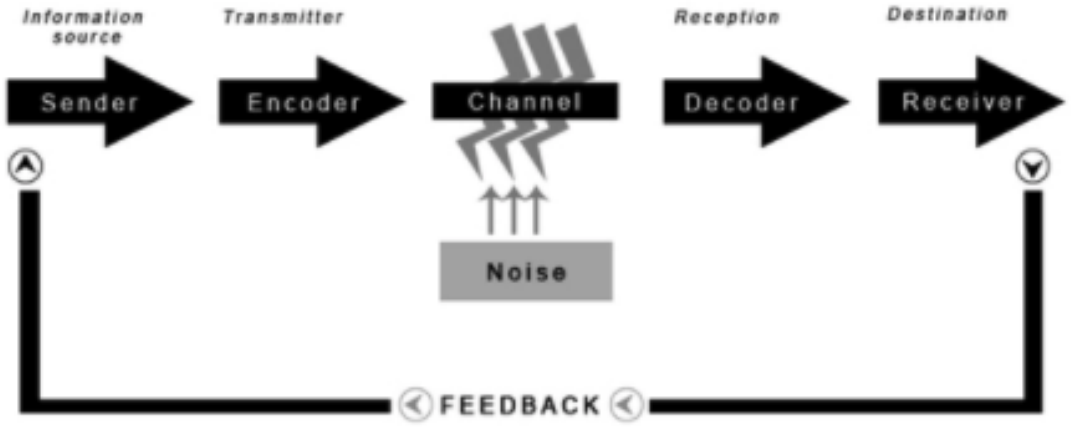


Figure 4: Claude Shannon's Information Communication model

A simple description of the components that is involved in the communication model is described below.

- Sender - originator of the message.
- Encoder - converts the content of the message to a code[1].
- Channel - message carrier.
- Noise - anything that is not part of the message but occupies space on the channel and is transmitted along with the message.
- Decoder - converts the message into a format that can be understood by the receiver. listening Receiver - destination of the message received.

- **Blum's model:**This model provided more in-depth analysis of information in medical computing. Applications were grouped according to the objects that processed Data,Information and Knowledge.A further extension to these objects was added,which is 'Wisdom'. Figure 5 shows the Nelson Data to Wisdom continuum where the concepts of data, information, knowledge and wisdom has an overlapping relationship between them.

