Technology Validation for e-Trial Systems

By

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ABSTRACT

This research study presents a Hypothesised Model, developed on the basis of the Unified Theory of Acceptance and Use of Technology (UTAUT). Its aim is to evaluate innovative Health Information Technology (HIT) at the early stages of projects. It is contended that this practice would support system developers at the design and implementation phases, and reduce the risk of underutilisation or rejection. The performance of the model was tested in three studies within the Clinical Trial Management Systems framework.

The Hypothesised Model approaches Behavioural Intention from a socio-technical point of view, taking into consideration the complexity and need of HIT to achieve joint optimisation. Moreover, it simplifies and extends UTAUT so that it may fit soundly within the healthcare context. Hence, it excludes the moderators and adds three core constructs, including: System-Specific Features, Technology Anxiety, and Adaptation Timeline. However, the model is easily adjustable to fit specific situations, especially given that this research study posits the non-existence of a single model that suits all situations.

This approach appears to have improved the final outcome and outperformed the use of generic models within the healthcare context. The total explained variance reported from the three studies is: (76%), (86%), and (87%) respectively.

DEDICATION

To my late parents. Your unconditional love and countless sacrifices will continue to motivate me. Dear father, your bravery in pursuing what you believed in and being the ambitious person that you were, have always inspired me. Dear mother, your words of encouragement and prayers are still resonating in my ears. I hope I have made you both proud.

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LIST OF ABBREVIATIONS

Black Country Comprehensive Local Research Network (BBC CLRN)

Chronic Obstructive Pulmonary Disease (COPD)

Combined TAM and TPB (C-TAM-TPB)

Data Quality Tool (DQT)

Decomposed Theory of Planned Behaviour (DTPB)

Electronic Healthcare Record (EHR)

Electronic Primary Care Research Network (ePCRN)

European Union (EU)

General Practitioners (GPs)

Graphical User Interface (GUI)

Health Information Technology (HIT)

Heart of Birmingham Teaching Primacy Care Trust (HoB PCT)

Innovation Diffusion Theory (IDT)

Joint Optimisation Metamodel (JOM)

Kaiser-Mayer-Olkin (KMO)

Model of PC Utilization (MPCU)

Motivational Model (MM)

National Health Service (NHS)

National Health Service Programme for Information Technology in England (NPfIT)

Organisational Change Readiness (OCR)

Picture Archiving and Communication System (PACS)

Principal Components Analysis (PCA)

Remote Data Entry (RDE)

Social Cognitive Theory (SCT)

Structural Equation Modelling (SEM)

Technology Acceptance Model (TAM), TAM2, and TAM3

Theory of Planned Behaviour (TPB)

Theory of Reasoned Action (TRA)

Unified Theory of Acceptance and Use of Technology (UTAUT)

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CHAPTER 1: INTRODUCTION

This doctoral research project, investigates the introduction and evaluation of new technologies and computer systems into the healthcare practice, from a socio-technical point of view. Chapter 1 gives a concise overview of the research questions (more details will follow in Chapter 2). This investigation not only involves technical aspects, but also human and organisational viewpoints. Therefore, understanding and incorporating all of these positions is crucial in predicting end-user acceptance, as well as the future utilisation of new technologies and computer systems, particularly at the early stages of projects, when pointing endeavours in the right direction is easily managed. The literature relevant to this field was reviewed and presented in a way that puts this research in the appropriate socio-technical systems context, along with related issues and examples.

1.1 Research Overview and Questions

The introduction of new technologies and computer systems into diverse fields of practice is acknowledged to be an undertaking that includes tremendous advantages and disadvantages. On the one hand, it may boost the overall quality of work in a given organisation as it helps to increase efficiency, reduce errors, provide better ways to do routine tasks, support staff in handling demanding workloads, simplify dealing with comprehensive information, and so on [1]. On the other hand, it may also create a multitude of problems such as: disrupting accepted work practices, replacing valuable knowledge and skills, and posing a threat to some staff members.

This doctoral research project is concerned with introducing new technologies and computer systems into the healthcare practice, the implications of its socio-technical aspects, and also how to extend one of the most prevailing Technology Acceptance Models (TAM) in order to predict end-users' acceptance and future utilisation. Three main questions are asked therefore:

1. How do contemporary healthcare professionals respond to new technologies and computer systems at the workplace?
2. Which factors (attributes and skills) do healthcare professionals rely on if they were to change the way they do things in favour of better outcomes?
3. How can the success of introducing a specific piece of technology into the healthcare practice be predicted?

1.2 Research Problem and Background

The successful implementation of new technologies and computer systems in any work environment depends largely on the individuals or groups who will utilise these innovations. Therefore, understanding and manipulating the potential factors that might boost end-users' adoption is essential; it is also valuable to both researchers and practitioners alike [2]. It is this writer's contention that the technical aspects related to the use of computers cannot be separated from their social aspects. Stated otherwise, there will always be some socio-technical challenges involved whenever computers are first introduced and/or routinely operated (this will be detailed in 1.3). Features such as end-users' knowledge, skills and abilities, and willingness to change, have to be fully understood and effectively incorporated, as they can facilitate, as well as complement any implementation.

Health Information Technology (HIT) or Health Informatics has many designations in the literature. However, the generally accepted broad characterization is that it is "the knowledge, skills, and tools that enable information to be collected, managed, used, and shared to support the delivery of healthcare and to promote health and wellbeing" [3]. It is interchangeably referred to as Medical Informatics, Clinical Informatics, Biomedical Informatics, or eHealth. There might be very slight differences amongst these terms and definitions, but their main intent is to improve healthcare delivery. Recent studies have demonstrated that the implementation of HIT is often susceptible to failure [4] [5] [6] [7]. To date, HIT has not shown many clearly detectable enhancements in the quality, safety, or cost of healthcare [8]. Failure to implement HIT has traditionally been attributed to technical factors [9] [10], however more recent studies have stressed the importance of behavioural factors as well [8] [11]. Nonetheless, information technology-related research still pays more attention to the design and implementation than to how end-users respond to systems which have been implemented already [12] [13] [14] [5].

Zayim et al., 2011, have specifically emphasized the complexity associated with the human-technology interaction in the healthcare domain; as end-users interact with such technologies alongside other organizational processes and influencing cultures in a multidimensional context [8]. This suggests that interaction has to be thoroughly examined in order to gain a better understanding of its various effects over the development and implementation of HIT applications [8]. Saleem et al., 2009, designed a framework to integrate the research on the human factors with the development of clinical information systems [15]. They identified six elements of human factors which include: informatics and patient safety, user interface design and evaluation, workflow and task analysis, clinical decision making and decision support, distributed cognition, mental workload and situational awareness. Furthermore, the authors suggest that if these factors were identified early in the design stage, then they could be incorporated in the application's development. As a result, this effort aspires to enhance end-users' satisfaction and performance, as well as better integration into the clinical workflow [15].

In addition to identifying these factors, it is important to have techniques which allow them to be measured. Without the ability to measure these factors, it is difficult to determine how extreme a workforce's attitudes might be, and without a sense of attitudes, it is difficult to determine how likely these are to change (or in what direction change might occur). In other words, technology acceptance is believed to be the gateway for end-users' approval and usability of a given technology. In addition, this will ultimately result in improved organizational productivity and work quality [15]. It was thought initially that end-users' would be accepting of technology that facilitates their job and improves their work quality mostly by producing data characterised as accurate, complete, timely, relevant, appropriately presented, and which came with a certain level of relevant detail and context [16]. However, in many cases, end-users opposed technology even when this basic criteria was fulfilled, and that is when research into the reasons behind this resistance started. It transpired that there is a lot more to technology acceptance than meets the eye, on many levels: technical, human, and organisational (more information about this will unfold as the chapter continues). Accordingly, numerous academics have conducted a significant amount of research on information technology acceptance and usability in different practices for at least four decades [2]. This extensive work has had origins in information systems, psychology, and sociology; and made this particular research area one of the most productive and mature in the modern information systems literature [2] [17] [18]. It had also resulted in a number of dependable and reputable models which have the reliability to evaluate technology and predict end-users' behavioural intention of using it; they are known as Technology Acceptance Models (this will be detailed in 1.7). Nevertheless, there is still need to build on the available knowledge and extend these models even further. Especially that a significant lack in understanding end-users' adoption of HIT has been indicated [8], and a noteworthy amount of emphasis has been placed on gaining understanding for smoother and more successful implementations to happen. What is needed now is focused extensions that would improve the models' explanatory power, and allow theses to be adapted specifically to fit within target fields of practice so that they may give more accurate predictions (such as the healthcare practice in this context).

In summary, the literature had recognized the challenges of assessing technology acceptance since the boom of using computers back in the 1980's [19] [20]. Many of these challenges have been acknowledged [15], but not all of them have been identified formally nor measured yet. Although the literature continues to point research in certain directions and makes future investigative recommendations, new challenges will continue to arise as modern work environments evolve. For that reason, this doctoral research project will identify such factors, use them to extend one of the most prevailing Technology Acceptance Models, and empirically test the extended model (this will be detailed in Chapter 3).

1.3 Socio-Technical Systems

As new technology and computer systems become increasingly advanced and multifaceted, engineering related to this change is becoming increasingly complex [21]. This section introduces socio-technical systems and their categories, lists their layer stack, mentions their characteristics, and demonstrates the reasons why judging whether they have succeeded or failed varies from one type to another.

A system here, is defined as "a purposeful collection of inter-related components working together to achieve a common objective" [22], and is usually managed or owned and operated by an organisation. A case in point would be a military system that is used for surveillance over a large ground area. Such a system has many components including: software, hardware (could be mechanical, electrical, and/or electronic), and personnel (responsible for its installation and operation) [22]. These components are inter-dependent and interact in a multiplicity of directions to achieve the task. It is this interaction that leads to complexity, therefore the behaviour of complex systems is often extremely difficult to predict in terms of outcome [22].

There are two broad categories of systems:

1. **Technical Computer-Based Systems:** defined as "systems that include hardware and software which are not self-aware; i.e. the operators and operational processes are not normally considered to be part of the system" [22]. For example: a word-processing system which is used for writing books, the system itself does not know what it is doing [22].

2. **Socio-Technical Systems:** this is a broader type of systems defined as "systems that include technical systems, as well as operational processes and people who use and interact with the technical system" [22]. Nonetheless, the term "socio-technical" is more loose than exact. A later reference explains that about three million responses

> would result if this term was googled [23]. Although “interdependence” is at the core of the term, a potential dispute may still always arise when trying to precisely pinpoint “interdependence between what and what” [23].

Socio-technical systems are governed by organisational policies and rules. For example: a book-publishing system which is used for publishing books, it has many people working together with technical systems to produce a book [22]. Such a system is self-aware of its existence and assigned duties. Another example is: a weather forecasting system, it is usually a part of a broader system and encompasses a technical system for recording and forecasting. It may also include: hardware, software, forecasting processes, system users, weather forecast-dependant organisations, and so on [22].

The socio-technical systems concept and term originated in the 1950’s at the London Tavistock Institute of Human Relations. The researchers, Eric Trist and Fred Emery, wanted to understand the effect of human skills and work methods on productivity, particularly in coal mines [24]. A primary interest of the socio-technical systems was to highlight the importance of choice and organisational design when it comes to the interaction between the social system (people) and the technical system (tools, technologies and techniques) [25] [26]. It argues that social and technical systems could be aligned and harmonised in order for productivity, worker satisfaction, and safety to be optimised simultaneously [27] [28] [29].

In the 1960’s and 1970’s, the socio-technical systems research mostly studied issues related to the effect of new technologies on work organisation and jobs [30], as well as on the quality of working life [31].

More recently, the socio-technical systems have contributed to the development of several research domains under the human factors and ergonomics umbrella, including systems ergonomics, which has emerged in the 1960's in the UK and Europe [32]. Systems ergonomics is the study of complex systems from a socio-technical point of view, and it looks at an organisation, employees, and technologies as interrelated and have unique properties when put together [33].

Furthermore, the socio-technical systems concept has mostly been applied to the domains of new technology and work design, and has been enthusiastically studied over a sixty-year period [34]. Nonetheless, a recent call for bravery was made, and it recommended to expand the concept's reach. Particularly, to extend the idea of what a system is and what it is actually composed of, relate the concept to a wider range of domains and complex problems, and take part in predictive work [34]. Though this mission will be risky and difficult, it will generate a greater impact [34]. Hence, this research study is in line with these recommendations, as it is an attempt to formulate better verdicts for engineering or procuring technologies used in healthcare and maximise their impact, principally by reducing the risk of underutilisation or rejection.

One of the most renowned and internationally recognised researchers in the socio-technical field is Professor Ken Eason, who started his long journey by investigating human-factors and ergonomics [35]. Many themes emerged from his work, and a key theme has been to develop information systems that truly meet the demands of complex organisations. As a result, it was recognised that the old methods were insufficient for specifying, designing, and implementing such systems. Therefore, the professor started to investigate and address the issues of "multi-user systems" and "co-operative support systems" in order to explore their requirements and develop methods for designing them [35]. The findings have been very valuable and have enhanced the experience of information systems' end-users in diverse contexts [35].

At the present time, what is available are "collections of people engaged in complex tasks with and through sophisticated technologies" where most things get done automatically, not 100% automated work processes and factories which require no human involvement at all [26]. So, the biggest challenge for socio-technical practitioners now is to take part in the different design processes and produce better work systems [26]. Nevertheless, designing social and technical systems that work well together in order to carry out complex tasks has been found to be very poor. Consequently, there is a lot of potential to extend this research area, especially in the presence of conceptual tools and design practices that wold deliver much improved socio-technical systems [26].

1.3.1 The Socio-Technical System Stack

A socio-technical system consists of seven hierarchal layers [Figure 1] [22], including:

1. **Equipment:** this consists of hardware devices which may include computers. Most of these devices have some kind of embedded systems.
2. **Operating Systems:** a collection of mutual facilities which are needed to operate the higher levels of the system.
3. **Communication and Data Management:** these are middleware systems which offer access to remote databases or other systems.
4. **Application Systems:** these are systems which have a specific functionality and are usually required by the organisation.

5. **Business Processes:** a collection of processes which involve people and computes aiming to support business activities (the entity could be a business, an army, a government body, a defence department, and so on).
6. **Organisations:** a higher level of strategic business activities which affect the system's operation.
7. **Societies:** these are the cultures, laws, and regulations which govern or affect the operation of the system.

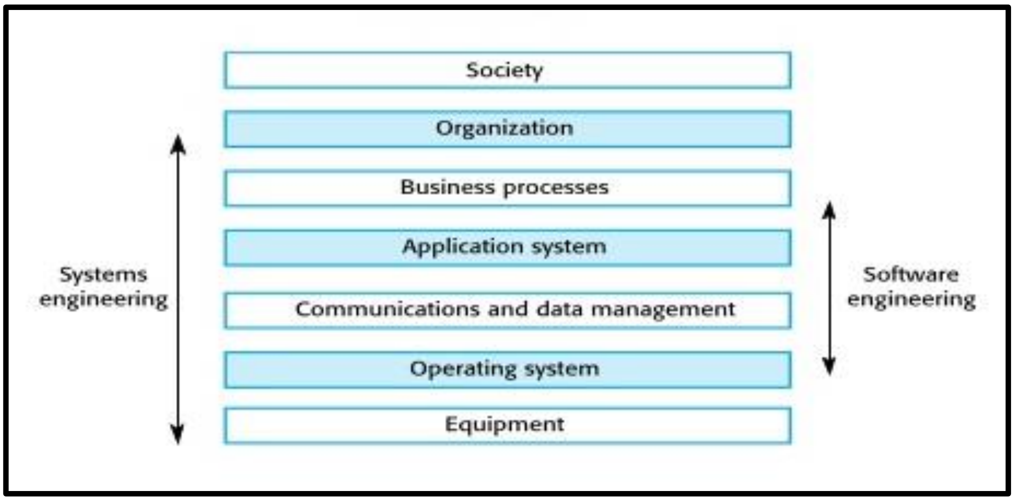


Figure 1: The Socio-Technical System Layer Stack [22]

These layers are interdependent because they interact together, and are dependent on one another, so changes that happen in one layer affect the rest of the layers. Therefore, system designers and stakeholders should think of the entire socio-technical system rather than focusing solely on the technical aspects [22]. Consequently, to achieve dependability, containing failures in the technical system is essential to stop failures from spreading to the other layers and causing severe damage [22]. For example: if the regulations change at the society layer, consequent changes will follow at the application systems and business processes layers. Assuming a scenario in banking, if a society pushed for strict controls over all risky lending, the regulations would change, and this would affect the bank's business processes and application systems so that they became capable of supporting the change [22].

1.3.2 Socio-Technical Systems' Characteristics

There are three main characteristics that distinguish a socio-technical systems [36], including:

1. **Emergent Properties:** the notion of having system properties which only become apparent when the system is put together as a whole [36].
    - These cannot simply be derived from the properties of individual parts. To be precise, they are much more than adding up the properties of the system's separate components.
    - They are a result of the relationships between the system's components.
    - They can only be measured and assessed when the system's components are integrated.
    - Dependability properties are all emergent properties (safety, security, reliability, and availability), so they cannot be predicted in advanced.
    - There are two types of emergent properties [36]:
        - **Functional Emergent Properties:** these appear when the system as a whole works to achieve a given objective. For example, an assembled bicycle has the "functional property" of being a transportation method, but its disassembled parts are not functional on their own. Accordingly, the system development target is to design a system that has one or more predefined functional emergent properties.
        - **Non-Functional Emergent Properties:** these are about the behaviour of the system in the operational environment, not its functionality. For example: volume, performance, reliability, repairability, usability, security, and safety. These properties are very important for computer-based systems. If systems do not achieve the minimum defined level of their non-

functional emergent properties, they will be deemed useless. Thus, a functional system that is not reliable is inadequate.

2. **Non-Deterministic:** means the possibility of having a different output for the same input or series of inputs, mainly because the system's behaviour depends partly on its operators [36]. It is important to differentiate between software systems and socio-technical systems here [36]:
   - Software systems are deterministic, because a given input will always produce the same output.
   - Socio-technical systems will not always produce the same output if given the same input. These are non-deterministic because they include people who will not always behave in the same way. Additionally, the system itself might be unpredictable due to frequent changes to its hardware, software, and data.

3. **Subjective Behaviour:** entails the system's ability to support the organisational processes and objectives depending on the end-users' interpretations [36].
   - Socio-technical systems are used by different stakeholder groups who might have conflicting objectives. For example: in a university hospital, the management might want a system that helps to reduce the time it takes nurses' to file data, so that they could see more patients per hour. However, the clinical research department might want detailed, quality data for their studies despite the time it takes to record it.
   - One group might find a certain behaviour effective whereas another might not. For example: using a system that records very detailed patient episodes might be seen as ineffective by physicians; they might waste a considerable amount

of valuable time doing this type of task instead of reviewing their patients' conditions. However, mangers might see it as an effective system because it would ensure them better reports.

1.3.3 Socio-Technical Systems and Success

The criteria for success that might be agreeable to each stakeholder is unachievable [37]. Complex systems are designed to address complex problems. However, it is extremely challenging to formulate criteria to satisfy all involved. Specifically, the problem is that, each group of stakeholders understands the problem only partially and sees it solely from their own perspective [37]. Consequently, whether a system is a success or not is a judgement that cannot always be objectively measured. Such judgments are usually made once the system is deployed and not against the original criteria which were developed at the design phase [37].

1.3.4 Socio-Technical Systems and Failure

A failure is defined as "a deviation from a specification" [38]. Although specifications are important, they are not more than a reduced interpretation of what the reality is [38]. Moreover, because of the inter-dependency of components in a socio-technical system, faults may spread throughout the system. Some faults also happen because of unforeseen inter-reactions between certain components, and these latter cannot always be pre-empted either [38]. Like success, failure is also a judgement, and a system can either fail or not from a particular observer's perspective. Such judgements depend on factors such as : knowledge and experience, context or situation, role, expectations, and authority (the person or group enforcing the implementation) [38].

There are two categories of reasons as to why socio-technical systems fail, including:

1. **Technical Reasons:** building systems out of unclear, dense, and uncontrolled components means that their behaviour may not be fully understood. In this scenario, failure could be mistaken for deficiency in data, not in behaviour [38].

2. **Socio-Technical Reasons:** if the "context of use" changes, then the criteria for judging failure changes accordingly. Hence, the effectiveness of the system matches the required changes, so that, a behaviour that might have been accepted before changes took place may no longer be accepted afterwards. In addition, as mentioned previously [38], different stakeholders have different views as to what the problem is and are likely to interpret the same behaviour relative to their understanding and expectations [38]. As a result, what one party might perceive as failure, could very well be seen as success by someone else. Subsequently, it is usually impossible to define requirements that all stakeholders agree on and that might resolve all possible conflicts. Given the laws of probability, failure or faults are bound to happen, but are not always devastating. They may be accepted as normal disturbances of routine work that require an end-user to spend more time to finish a certain task [38].