[1]code can be letters,words,symbols,music or a piece of code

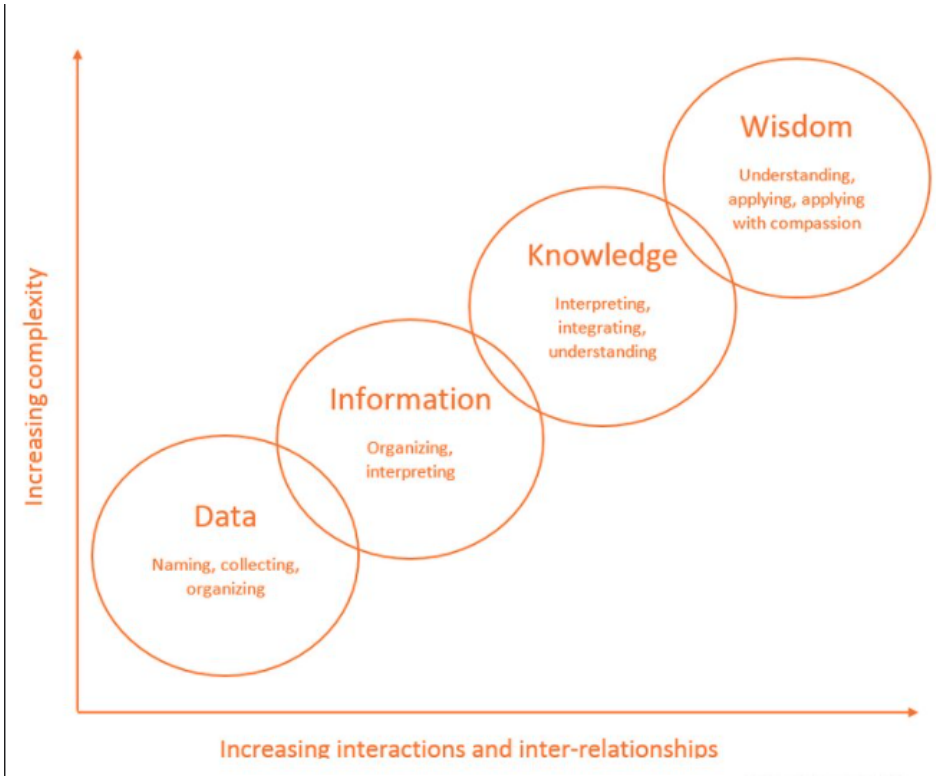


Figure 5: Nelson Data to Wisdom Continuum

Table 2 shows a clear description of each concept in relation to the health care system and it's related level of computer system.

Table 2: Terms,Meaning with related system and example

Term	**Meaning**	**Example**	**Level of computer system**
Data	Unfiltered data	Patients name, age, height, weight	Information System
Information	Processed data	Patient's medical record	Information System
Knowledge	Sum of interrelated piece of information and data	Automated Pharmacy Information system	Decision-support system
Wisdom	Application of knowledge base to human problems	Automated Expert system	Expert system

4.2.3 Change Theories

This theory discusses about the significant change in social system as a whole, individuals or organizations.Understanding this theory helps Health Informatics specialists act as *change agents* be playing a major role to effectively plan, guide,design and implement changes.

Planned Change - Change is divided into three stages.

1. **Unfreezing -** Initial stage which causes increase instability of the system by increasing the driving force and limited restrained forces.

2. **Moving -**Implementation of the planned change and is a unstable stage.Resistance is increased which can be minimized by simple and complex approaches, otherwise it fails.Anxiety level is on the higher side.

3. **Refreezing -** This is the maintenance phase characterized by increased stability once the system is in place, but additional energy and increase in resistance force is encouraged to maintain a constant behaviour.

Diffusion of innovation - is the process by which an innovation is communicated to members of a social system through certain channels over time. There is a possibility of acceptance or reluctance of an Innovation. Health care automation techniques, with evolving new ideas and technology, involves diffusion of innovation.By understanding this process and the influential factors, HI specialists can assist not only individuals but organizations also in maximizing the benefits of automation.Figure 6 shows Diffusion of Innovation curve which aims on five groups of individuals based on their responses to change. They are *innovators, early adopters, early majority, late majority, and laggards.*

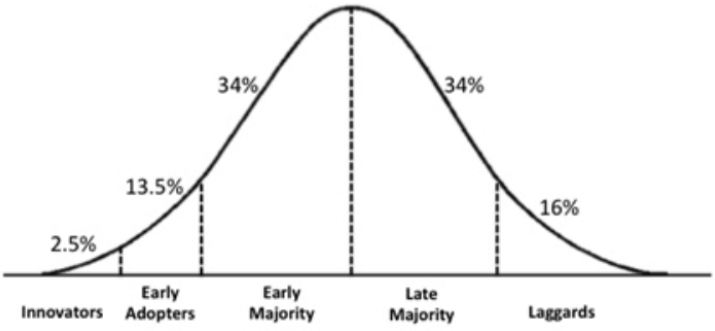


Figure 6: Diffusion of Innovation curve

Using change theories Understanding and managing reactions plays a vital role to change throughout the change process by change agents.Reactions to change may be positive such as support and encouraging peers,overall acceptance, demonstrating how the innovation improves the organization and appreciation of the same.Sometimes,reactions to change may be negative,such as aggression,ignorance, frustration,indifference, organized resistance or skimmed level of acceptance.Therefore,it is appreciated to effectively support the positive reactions than to spend time and effort responding to negative reactions.

4.2.4 Learning Theories

Learning Theories are interrelated and often overlap with each other.They are not mutually exclusive.This section focuses on four types of learning theories as presented below in the table 3

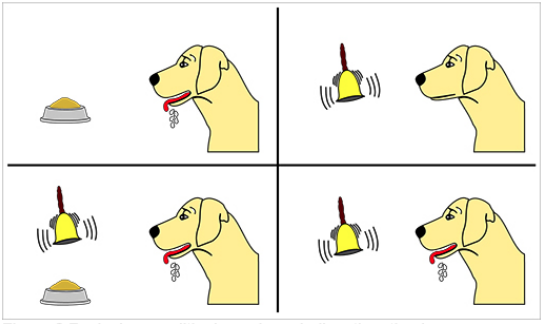
Theory	Concept
Behavioral Theories involves Stimulus-Response unit.These are Pairing and Reinforcement. 	Figure on the left shows an experiment conducted with a bell and dog.Initially,the dog would salivate only on seeing food.Over time, only the sound of the bell would stimulate dog's salivation. **Reinforcement** - can be positive or negative.Positive reinforcement is more of appreciating the learner,"You are right" while negative reinforcement is telling the learner,"This is not the correct way!"
Information Processing, or Cognitive Learning Theories. Here ,Learning is divided into four steps.	1. How the learner takes *input* into the system. 2. How is that input *processed.* 3. What type of *learned behaviors* are interpreted as *output.* 4. How the *feedback* can be used for system behavioral change or correction.
Adult Learning Theories	It is focused on the *learning characteristics* of adults.Most of the adults share similar learning styles and these can be used for planning educational programs among them.
Learning Styles Involves a four stage process.	1.Learning by *concrete experience.* 2.Learning by *reflection.* 3.Learning by *abstract conceptualization* 4.Learning by *using the system.*

Table 3: Types of Learning theories

5 Current Research:Adoption of EHR systems

Electronic Health record management system has been adopted in few countries as early as 90s, while in Nordics, the implementation started around the late 90s.Figure 7 shows the timeline of eHealth adoption in countries from 90s to late 2000.It is more evident and clear from the figure that the eHealth adoption has seen a dramatic increase from late 2010.The first exchange of EHR took place between Estonia and Finland in January 2019. By 2021, 22 EU countries are expected to exchange such health information.[cite] One surprising fact to observe is the visible gap of implementation in Nordic countries.While Norway and Finland adoption was at the earliest, implementation in Denmark was introduced in the year 2007 (Jens,2013) and Sweden in 2010 posing a decade long gap.