To demonstrate how user requirements may vary, a good example would be the design and implementation of Electronic Healthcare Record systems. Such systems certainly serve many purposes, and are utilised by different user groups. A recent investigation covered four case studies of Electronic Healthcare Record systems, and found that the reported systems were indeed fit for the purposes of the strategic and managerial users, yet proved to be problematic for the frontline users who are actually the ones entering data into these systems and interacting with them on daily basis [39]. In fact, the frontline users were negatively affected to the point where they had to come up with alternative ways to fulfil their work targets, such as entering the same data into many systems [39]. But, why did this happen? When the design processes were scrutinised, it was found that these had considered the strategic and managerial users' requirements because of the "top-down" approach followed, but an assessment of the frontline users' requirements was not carried out [39]. The investigation concluded that, failure to address the needs and requirements of all user groups involved will have severe consequences, and that it will be extremely difficult to rectify after the system had already been implemented [39].

In summary, it seems extremely difficult to build failure-free socio-technical systems. It also appears impossible to avoid all possible conflict when dealing with different groups of stakeholders. What is possible is, to have routine failure and a reasonable amount of conflict which is relatively minor or unimportant, that entails limited consequences, and can be rectified in a reasonable amount of time with zero or minimal side effects [22]. Another point to consider is that a number of failures happen as a result of human error in operating the system, especially by those who might have inappropriate expectations, in particular, those who imagine that the system will deliver an outcome that is over and above its actual capabilities [22].

1.4 Socio-Technical Systems in Healthcare

Many researchers who work on healthcare projects have thought of technology in the healthcare domain as "socio-technical systems", and managed their projects accordingly. One of the earlier attempts to link the socio-technical concept with the development and evaluation of patient care information systems was Berg, 1999 [40]. In addition, more researchers have considered the inadequate understanding of the socio-technical aspects which are involved in information technology, in particular, the understanding of how people and organisations accept such technologies, as one of the major reasons leading to failed HIT projects [41] [42] [43] [44].

Moreover, a great example of that would be the National Health Service Programme for Information Technology in England (NPfIT). The programme's goal was to create electronic patient records which could be exchanged on a national level [45]. Standard technical systems were the approach of choice to achieve this goal. As a result, a serious challenge appeared, namely how would the ample socio-technical work systems which were already in place adopt one common solution?

This approach was descripted as a "push" [46]. If there was no room for customisation, then many end-users would naturally resist the programme in order to preserve the local methods of delivering care. This would consequently limit the programme's impact [45]. A suggested solution was to establish a local socio-technical design process to possibly customise the technical systems (if possible) [45] [47]. By doing so, the potential of technology could be offered to end-users in a way that matched their needs [45]. Interestingly, this suggestion was put forward in 2007 for one part of the NPfIT programme [45], and proved to yield more success for a similar attempt at implementing systems that allowed the sharing of patient information in 2013 for other parts of the same programme [47]. This emphasises the importance of considering the socio-technical factors involved when introducing and evaluating technology in healthcare.

1.5 Problems Associated with Introducing Technology in Healthcare

Introducing technology to the healthcare practice has a reputation of being very challenging. It has been estimated that an excess of 40% of information technology projects failed or were abandoned in several fields of practice including healthcare [48] [49] [50] [51] [52]. The main areas of concern are: the attitudes of healthcare staff towards HIT along with the factors that influence these attitudes, as well as the technical and human factors involved [53].

A comprehensive review was done in 2008 to ascertain the attitudes of healthcare staff, specifically, which factors influence their attitudes, and which factors can be used to change these attitudes [54]. The findings demonstrated some complex factors which involve a wide range of elements, such as: systems' fit to job and flexibility, end-users' experience and confidence in using HIT, end-users' attitudes towards using HIT, and availability of sufficient education and training. These factors appear to be of significance when it comes to the success or failure of projects; therefore organisations need to plan very carefully when proposing to introduce HIT systems [54].

Some of the most discussed key issues include scenarios which are not always purely technical, yet have a profound impact on the failure of HIT projects [53]. In point of fact, the human factors have a role which is as important as the technical one. This is because introducing technology is a two-way process, where the technology transforms the way organisations work and similarly in which the users determine the future evolution of the technology. Consequently, such a process can only succeed if appropriately supported by management and future end-users. The responsible information systems team also needs to strike a balance between initiating change and managing the project at hand in a cooperative and involved/participative manner [55].

Of course, poor performance and inadequate design are valid technical problems and may indeed break any system [55]. However, some of the most problematic aspects may actually be caused by underlying organisational issues. This requires the Social Sciences point of view to be resolved [40] [56], namely, the existing interrelation between the technical aspects and the social aspects necessitates following a socio-technical approach [40]. Moreover, the interrelation itself can range between simple and complex, depending on the system and environment in which it is being introduced. An example of this is, when the logical sequence of actions in a given system does not agree with the end-users' working routines. This mainly has to do with the lack of involvement of end-users' in the design process, which is an organisational issue resulting in a technical one [57]. Another example is, when a group of end-users decides to run their own agenda by taking advantage of the system, as it afford the opportunity of accessing another groups' information resources. This creates an open conflict which might stop certain individuals from using the system and is principally a personal clash that results in rejecting or underutilising the system [58] [59]. These examples explain why judging whether introducing a system is a success or failure is dependent on being socially negotiated [60] [61].

Ultimately, the attitudes, factors, and key issues mentioned above are as valid and crucial today as they have always been. A considerable amount has been written about these influential constituents, but further research is still needed to uncover more of the dynamics that prominently affect the healthcare professionals' attitude, in order for the key issues to be resolved. It is the contention of this author, therefore, that since these systems are the available tools to expand the evidence-based practice, then the human considerations of the target end-users' need to receive as much attention as the technical ones [54].

1.5.1 Measures of Success

What is a successful technology implementation? This simple question is not that easy to answer. On one hand, an organisation could consider a system to be successful based on the opinions and deliberations of its top managers, middle managers, and staff [55]. But, this approach carries a great deal of bias because it is mostly subjective, and that might interfere with the final decision, mislead the truth, or overlook the reality. On the other hand, **there are more objective approaches to measure success**, but these usually tend to consider the concept of success from a specific point of view. The first method takes into consideration the end-users' perspective, so that a successful system is one which is perceived as useful and is utilised majority of the time to carry out routine tasks [55]. The second method takes into consideration the economical point of view, so that a system is successful when it meets the planned budget, reduces spending, and/or generates profit [62]. The third method takes into consideration the functionality for both managers and end-users, so that a system is considered to be successful if it does things like saving time, and reducing errors. [55].

In brief, there are many dimensions to success including: effectiveness, efficiency, organisational attitudes and commitment, and end-user satisfaction. Though there is no consensus as to which of these is the most relevant in a given implementation, nor a fixed way to measure any of these dimensions. Success is a multi-dimensional concept also and it evolves over time, therefore it can be defined differently depending on which of the involved parties is defining it and when [55].

1.5.2 Examples of Failed Attempts

There are many examples of problematic and even failed attempts at introducing technology into healthcare in many countries around the world like: South Africa [50], the UK, and North America [63]. However, five examples from England (UK) will be presented below because the healthcare delivery system there is considered a world class one, and their NPfIT national programme for implementing a standard Electronic Healthcare Record system (EHR) is a leading example, despite all the challenges it has faced. It has actually been considered "the largest civilian information technology project in the world", starting in 2002 and taking ten years until completion [64] [65]. Moreover, the lessons learned from this extensive experience are extremely valuable on many levels and have been well documented [47] [66]. Before proceeding with the examples, it is worth mentioning that an EHR is defined as "a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports" [67].

1. The Mental Health Trusts in London were given an EHR system by the National Health Service (NHS). This system was originally designed for acute hospitals, it just could not deal with mental healthcare-related issues; and had no provisions for dealing with patients according to the Mental Health Act as actions like sectioning were not included. These requirements are mandatory for this particular Trust, and the system could not deliver what was needed. Instead, the Trust was allowed an "interim system" [45].
2. Other Trusts, especially the ones that have teaching hospitals already had EHR systems which were well-developed. They found that the offered system was not

sophisticated nor did it suit their needs. Bringing everybody to a common standard might mean lowering the standards of those who have a long history of developing their own systems [45].

3. General Practitioners (GPs) were particularly frustrated when the NHS wanted to replace the system that 60% of them had bought, especially that their system had the exact same functions as the NHS's system of choice. Eventually, after long deliberations, the vendor that the GPs purchased their system from, offered the vendor that the NHS chose a compatible version. This version is being used now as part of the EHR standardisation programme [45].
4. The Royal Marsden Cancer Hospital concluded that it could not maintain patients' records for cancer research purposes using the system offered nationally. It decided to continue using their own advanced system, despite the programme's investment and nearing the end period of ten years [68].
5. The latest collective report on recent developments within the UK NHS concluded that the overall implementation of NPfIT was a "catastrophic failure" for the lack of end-users' acceptance, underutilisation, and for not realising an economical return on investment [66]. The final recommendation was to robustly embrace a holistic socio-technical approach when designing large-scale HIT systems, as well as local developments that fit local needs. Nevertheless, such systems will need standards for interoperability to be put in place, and these standards are yet to be developed based on thorough research.

Evaluating the implementation of the earlier examples indicated failure from the managers' and end-users', functional, and economical perspectives; principally because the offered system did not meet the needs of all the NHS Trusts, hospitals, GP surgeries, and cancer hospital involved. One size does not always fit all!

1.6 Problems Associated with Evaluating Technology in Healthcare

An evaluation can be defined as "the decisive assessment of defined objects, based on a set of criteria, to solve a given problem" [69]. As technology emerges in the healthcare practice, evaluating it is recommended and is of high importance for decision makers and end-users so that they may manage projects in better ways, and be encouraged to use new technologies and computer systems, respectively [1]. Although technology could bring tremendous improvements, it might also be of risk in such a sensitive environment leading to a minimised impact. Yet, these systems are different and vary in complexity and size, so should their evaluation approaches.

For example, EHR are used routinely for data entry and retrieval purposes. Yet, they could also be used to support the decision making process, generate knowledge, conduct clinical research, and much more. While Picture Archiving and Communication Systems (PACS) are mainly used for medical imaging related purposes and produce images rather than data, but they could also be integrated with other systems to provide a more complete picture.