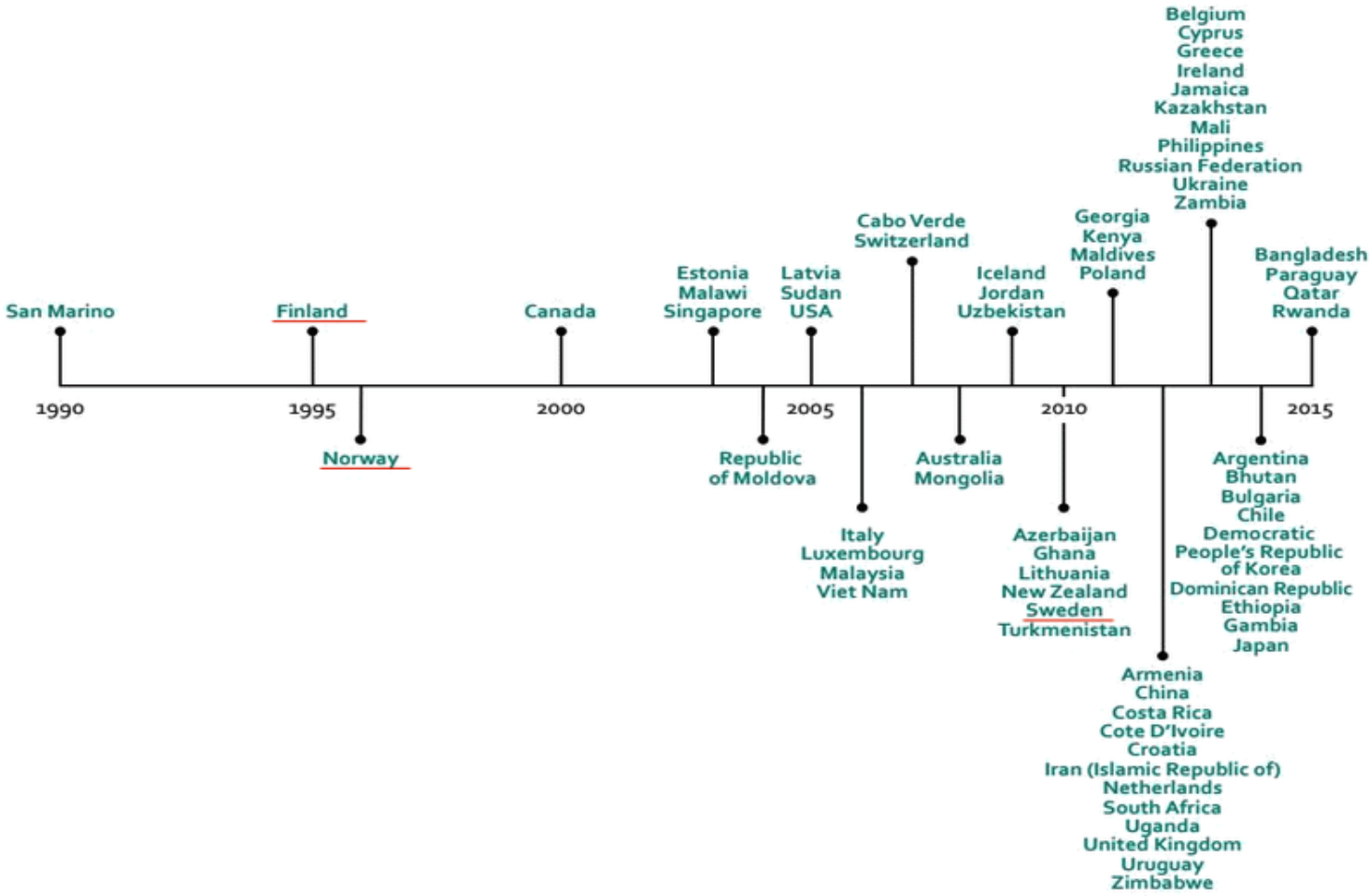


Figure 7: Timeline of eHealth adoption in Countries

The European Commission (EC) strives to empower citizens by building a healthier society which can be achieved by providing top quality services .The European Commission has published a communication in 2019 on the digital transformation of health and care.This is done in order to understand and measure the current use of information and communication technology (ICT), eHealth applications by general practitioners (GPs) in the European Union (EU) as well as changes in eHealth adoption and implementation over time.(eHealth, 2021)

The top 3 priorities for digital transformation of health care identified by the EC is as follows.

- Enabling secure access to citizens to access their health data across the EU.
- Resource pooling across the EU by researchers and other health professionals across the EU to provide personalised medicine through shared data infrastructure.
- Empowerment of citizens by educating about about the digital tools for self-care, prevention and viable interaction between users and care providers.

Figure 8 shows how a prescription given in one country can be used/accessed in another country while figure 9 shows the planned initiative by the European Commission to facilitate cross border ePrescription from the year 2018 to 2021 among the EU.