So, how similar or different can evaluating an EHR and a PACS system be? Which aspects of these systems do decision makers want to evaluate at a given point in time? What are the representable measures for each? For such questions to be answered, appropriate evaluating models need to be used (this will be detailed in 1.7). However, in spite of the availability of many reliable Technology Acceptance Models, the literature reports many problems that stand in the way of comprehensive and accurate evaluations. Ammenwerth et al., 2003, categorised these problems and their consequences in three areas [1]:

1. **Complexity of the Evaluation Object:**

   When a system is being evaluated, it is usually a part of the organisation's information system, and its interaction with the end-users in a given environment is the ultimate target. Therefore, the evaluation becomes a situation or a process rather than a single product [1]. Thus, an overall understanding of social and behavioural aspects as well as technical aspects will be required. Things like: logical workflow, technology introduction methods, quality of information, training and support, depth of use, and end-users' motivation need to be incorporated [40].

   <u>This complexity leads to the following consequences</u>:

   - Introducing and evaluating technology is time consuming. End-users and organisational workflow take a lot of time to adapt to new ways and explore potential opportunities [40] [70]. As time goes by, modifications might be done to the software and hardware, some routine functionality might change, and so might the target of the evaluation.
   - Over time, changes might happen in the organisation or staff, the matter that would have an effect on technology [71]. Therefore, in the dynamic healthcare environment, the results of a given evaluation will be relevant and valid at the point in time in which it happened [1].
   - At a specific point in time, the same technology might be introduced but its effects may vary from an organisation to another, making the same technology unique when it becomes part of a bigger information system [1]. This depends

on the department workflow, end-users' skills and motivation, and used functionality [5].

2. **Complexity of the Evaluation Project:**

When a system is being evaluated in healthcare, many things have to be taken into consideration. The environment is complex, hence, the professionals belong to different groups and have different needs (physicians, nurses, patients, administrative staff, information systems team, management, funding bodies, and so on). In addition, there are some external influences (legislation, economic constraints, patient rights, and so on) [1]. This multitude of stakeholders may lead to different and possibly conflicting evaluative questions [72]. Moreover, evaluations can also be seen from many dissimilar points of view, including: economic, sociological, psychological, organisational, technical, logistical, or clinical points of view [73].

<u>This complexity leads to the following consequences</u>:

- When it comes to what success is in terms of technology, the definition is elusive [70]. Therefore, it is difficult to establish a precise and 100% complete criteria to measure it accurately. Different groups of stakeholders have different questions, therefore a universal determination of absolute and relative benefits is not usually feasible. Moreover, it is neither easy nor direct to measure the overall quality of the outcome that represents the full picture. Instead, indirect measures such as: end-user satisfaction and positive changes are usually used [1]. Consequently, some studies become complex as they have to include questions reflecting different points of view, and have to be carried out given limited resources and a specified timeframe [1].

- If the evaluation criteria was narrowed down, there is a risk of having an evaluation study that is meaningful for a specific group of stakeholders only, or that gives a distorted picture of the reality [1]. For example: it would not be reasonable to only pay attention to the time required to register events by using a given system, without analysing the quality and completeness of the information generated as a whole [1].
- After determining the evaluation questions, a need to change them might arise due to new insights, changed stakeholders' opinions, or changed technology scope [74].
- The choice of an evaluation model has to be suitable to answer the asked questions, otherwise the evaluation will not be useful. However, the responsible person or team might not be aware of all the possibilities out there, the matter that may limit the findings [75].

3. **Motivation for Evaluation:**

It takes many parties to conduct a successful evaluation study. A motivated management that is not too worried about revealing negative outcomes or deficiencies in a system would facilitate that. Besides, end-users who are willing to make the effort and time for the evaluation study, as well as have the flexibility to accept possible disturbance in the workflow. Moreover, the availability of suitable resources and a sufficient number of participants are also important [1].

This complexity leads to the following consequences:

- The lack of support and motivation by stakeholders will result in the lack of allocation of appropriate resources and participants for an evaluation study [1].
- Recruiting only participants who volunteer to participate might lead to having the known "volunteer effect" which reduces the external validity of the study (by reporting positive opinions mostly). Hence, such participants are usually more motivated than the other end-users [1].
- The results of the evaluation study are important for the involved unit, the organisation, and possibly similar external units. However, it is difficult to find a truly "representative sample" of participants to generalise the results. Moreover, the sample numbers might be small, and the workflow might be different in each case [1].

1.7 Joint Optimisation in Socio-Technical Systems

Broadening the understanding of systems from pure technical pieces, to socio-technical ones has been advantageous to designing more pleasant and humanistic systems. Nevertheless, their complexity, performance, and outcomes have obviously become subjects of interest in the literature. According to Appelbaum, 1997, "Because the social and technical elements must work together to accomplish tasks, work systems produce both physical products and social/psychological outcomes. The key issue is to design work so that the two parts yield positive outcomes; this is called joint optimization" [76].

Socio-technical systems typically consist of three interdependent subsystems: social subsystem, technical subsystem, and the environment [77]. These subsystems must be aligned to work together in order to achieve optimal functionality [78]. Thus, a jointly optimised organisation proves to be integrally stable and self-correcting as it behaves like an open system, where symmetry is obtained by the free flow of the exchanged inputs and outputs with the environment [79]. This is also known as self-synchronisation [80], i.e. the organisational functioning is interrelated [81]. Inevitably, when designing a work system "focusing on one aspect alone is likely to be sub-optimal and to waste money" [82]. Hence, work systems consist of a social system (people, job roles, culture, goals, work practices), and a technical system (the technologies and tools which support and enable the work processes) [82] [Figure 2]. However, accomplishing joint optimisation is challenging because the needs of the multiple subsystems need to be addressed simultaneously, and because of the unpredictable dynamic relationships amongst them [83]. Nonetheless, socio-technical systems are supposed to achieve it in order to become efficient and useful [83]. Moreover, organisations can only perform optimally if the technical and social aspects are designed to fulfil the needs of each other as well as the needs of their environment [84] [85]. But, how can this be achieved? To date, there is no fixed model to develop a system that will ultimately achieve joint optimisation, but there are respectable early attempts towards doing so. An example of such a model is the recent Joint Optimisation Metamodel (JOM) [83]. This work presented the rationale behind the endeavour, a brief analysis of related approaches, and an outline of the JOM which builds on the available theories and fills the theoretical gaps. The model is still in the early stages and requires further replication, evaluation, and manipulation; yet it appears to be promising. Some of the principles on which it was built include [83]:

1. Responsible Autonomy: meaning that the target end-users would be responsible for the system's performance and overall outcome, and have the capability of making autonomous decisions.

2. Adaptability: meaning that the tasks, schedules, and work procedures would be adjusted by the end-users to increase optimisation that is more distributed than central.
3. Tasks' Meaningfulness: so that the system would be holistic enough to achieve a common goal smoothly, besides having the capability to support the end-users' variant skills and identified duties [78] [86] [87].
4. Feedback Loops: meaning that the system's output could be recycled as an input if necessary, whether to produce more information or assist in decision making [88]. The feedback could also become helpful in designing organisational processes which would possibly evolve to better the overall socio-technical system.
5. Minimal Critical Specification: meaning that what the system has to do should be precisely stated, but how it is supposed to do it is flexible to accommodate the organisation's needs [89]. So, the crucial functions, relationships, and controls are specified by the designers early on, while the details could be open to the frequent evolution which is realised by iterative use.

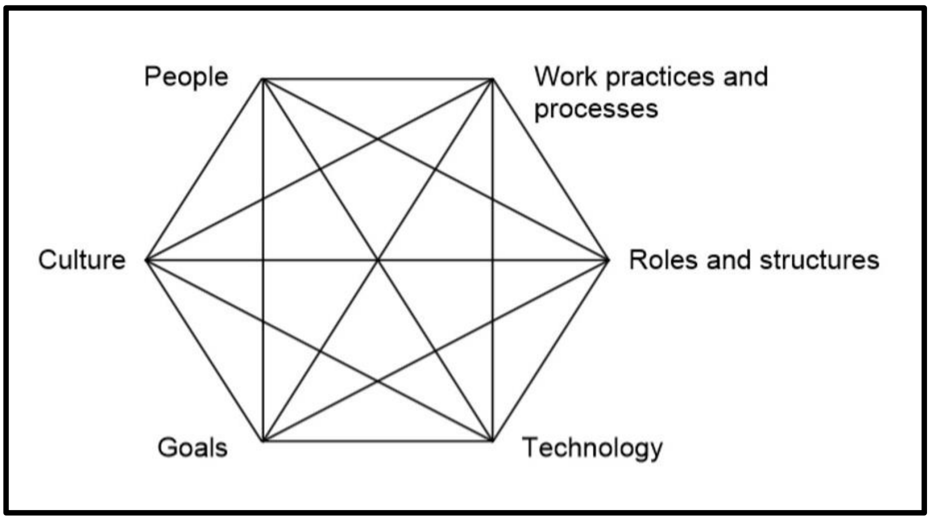


Figure 2: Core Components of any Work System [82]

Furthermore, the JOM shows, at a very-high level, the minimum yet essential core entities which constitute a socio-technical system. It is more of a summarised clarification of how these core entities are interdependent, and play a role in one or more dimensions (the social/human dimension, technical dimension, and environmental dimension) [Table 1].

Table 1: Schema of Joint Optimisation Model (JOM) Core Entities, and How They Relate to the Three Main Aspects of Socio-Technical Systems [83]

Core Entity	Social/Human	Technical	Environment
Stakeholder	X	X	X
Goal / Requirements	X	X	X
Culture	X	X	X
Task (Function / Process)	X	X	X
Resource / Input	X	X	X
Resource / Output	X	X	X
Feedback	X	X	X

1.8 Linking Socio-Technical Systems with Technology Acceptance Models

Since socio-technical systems typically consist of three interdependent subsystems: the social subsystem, the technical subsystem, and the environment [77]; their primary objective is to develop an optimal organizational system which enables these three parts to work together efficiently [78]. These subsystems include: the people who work inside the organization (social subsystem), the required technology to produce work (technical subsystem), and the customers, government bodies, and suppliers with which the organisation interacts (environment) [77].