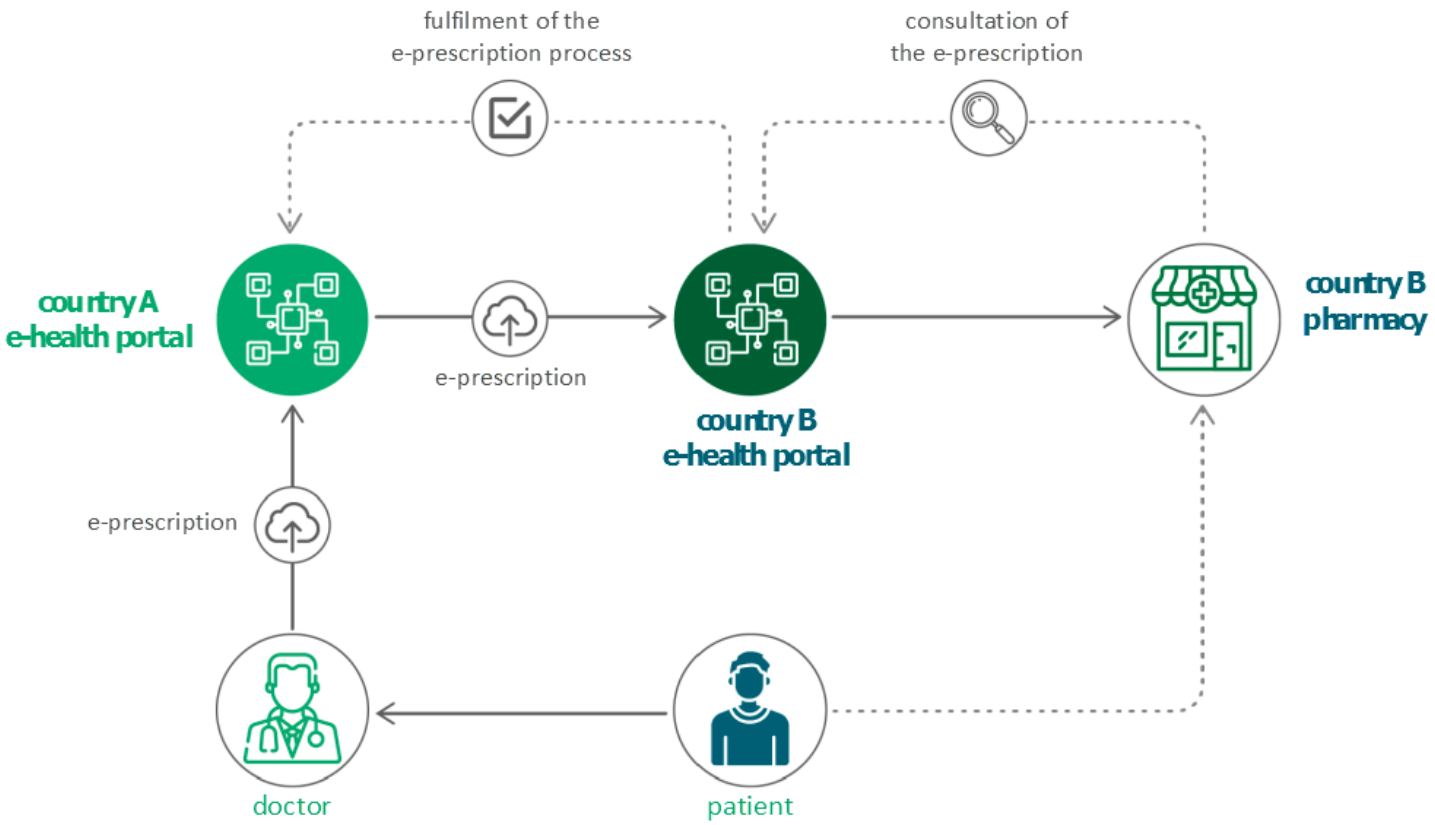


Figure 8: Dataflow showing how a cross border ePrescription works

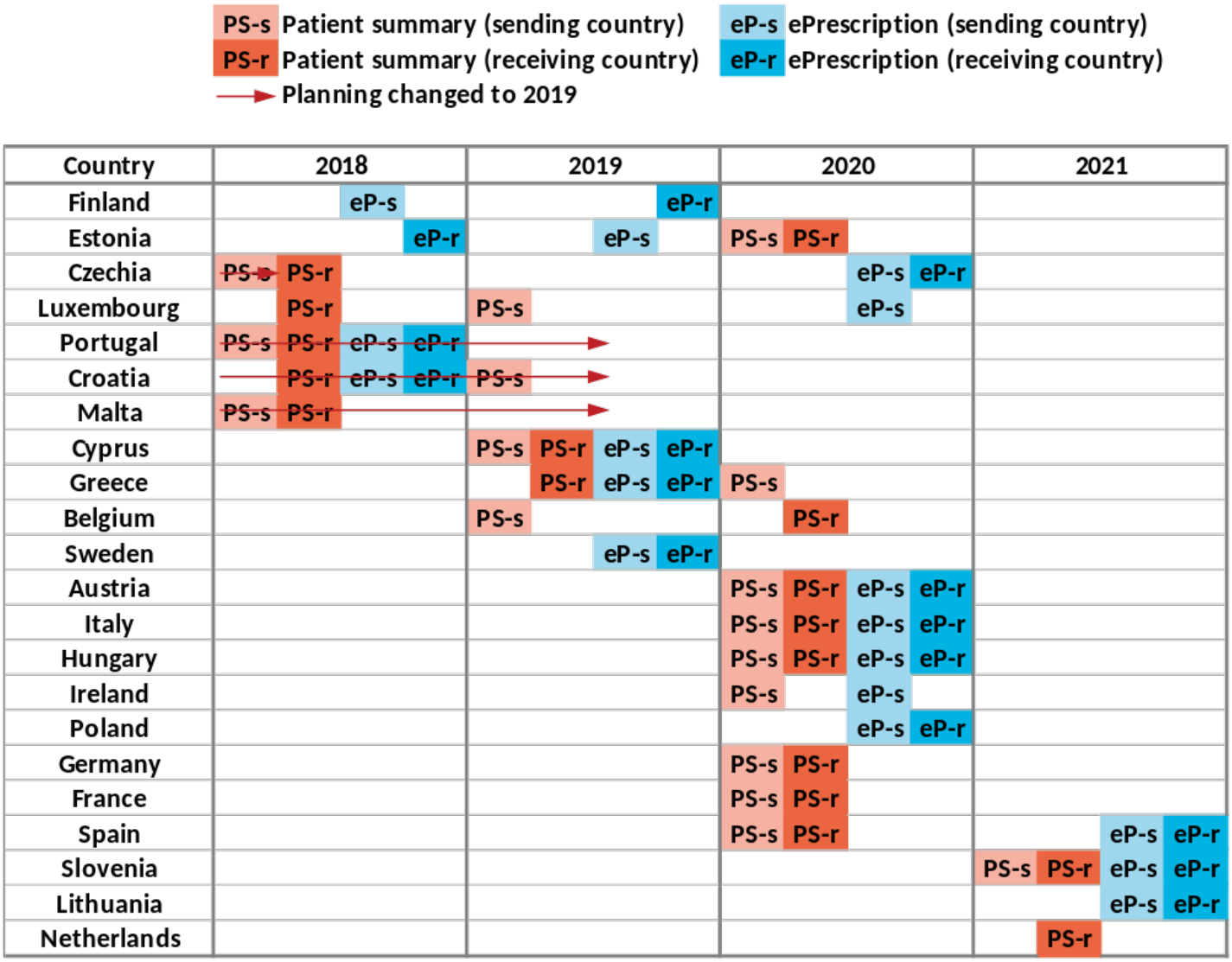


Figure 9: Planned initiative for cross border ePrescription in the EU

6 Discussion

This section will provide a thorough discussion of the theories presented in section 4 in a constructive and arguable manner.Then, the current research related to theories in the field of Health Informatics is presented with Study 1 as reference from section 4.This is due to the limited availability of articles and more or less similar set of theories were discussed in Study 2.All the theories presented in this report act as a supportive framework as well as a management tool to handle enormous degree of change experienced by health care professionals and within the system itself.However,analysis upon the presented theories is necessary to extend the thoughts on a broader perspective in relation to further developments.

6.1 Analysis of theories in Study 1

Scott, Keizer and Georgiou(2019) has articulated the reflection of multiple authors explicitly with respect to their theoretical analysis.The author indicates this in this section for

some of the theories listed in case study 1 under section 4.Let us take User Centred Design and Activity Theory,there is always a necessity for the software application to collect users information and infer it with relevant context to understand the situation,Also,each user's expectation,understanding, perceptions is unique which in turn is influenced by historical, social and cultural values.If we consider Systems Theory,anything could be considered as a system depending on the set boundaries.'Noise' in Shannon's information-communication model needs to be explicitly modelled as it is an essential attribute.Although,Distributed cognition theory renders itself to developing design ideas,the role of an individual or emotions is not emphasised because the focus is more on the systems,process and other observable functional issues.

6.2 Analysis of theories in Study 2

The author argues that theories like *Planned change* and *Diffusion of Innovation* focuses mainly on the change process.While Planned change gives us information about how a change agent can guide the process, Diffusion of Innovation throws light on process change made by people and social systems.One surprising fact revealed during a research conducted during the change process was observance of a similar pattern in the chat followed by people belonging to various cultures.Both of these theories provide a framework to understand people's reaction during innovation and thus guide the change process.When it comes to *Learning theories*,there are three reasons to consider it important for the development in Health Informatics.(Nelson, R., lerms-cont'd, K.,2010).It is listed below.Learning theories helps to

- impart knowledge to health care users about usage of new applications and systems by planning and implementing educational programs.
- design and develop user interface for digital solutions.
- understand and build decision support systems in health care.

6.3 Current research related to theories

Despite the meeting ground of Information science,Health Systems,Medical science with Informatics playing a key role,there is a fertile ground for theory development. Clinical decision support, which has long been an important field of research in health informatics, is a crucial part of this convergence, albeit the robustness of its evaluation still has a long way to go in terms of scientific measurement practice.Even though,the importance of solid theoretical underpinnings for this work has been recognized, yet the challenge lies in the technical implementation in some areas.(Scott, Keizer and Georgiou,2019).The author argues that it is a prime area for emerging theory.

Scott, Keizer and Georgiou(2019) conducted an informal review from a broad range of literature during the preparation of literature.This gave way to proposal of few theoretical topics for future research.The specific areas for consideration are highlighted below.

- Theory of clinical communication patterns
- Theory of computational diagnostic support
- Theory of Computerised Physician Order Entry[CPOE] implementation

- Theory of healthcare protocol adoption
- Theory of personally controlled EHRs.
- Theory of sociological design of EHRs
- Theory of systemic evaluation

6.4 Viewpoint

This section expresses the author's perspective on the analysis of all the theories captured in this report.The author discovered that development of a theory doesn't happen in a short span of time,it is a historical approach and process. However, during the study, it is clear enough to indicate that there has not been a transparent criteria or guidelines which says when/how a model becomes a theory.This selection of criteria is important to enhance conceptual clarity, identify key constructs, clarify terminologies, hypothesize relationships, and finally data collection and processing.In other words, the terms are used interchangeably. While one reference may use a phenomenon as a theory, other may refer to a model.This suggests a need for comprehensive criteria list to choose a theory which serves as an important contribution factor in Informatics field.

The author claims that there is a general paucity of replication studies in health informatics,in addition to specific areas of discipline.In general,Informatics may be dominated by single-case evaluations that do not lend themselves to larger theoretical generalization unless there is a culture of replication research. Although theories may not lend themselves to the same level of replication as results, validation is still required.To speak in the context of Health Informatics,this approach of theory selection, change process and avoidance of replication studies may result in efficient and effective delivery of health care systems, but chances of disruption and dissatisfaction is to be anticipated.

It is evident that there is a lot of research work to be accomplished to get more evidence and proof of concept.

7 Conclusion

One of the main aims of this work was to give the reader an understanding of Health Informatics and it's relevance in adoption of EHR system and theories which help in this transition.The work was mainly done using a comparative study of various theories focused on different study areas.Health-care informatics professionals are at the heart of this digital transformation which will lead to a cost-effective and efficient way to manage enormous amounts of data and information accompanied with proper knowledge and understanding.This can be fulfilled easily by collaborating closely with the organization's clinical, administrative, and technological departments.But,this transition may be accompanied with excitement,worry as well as resistance.

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