A vast variety of socio-technical systems models are available for use in the literature. However, many of them are considered to be “difficult to use, time consuming, and requiring a lot of training" [32]. In addition, these models may be very confusing for researchers and practitioners who are not familiar with the human factors research field [32] (to learn about the available socio-technical systems models refer to [90] and [91]). Moreover, the socio-technical systems theory is under-specific and makes it difficult to conduct a quantitative research study and analysis, which would produce meaningful feedback and managerial guidance promptly. Furthermore, it is not always clear and easy to decide which of the available models would fit a given context and purpose best, nor there is sufficient descriptions of how to replicate the procedural steps followed [32]. Besides that, many of these models typically use more than one data collection method to produce good outcomes. In other words, a combination of interviews, observations, questionnaires, scenarios, task analysis, workshops, and/or other data collection methods might be necessary depending on the context and purpose of the research study [32]. However, using many data collection tools in each and every study would take a lot of time, effort, and resources which may be limed or unavailable.

For the reasons mentioned above and in order to save valuable time, this research study proposes to only link the broad concept of the socio-technical systems with a selected Technology Acceptance Model (Chapter 2). This link would be particularly useful because Technology Acceptance Models are more specific and prompt for making definitive predictions about user acceptance and systems usability; especially that this research study is an attempt to formulate better verdicts for engineering or procuring technologies used in healthcare. Technology Acceptance Models are also more coherent and have already been validated and applied extensively in the literature (Chapter 2).

Hence, the two theories will be linked by incorporating the "idea of having to study both, human and technical factors" that are interdependent from the socio-technical systems theory, with “a selected Technology Acceptance Model” to collect and measure quantitative outcomes (as explained and justified in Chapter 2 – 2.3). Likewise, the socio-technical systems concept will be represented in the form of situation-specific socio-technical factors which are considered fundamental in the healthcare context, while the selected Technology Acceptance Model will be represented as a framework on which the Hypothesised Model will be designed (as detailed and demonstrated in Chapter 3 – 3.3 and 3.4).

The Hypothesised Model and added socio-technical factors have to be practical and adhere to the given situations, as well as to the complexity of the healthcare context. This research study posits the non-existence of a single model that might fit each and every healthcare situation [92] [93]. Consequently, the Hypothesised Model should have a certain degree of flexibility to accommodate predefined socio-technical factors which are situation-specific in order to fit the research study’s context and purpose soundly, and consequently yield meaningful outcomes given the limited timeframe [94] [95].

1.9 Conclusion

In light of the topics, concepts, and principles mentioned in Chapter 1, **the research objective** is to identify and measure some of the critical socio-technical factors which may influence the acceptance of new technologies and computer systems by healthcare professionals in their field of practice. This is with particular reference to the early stages in the system's development lifecycle [96]. The proposed argument is that knowing, understanding, controlling, and manipulating such factors at the planning, analysis, and design phases would more likely lead to successful implementation and easier routine maintenance. It would also serve to maximise a given system's impact by reducing the risk of underutilisation or rejection.

The expected research outcome is to provide a better understanding of the contemporary healthcare professionals' attitudes towards the introduction of new technologies and computer systems. Exploring the factors that underpin their behavioural intentions is crucial, especially as the literature had established and suggested a positive relationship that links attitude, intention, and usage together [17]. Thus, this would allow decision makers to put the right facilitating conditions and training sessions in place, the tactic that would increase the likelihood of end-users' acceptance and system utilisation. Since healthcare is a vast research domain, and given the limited time and resources to complete this research, only three novel Clinical Trial Management Systems were studied at the prototyping phase.

The tool to achieve this is the creation of a research model, designed specifically to suit the healthcare context. It is derived from the Unified Theory of Acceptance and Use of Technology (UTAUT) literature. The model was first extended with healthcare-relevant socio-technical factors which were carefully identified, validated, and measured. Then, the scales were further refined to produce a simpler yet effective version of the model based on the collected results. Two of the tested systems were designed for a wide range of end-users working in Europe and the UK. These were being prototyped when the testing took place. The third was only designed for end-users in the UK and its first prototype was recently deployed when the testing took place. These systems have a lot of design elements and characteristics in common, but are still individually unique. By comparing and contrasting the findings, a meaningful conclusion on which factor correlates most to the intention to use new technologies and computer systems in healthcare might finally be yielded.

Moreover, **the primary research interest here** is to study the healthcare professionals' attitudes and intentions of using new technologies and computer systems. Therefore, **this research is only interested in the end-users' point of view**, and considers that a successful deployment of a given piece of technology means that it is indeed accepted and utilised. Although the literature offers many technology acceptance models to assess end-users' attitudes and intentions of using new technologies and computer systems, the UTAUT Model was found to be the most dependable and suitable for the purposes of this research (as detailed in Chapter 2).

Despite the observed tendencies in the literature to "standardise" and "generalise" the available technology acceptance models, they are being used merely as effective tools to support the design and implementation of innovative healthcare technologies that would truly serve an organisation's needs, and satisfy end-users' social and technical requirements equally. In other words, this is an attempt to ascertain whether a given piece of technology is definitely desirable in a given situation/department/organisation before spending valuable time, resources, and effort developing/acquiring it in the first place. Consequently, if the concept and preliminary requirements of a technology on offer were found suitable, then proceed. If not, a better choice could be made early on. Think of it as an “exploratory study” to make better verdicts for engineering or procuring technologies in healthcare, on the basis of valid theoretical models and with the flexibility to accommodate predefined socio-technical factors which are situation-specific.

This research posits that there will not be a single model that fits each and every situation [92] [93]. Instead, it moves past the common “standardising” and “generalising” efforts and adheres to the practicality of real life situations, especially in evolving environments such as healthcare. For that exact reason, three questionnaires were developed and used to collect data for the three conducted studies. They were mostly the same, yet slight variances were made to best suit each individual situation. Following this approach did not affect the final outcome, it rather enlightened the involved stakeholders with specific information to make appropriate adjustments sooner rather than later. Moreover, this approach seems to be well in line with the recommendations of the literature to develop local systems that fit local needs with interoperability standards, instead of big centralised developments that are unmanageable [65] [66].

Given the availability of cutting edge technologies and computer systems that are capable of delivering what is needed to support professionals in their work adequately, if designed with joint optimisation in mind. Besides the ever-evolving healthcare environment, pressing regulations, and almost unavoidable need to use technology in numerous forms. **The main question of this research project is:** what are the motivational factors that influence the intention of contemporary healthcare professionals to use new technologies and computer systems?

This question can be broken down into smaller and more manageable ones:

1. How do contemporary healthcare professionals respond to new technologies and computer systems at the workplace? In other words, is their general attitude positive or negative?

   The literature indicates that their attitude tends to minimise the effect of new technologies for one reason or another. However, this needs to be looked into further, because it seems unlikely for all situations. Consequently, is it true that contemporary healthcare professionals do not want to use technology at all, or is that reaction linked to what is being offered in a specific case? What if this technology helped them without causing major negative doubts or apprehensions? Would they then accept it, utilise it, and adopt it as part of their routine? Our exploratory studies asked specific questions to gauge their tendency in relation to each of the tested systems. If there is consensus that end-users agree with the concept and preliminary requirements of a specific system, that is an indication that the system actually satisfies their needs and would potentially be accepted. If not, then the concept and preliminary requirements have to be revisited and refined to reach consensus.

2. Which factors (attributes and skills) do healthcare professionals rely on if they were to change the way they do things in favour of better outcomes? In other words, is it all attributable to open-mindedness, flexibility, and skilfulness?

   If that is the key to change, then in spite of the individual characteristics and work preferences, what are the best possible facilitating conditions and training sessions that could be put in place? If these elements could be collaboratively arranged and offered by the stakeholders involved, then making the desired change is more likely to be smooth.

3. How can the success of introducing a specific piece of technology into the healthcare practice be predicted? In other words, can the UTAUT be extended to fit within the healthcare context and offer predictions on the future deployment of new technologies and computer systems?

   Empirically testing the Hypothesised Model on the three available systems is a good place to start answering these questions (as detailed in Chapters 3, 4, 5, 6).

Finally, this research is expected to make some original theoretical contributions as it is one of the first scholarly attempts to approach user-intention from a socio-technical point of view within the healthcare context. It extends the prevailing UTAUT Model so that it would fit soundly within this field of practice, by adding healthcare relevant variables to it. This endeavour also puts great emphases on two crucial activities: revisiting the basics of joint optimisation and validating the all-important system specifications with potential end-users' early in the project's lifecycle [96]. These activities might ultimately rule the overall functionality of HIT systems as an integral part of organisations, as well as help in simplifying UTAUT extensions for future evaluation studies. In addition, this work has the potential of updating the available knowledge on how to deal with problematic developments and resolve conflicting needs when introducing HIT systems.

CHAPTER 2: TECHNOLOGY ACCEPTANCE MODELS

This chapter covers two main areas. Firstly, the most commonly applied technology acceptance models were reviewed and assessed for their suitability of use within the healthcare practice in preparation to adapt one of them for the purposes of this research. Secondly, examples of the chosen model's applications in healthcare were briefly reviewed.

2.1 The Most Commonly Applied Technology Acceptance Models

This section discusses some of the most prevailing and generic technology acceptance models. These models were extensively validated and applied to gain knowledge on user acceptance of new products and services. Moreover, they have different sets of acceptance variables (determinants), and therefore their explanatory powers, strengths and weaknesses vary.

The foundations on which these models were developed are in fields such as psychology, sociology, and information systems. Some of the models go back to the 1970's and 1980's when explaining general human behaviour was popular in research. Then, in the 1980's, when the boom of using technology and personal computers happened and affected almost every field of work, researchers realized that there was a need to develop models that could explain this phenomena. Since understanding how technology changes people and organisations (on personal and organisational scales), they were the tool of interest for decades, only through this understanding that the avoidance of wasting valuable time and resources over "underutilized systems" would be possible. Later on, by the late 1980's and 1990's, researchers were faced with another dilemma, namely that a multitude of models to choose from had become available, and that is when comparing and validating them became a significant challenge. Consequently, substantial efforts were made to unify these models, or at least, the most predominant of them [17]. These efforts meant further validations, modifications, and in some cases even using real data to arrive at the most reliable conclusions possible [97]. After all that work had been done, researchers in sectors like healthcare started to contemplate adopting the best models to their fields [11].

These models are key to the current thesis because the aim is to extend one of them to predict end-users' acceptance and future utilisation in healthcare. The following sections (2.1.1 – 2.1.9) will compare them in terms of origins, strengths, main uses and findings, as well as core constructs, moderators, and suitability for this research study.

The criteria followed to decide the suitability of a given Technology Acceptance Model to this research study include:

1. Whether this particular model is fit for **context** (healthcare) and **purpose** (if the model has the capacity to predict end-users' acceptance and future utilisation of the studied systems).
2. Whether minimal or considerable modifications would be necessary to adapt the model to the context and purpose.
3. Information available in the literature about the model's reliability, and whether or not there are specific recommendations to adapt it to the healthcare context (as detailed in 2.3). The choice will be guided by the literature, especially review papers and comparable studies.

Only first thoughts will be given about each of these models suitability through sections (2.1.1 – 2.1.9), however sections (2.3 and 2.4) will provide supplementary details.

2.1.1 Theory of Reasoned Action (TRA)

This theory originated in the social psychology context, and is considered one of the most basic yet powerful theories of human behaviour. It was used to understand a variety of behaviours initially [98], and then Davis et al., 1989, applied it to individual acceptance of technology and found that the explained variance was as good as it was in other behaviours [20]. It has two core constructs, but no moderators were used in the original TRA:

1. Attitude Toward Behaviour: “an individual’s positive or negative feelings (evaluative effect) about performing the target behaviour” [99].
2. Subjective Norm: “the person’s perception that most people who are important to him think he should or should not perform the behaviour in question” [99].

This theory is not suitable for the purposes of this research as considerable modifications will be needed to predict end-users’ acceptance and future utilisation.

2.1.2 Technology Acceptance Model (TAM), TAM2, and TAM3

These theories originated in the information systems context. TAM was based on TRA. Then, TAM2 was an extension of TAM when (subjective norm) was added as a construct for mandatory settings [100]. Similarly, TAM3 was an extension of TAM2, and was mainly used to assess how managers make informed decisions about the steps necessary to achieve better acceptance and utilisation [2]. These theories are versatile, easy to apply, and give good results, especially the original one. Therefore, they were used to predict information technology acceptance and usage at work, and have been applied far and wide to test various technologies and user types. They generally gave good results, in particular, when they excluded the (attitude) construct to explain intention in a more transparent manner. While no moderators were used in the original TAM, (Voluntariness and Gender) were used in TAM2 and (Experience) was also added in TAM3. They mainly consist of the following constructs:

1. Perceived Usefulness: “the degree to which a person believes that using a particular system will enhance his or her job performance”[20].
2. Perceived Ease of Use: “the degree to which a person believes that using a particular system would be free of effort” [20].
3. Subjective Norm: as in TRA/Theory of Planned Behaviour (TPB), but used only in TAM2.

All of the TAM versions are suitable contenders for the purposes of this research, especially the original TAM because of its well reported performance and dependability. In addition, only minimal modifications will be needed to predict end-users’ acceptance and future utilisation within the target context. However, there is an updated and a more comprehensive version of TAM (mentioned in 2.1.9), which will be taken in consideration and contrasted with the original TAM.

2.1.3 Motivational Model (MM)

This theory originated in the psychology context as motivation was found to be a good explanation for behaviour, and had a lot of support from researchers in the field of psychology. There is an outstanding review of the fundamental principles of this theory by

Vallerand, 1997 [101], and it was applied in the information systems context by Davis et al., 1992 [102]. It has two core constructs, but no moderators were used in the original MM:

1. Extrinsic Motivation: users will want to do an activity "because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions" [102].
2. Intrinsic Motivation: users will want to do an activity "for no apparent reinforcement other than the process of performing the activity per se" [102].

This theory is not suitable for the purposes of this research as considerable modifications will be needed to predict end-users' acceptance and future utilisation.

2.1.4 Theory of Planned Behaviour (TPB) and Decomposed TPB (DTPB)

This theory is an extension of TRA, (perceived behavioural control) was added as a construct to determine intention and behaviour. It generates good results on predicting intention that resemble TAM's. There is a good review of the uses of TPB in multiple settings by Ajzen, 1991 [103], and another review of the theory's acceptance and use of many technologies [104] [105] [106]. Moreover, DTPB was found to be identical to TPB in terms of predicting intention, and similar to TAM in terms of collapsing the constructs of (attitude, subjective norm, and perceived behavioural control) into their fundamental belief structure within technology adoption contexts. It has (gender and age) as moderators, and has the following constructs:

1. Attitude toward Behaviour: as in TRA.
2. Subjective Norm: as in TRA.

3. Perceived Behavioural Control: “the perceived ease or difficulty of performing the behaviour” [103], and within the information systems context “perceptions of internal and external constraints or behaviour” [104].

This theory is a suitable contender for the purposes of this research, but considerable modifications will be needed to predict end-users’ acceptance and future utilisation within the target context. Therefore, TAM –for instance- will be more straightforward in comparison.

2.1.5 Combined TAM and TPB (C-TAM-TPB)

This theory is a combination of TAM and TPB (C-TAM-TPB), it is a hybrid model that combined the constructs of TPB with the (perceived usefulness) construct from TAM [107]. Its performance was not clearly reported, but it was mainly used to understand the behavioural intention of things like using on-line tax [94]. It has (experience) as a moderator, and the following constructs:

1. Attitude Toward Behaviour: as in TRA and TPB
2. Subjective Norm: as in TRA and TPB
3. Perceived Behavioural Control: as in TRA and TPB
4. Perceived Usefulness: as in TAM

This theory is a suitable contender for the purposes of this research, however there is a slight reservation because TAM, TPB, and DTPB reported better evidence in the literature compared to it.

2.1.6 Model of PC Utilization (MPCU)

This theory originated from the theory of human behaviour by Triandis, 1977 [95], it was especially designed to predict PC utilization in the information systems context as the authors tried to find a way to predict usage behaviour rather than intention to use Thompson et al., 1991 [108]. Moreover, it is considered to be a competitor of TRA and TPB. It has (experience) as a moderator, and the following constructs:

1. Job Fit: “the extent to which an individual believes that using [a technology] can enhance the performance of his or her job” [108].
2. Complexity: “the degree to which an innovation is perceived as relatively difficult to understand and use” [108]. This definition is based on Roger and Shoemaker, 1971 [109].
3. Long-term Consequences: “outcomes that have a pay-off in the future” [108].
4. Affect Towards Use: “feelings of joy, elation, or pleasure, or depression, disgust, displeasure, or hate associated by an individual with a particular act” [108]. This definition is based on Triandis, 1977 [95].
5. Social Factors: “the individual’s internalization of the reference group’s subjective culture, and specific interpersonalization agreements that the individual has made with others, in specific social situations [108]. This definition is also based on Triandis, 1977 [95].
6. Facilitating Conditions: described as “objective factors in the environment that observers agree make an act easy to accomplish” [17]. In the information systems context, they are defined as “provision of support for users of PCs which may be one type of the facilitating conditions that can influence system utilization” [108].

This theory is not suitable for the purposes of this research. Even though MPCU appears to have convenient core constructs and a relevant moderator at first; it actually predicts the actual usage behaviour rather than intention to use. Therefore, it might not produce accurate results when used at prototyping or early deployment stages.

2.1.7 Innovation Diffusion Theory (IDT)

This theory originated in the sociology context [110], and has been sensibly adapted to the information systems context by Moore and Benbasat, 1991 [111]. It has been applied to study different innovations since the 1960's ranging from agricultural tools to organizational models [112]. Moreover, within the information systems context, it was refined by studying the characteristics of innovations [111]. The researchers came up with a set of constructs that could be used for studying individual technology acceptance, and had support for their predictive validity [113]. No moderators were used in the original IDT, and it has the following constructs:

1. Relative Advantage: "the degree to which an innovation is perceived as being better than its precursor" [111].
2. Ease of Use: "the degree to which an innovation is perceived as being difficult to use" [111].
3. Image: "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system" [111].
4. Visibility: "the degree to which one can see others using the system in the organization" [17]. This definition is based on Moore and Benbasat, 1991 [111].

5. Compatibility: “the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters” [111].
6. Results Demonstrability: “the tangibility of the results of using the innovation, including their observability and communicability” [111].
7. Voluntariness of Use: “the degree to which use of the innovation is perceived as being voluntary, or of free will” [111].

This theory is a possible contender for the purposes of this research. It has convenient core constructs and a relevant moderator. However, TAM reported better evidence in the literature and will be more straightforward in comparison.

2.1.8 Social Cognitive Theory (SCT)

This theory originated in the social psychology context, and is amongst the most powerful theories of human behaviour [114]. It was used in psychology, education, and communication. Moreover, it was expanded and applied to suit the computer utilization and acceptance contexts by Compeau and Higgins, 1995 [115], and the researchers studied the usage behaviour rather than intention to use by means of this theory. Moreover, it was examined for its predictive validity of (intention) to allow a fair comparison with the other models by Venkatesh et al., 2003 [17]. It does not have a moderator, but has the following constructs:

1. Outcome Expectations (Performance): “the performance-related consequences of the behaviour”. Specifically, performance expectations deal with job-related outcomes” [115].

2. Outcome Expectations (Personal): “the personal consequences of the behaviour, Specifically, personal expectations deal with the individual esteem and sense of accomplishment” [115].
3. Self-Efficacy: “judgment of one’s ability to use a technology (e.g. computer) to accomplish a particular job or task” [17].
4. Affect: “an individual’s liking for a particular behaviour (e.g., computer use)” [17].
5. Anxiety: “evoking anxious or emotional reactions when it comes to performing a behaviour (e.g., using a computer)” [17].

This theory is a possible contender for the purposes of this research. It has convenient core constructs. However, TAM reported better evidence in the literature and will be more straightforward in comparison.

2.1.9 Unified Theory of Acceptance and Use of Technology (UTAUT)

This theory is the most extensive version of TAM, designed especially for the information systems context. It actually covers the fundamental principles of eight of the most powerful Technology Acceptance Models including: TRA, TAM, MM, TPB, C-TAM-TPB, MPCU, IDT, and SCT [17]. The UTAUT was specifically designed to explain the behaviour of using information systems by individuals or organizations [97]. Moreover, it was validated on vast real world data, and was methodologically reviewed and showed the most noticeable difference in the explained variance of intention to use (70%) and usage behaviour (52%) by Tang and Chen, 2011 [2]. Its explanatory power gives it an advantage over the other theories and versions of TAM [2]. Furthermore, it has (experience, voluntariness of use, gender, and age) as moderators, and the following constructs:

1. Performance Expectancy (it is the equivalent of Perceived Usefulness in TAM, TAM2, and C-TAM-TPB. It is also the equivalent of extrinsic motivation (MM), job-fit (MPCU), relative advantage (IDT), and outcome expectations (SCT)). In UTAUT, it is defined as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” [17].
2. Effort Expectancy (it is the equivalent of Perceived Ease-of-Use in TAM and TAM2). It is also the equivalent of complexity in (MPCU), and ease of use in (IDT). In UTAUT, it is defined as “the degree of ease associated with the use of the system” [17].
3. Social Influence (it is the equivalent of Subjective Norm in TRA, TAM2, TPB, DTPB, and C-TAM-TPB. It is also the equivalent of Social Factors in (MPCU), and image in (IDT)). In UTAUT, it is defined as “the degree to which an individual perceives that important others believe he or she should use the new system” [17].
4. Facilitating Conditions: (it is the equivalent of perceived behavioural control in TPB, DTPB, and C-TAM-TPB. It is also the equivalent of facilitating conditions in (MPCU) and compatibility in (IDT). In UTAUT, it is defined as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system” [17].

This is the most suitable contender amongst all the theories for the following reasons: 1- it is the most comprehensive theory found so far, 2- it is the only theory to outperform TAM according to the literature [Table 2], 3- it already has convenient core constructs and relevant moderators, and 4- it will not need major modifications nor get overcomplicated when adapted to the target context.

2.2 Remarks on the Technology Acceptance Models

Although there are many obvious differences amongst the models discussed above (like the contexts in which they originated, their premeditated purposes, core constructs, moderators, and explanatory power), they are still very similar in the sense that they share the basic underlying concept [17]. End-users usually make early reactions to the new technology or information system offered, these reactions would then guide their intention as to whether or not they would want to use it, and their intention would finally result on actual use [Figure 3].

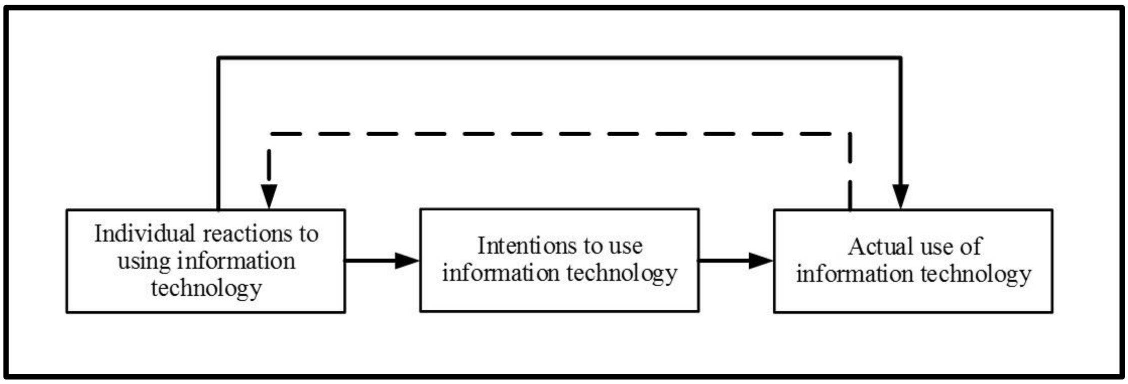


Figure 3: Basic Concept Underlying User Acceptance Models [17]

2.3 Which Model is Most Suitable for Healthcare?

As demonstrated above, significant developments have been made to explain and predict end-users acceptance of information technology [17]. Predominantly, “considerable theoretical and empirical support has accumulated in favour of TAM” [116] [20]. This particular theory has been replicated by numerous researchers who tested different types of information systems in various fields of knowledge such as: a) general purpose systems (windows, microcomputer or PC, WWW or e-commerce, workstation, computer resource centre, and groupware); b) office applications (word processor, spreadsheet, presentation, database, and groupware); c) specialized business systems (computerized model, case tools, hospital information systems like telemedicine, decision support systems, expert support systems, and others like: manufacturing and resource planning); and d) communication systems (e-mail, V-mail, fax, dial-up systems, and others like: cellular) [117].

Moreover, in 2011, Tang and Chen reviewed the evolution of the model and made a comparative analysis among its four well-known versions: TAM [116] [19], TAM2 [100], UTAUT [17], and TAM3 [118]. They concluded that, of the four models, the best performance came from the UTAUT which can explain (70%) of the variance in Usage Intention, and (52%) of the variation in Usage Behaviour. **In other words,** UTAUT has the capacity to predict end-users' intentions as to whether or not they would want to put a certain offered technology/system in use (up to 70%), and it has the capacity to explain their actual use of the technology/system (up to 52%) [Table 2]. Their work has also resulted on some valuable recommendations for future research including: i) introducing new variables into the model for easier interpretation, ii) renewing the determinants of the perceived ease of use factor for more stability, and iii) studying larger samples across different organisations at different time periods [2].

Table 2: Explained Variance in the Models [2]

	Explained Variance (Adjusted R2)	
	Intention to Use	**Usage Behaviour**
TAM	45%~61%	31%~74%
TAM2	34%~52%	----
UTAUT	70%	52%
TAM3	53%	35%
Note. " ----" means the value is not tested in the model.		

Nonetheless, many opinions have highlighted the importance of examining and advancing theories within relevant contexts. Thus, the use of the different versions of TAM to assess user acceptance of new technologies is well established and validated in the Information Systems field. However, there are concerns with regard to its applicability and performance in the healthcare domain, especially that it is undoubtedly a compound socio-technical system. Amongst the most inherit challenges of this domain are the organisational complexity and end-users' reluctance to change, and those cannot be overlooked when evaluating new technologies and computer systems [13] [119]. Therefore, it is important to understand the generalisability, differences, and/or limitations which may be associated with applying the UTAUT in healthcare [18]. On one hand, examining theories in new contexts can result in many inconsistencies and changes as it has been previously demonstrated. For example, relationships between factors can lose significance, positivity, or strength [120]. On the other hand, it offers opportunities to create new knowledge [121].

In 2007, Yarbrough and Smith have done a systemic review to explore the possibility of applying one of the technology acceptance models in healthcare. A similar effort was also done in 2010 by Holden and Karsh. Both studies specifically recommended to adapt a modified version of TAM to the healthcare domain, making sure that any added factors would make it fit well there [11] [122]. So, on those basis, this doctoral research project trusts that this recommendation is even more applicable to UTAUT, **because:** 1- it is the most comprehensive version of TAM found so far, 2- it is the only theory to outperform TAM according to the literature [Table 2], 3- it already has convenient core constructs and relevant moderators, and 4- it will not need major modifications nor get overcomplicated when adapted to the target context.

Hence, there are three reasons for that: it is theoretically the most comprehensive out of all the models, it has a superior explanatory power and been proven to perform better than the other versions of TAM [2], and its existing core constructs and moderators seem to be very appropriate for the healthcare domain with minimal modification. However, it should be noted that simply adding questions to a validated questionnaire does not guarantee that the validity will be preserved, or that the new questions will be equally valid. The addition of questions, in effect, creates a new questionnaire which requires further validation. Lastly, it is worth asking whether the additional questions load on their own unique factors, or whether they load on the existing factors that informs UTAUT.

2.4 Examples of UTAUT Applications in Healthcare

This section provides eleven examples of UTAUT applications in healthcare, presented in a chronological order. Seven studies are on EHR uses, two are on telemedicine uses, and two are on general HIT uses. Moreover, a couple of additional UTAUT-based model proposals were found, however these were not empirically tested and therefore excluded [123] [124].

To avoid terminology confusion, it is necessary to clarify that EHR are alternatively referred to as: virtual EHR, electronic medical records (EMR), computerized patient records (CPR), computer-based patient records, computerized medical records, electronic patient records (EPR), electronic health care records (EHCR), digital medical records (DMR), automated medical records, and provider-based patient medical records [125] [126]. Furthermore, Health Information Technologies (HIT) are also alternatively known as Information and Communication Technologies (ICT).

2.4.1 Harle and Dewar, 2012

A study titled "Factors in Physician Expectations of a Forthcoming Electronic Health Record Implementation" studied 256 doctors in a large multi-specialty medical group practice that is linked to an academic health centre in the USA [127].

It was carried out to explore the effect of physician characteristics on performance expectancy and effort expectancy for an upcoming EHR. A quantitative study using paper questionnaires was the research method used. The model of choice was UTAUT along with medical specialty, personality traits, and general openness to change in the work place as determinants of both performance expectancy and effort expectancy. The variables included: age, gender, computer self-efficacy, job role, medical specialty, openness to change in practice, and personality.

2.4.2 Venkatesh et al., 2011

A study titled " 'Just what the doctor ordered': a revised UTAUT for EMR system adoption and use by doctors" studied 141 doctors to measure their use of a newly implemented EHR system [18].

A hospital longitudinal study over 7 months was the selected research method, and it took place while a new EMR system was being implemented. To measure use, questionnaires and system logs were used through the collection of three waves of data. The models of choice were the original UTAUT and a reduced UTAUT.

2.4.3 Kok et al., 2011

A study titled "Exploring the Success Factors of Electronic Health Record Systems Adoption" studied 8 doctors from different hospitals and specialties [128].

It was carried out to identify the main technological and organisational factors affecting doctors' adoption of EHR. A qualitative field study using face to face semi-structured interviews research method was used. The model of choice was UTAUT along with four variables: organisational characteristics, system characteristics, external factors, and interdependency.

2.4.4 Whitten et al., 2010

A study titled "Keys to a successful and sustainable telemedicine program" studied 92 managers and supervisors of telemedicine programmes in the USA [129].

It was carried out to identify key or organisational characteristics that make a successful telemedicine programme. A quantitative study using online questionnaires research method was used. The model of choice was a combination of UTAUT and Organisational Change Readiness (OCR) assessment.

2.4.5 Hennington et al., 2009

A study titled "Information Systems and Healthcare XXXII: Understanding the Multidimensionality of Information Systems Use: A Study of Nurses' Use of a Mandated Electronic Medical Record System" studied nurses working in a large urban hospital. It was carried out to understand their experience of using EHRs in mandatory settings [126].

A qualitative research method was used, it combined deductive/inductive approaches using semi-structured interviews, and direct nonparticipant observation. It was then tested on 23 nurses. This particular approach was chosen because the use of questionnaires was not possible in such complex dynamics, yet was indicated as a shortcoming. The model of choice was UTAUT along with three variables: time spent using the system, timing of use, and mode of use.

2.4.6 Nwabueze et al., 2009

A study titled “The Effects of Culture of Adoption of Telemedicine in Medically Underserved Communities” studied 196 doctors from different hospitals and specialties who are perspective and actual telemedicine [130].

It was carried out to study the introduction of telemedicine in medically underserved communities. A quantitative study using questionnaires was the research method of choice. The model of choice was UTAUT along with culture. Culture was measured according to four dimensions: power versus distance, individualism versus collectivism, masculinity versus femininity, and uncertainty versus avoidance [131].

2.4.7 Kijsanayotin et al., 2009

A study titled “Factors influencing health information technology adoption in Thailand's community health centres: Applying the UTAUT Model” studied 1323 healthcare professionals working at community health centres in Thailand for general uses of different HIT systems [132].

It was carried out to study the factors that influence HIT adoption by healthcare professionals of a developing country. An observational research design and a quantitative study using questionnaires were the research methods used. The Model of choice was the original UTAUT.

2.4.8 Wills et al., 2008

A study titled “Examining healthcare professionals’ acceptance of electronic medical records using UTAUT” studied 52 Nurses (registered and certified) and Doctor Assistants in two healthcare centres for the use of implemented and upcoming EHRs [133].

It was carried out to study their acceptance of EHRs in order to predict, define, and enhance utilisation. A quantitative study using online questionnaires research method was used. The model of choice was UTAUT along with two minor changes: no moderators were included, and, (social influence) became a significant direct determinant of behavioural intention.

2.4.9 Hamidfar et al., 2008

A study titled “Using the UTAUT Model to Explore Iranian Physicians and Nurses’ Intention to Adopt Electronic Patient Records” studied 113 doctors and nurses working in three different hospitals in Tehran [134].

It was carried out to explore the factors affecting their adoption of EHR. A quantitative study using questionnaires research method was used. The model of choice was UTAUT with two minor changes: no moderators were included, and (facilitating conditions) became a direct determinant of behavioural intention.

2.4.10 Hennington and Janz, 2007

A study titled “Information Systems and Healthcare XVI: Physician Adoption of Electronic Medical Records: Applying the UTAUT Model in a Healthcare Context” studied an unspecified number of EHR's system logs to explore doctors' system adoption, and the factors that facilitate it [135].

The model of choice was UTAUT along with EHR-relevant questions covering three variables: financial performance, alignment with business process, and improvement in the provided quality of care.

2.4.11 Schaper and Pervan, 2007

A study titled "An investigation of factors affecting technology acceptance and use decisions by Australian allied health therapists" studied 1605 Australian occupational therapists for general uses of different HIT technologies [136] [137].

It was carried out to study HIT acceptance and utilisation of Australian occupational therapists so that the success rate of implementations will be improved. The research method was a mixed-mode of: substantial qualitative, quantitative, and longitudinal data collected through posted questionnaires in Australia in a three-phase design. The model of choice was UTAUT proposed as a generic framework with socio-technical aspects (social, technical, and organisational factors were added) [138].

2.5 Extending UTAUT for Healthcare Applications: Developing a Hypothesised Model

Chapter 2 has discussed the available choices of technology acceptance models. After comparing and contrasting their explanatory power, constructs, and moderators; UTAUT appeared to be the most suitable model to apply in the healthcare practice. Nevertheless, it needs to be extended with healthcare relevant socio-technical factors and take in consideration the principles of joint optimisation so that it would fit soundly.

The literature had also presented a number of attempts for applying UTAUT in healthcare. Most of the studies were carried out on EHR systems, perhaps because these have been very popular and highly needed in order to automate and optimise the healthcare delivery. Moreover, it might have been their problematic implementations that encouraged researchers to look for explanations and solutions in other research fields, such as information systems. So far, the findings mostly support adapting UTAUT to the healthcare practice. Especially that the model itself and extensions of it have been helpful in studying end-users' acceptance and utilisation of diverse HITs successfully.

On these basis, we propose to extend UTAUT with variables which we consider fundamental in the healthcare practice, including: *System-Specific Features*, *Technology Anxiety*, and *Adaptation Timeline*. We also propose adding *Specialty* to the existing key moderators. The Preliminary Hypothesised Model is illustrated in [Figure 4], but it will be detailed and justified in (Chapter 3). However, it is **not** sure yet whether this research study will thoroughly investigate the moderators' impact, or just use them as part of the participants' demographic profile. This decision will be made on the basis of preliminary analysis later on.

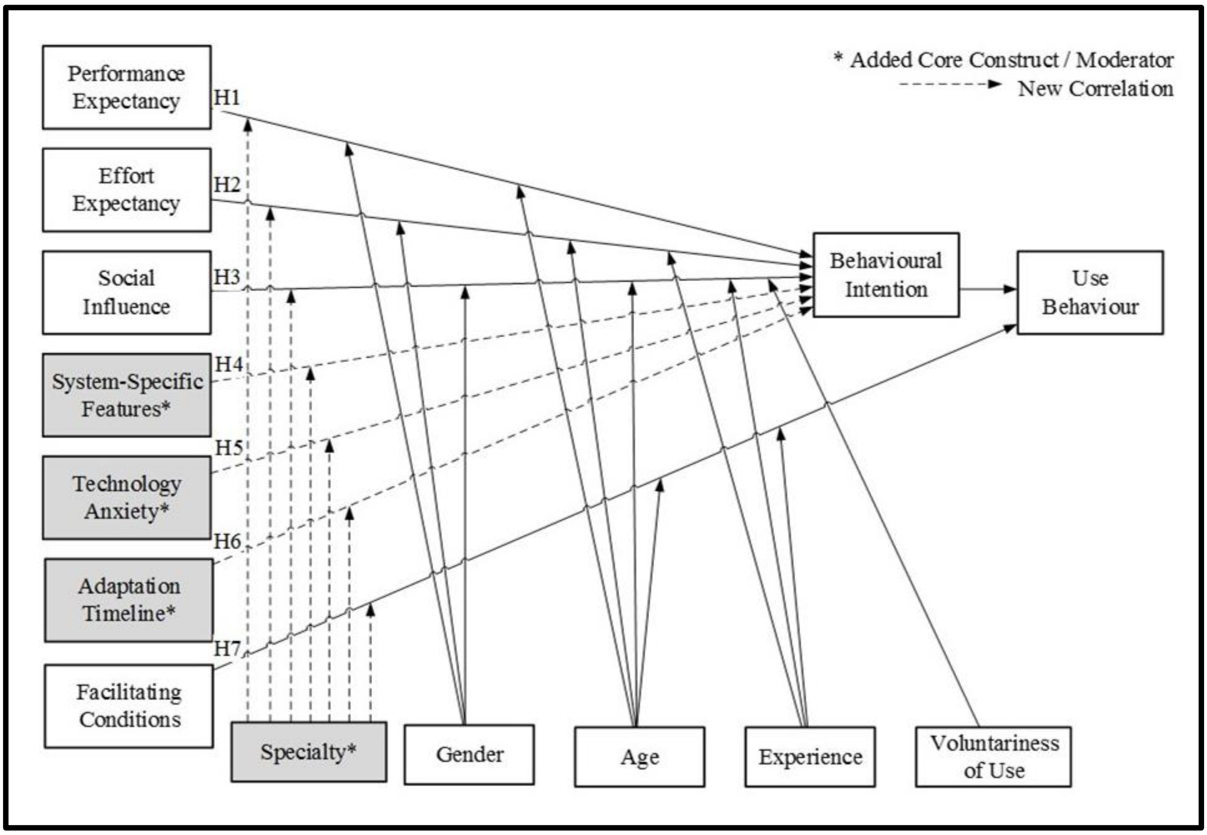


Figure 4: Preliminary Hypothesised Model

2.6 Conclusion

In light of the information presented earlier in this chapter, the Schaper and Pervan, 2007 study is similar to this endeavour [137]. To our knowledge, it was the only study to consider the complexity of systems used within the healthcare practice in light of socio-technical aspects. Therefore, its findings will be compared and contrasted with the findings of this research study in (Chapter 7).

CHAPTER 3: METHODOLOGY

This chapter explains the methodology followed to conduct this research study. It begins with a Hypothesised Model viewed as likely to be suitable for the purposes of predicting end-users' acceptance and future utilisation of HIT. It then presents the research hypothesis followed by the data collection instrument used. Following these steps, it discusses the statistical measures applied to analyse the research findings, and finally it provides an overview of the systems tested in order to examine the Hypothesised Model.

3.1 Research Objective

As discussed in Chapter 1, this doctoral research project is firstly concerned with introducing new technologies and computer systems into the healthcare practice, secondly, its consequential socio-technical aspects, and thirdly, how to extend one of the most prevailing Technology Acceptance Models to predict end-users' acceptance and future utilisation. This is a complex quest, especially that when new technologies and computer systems are being evaluated, they usually become part of an organisation's information system, and their interaction with end-users in a given environment is the ultimate target. Therefore, the evaluation becomes a situation or a process rather than a single product [1]. This implies, an overall understanding of social and behavioural aspects as well as technical aspects. Elements such as : logical workflow, technology introduction methods, quality of information, training and support, depth of use, and end-users' motivation need to be incorporated [40]. In light of these perspectives, we aspire to answer three research questions, one of which is: how can the success of introducing a specific piece of technology into the healthcare practice be predicted?

To answer this question, we propose to extend UTAUT with healthcare relevant factors to fit within the healthcare context. Then, the Hypothesised Model will be tested on three allocated HIT systems which are still at the “designing/prototyping/demonstrating” phase (an overview of the tested systems is given in 3.7, namely: Electronic Primary Care Research Network (ePCRN), Remote Data Entry (RDE), and Data Quality Tool (DQT)).

Moreover, participating end-users will either get a training session or a demonstration to experience the system in advanced. Then, they will be asked to fill questionnaires to validate and/or modify the desired functionality. The questionnaires approach healthcare professionals’ behavioural intention from a socio-technical point of view in order to pinpoint the factors that would help in achieving joint optimisation. Finally, the quantitative findings will be assessed to measure the Hypothesised Model’s capacity for predicting end-users’ acceptance and future utilisation.

However, since no two healthcare systems are identical, the Hypothesised Model **must be flexible** to accommodate slight variations that might suit a specific healthcare situation. In other words, its core constructs and associated questionnaire inquiries have to be easily adjustable for a better fit in a specified situation as not every construct will be appropriate for every study. Decisions on which core constructs and inquiries to include will be made in agreement with the involved stakeholders (mostly, system developers who know both the system they developed and the end-users they dealt with). **Overall, the aims of the three evaluation studies are, to:**

1. Present a Hypothesised Model that fits soundly within the healthcare context.
2. Empirically test the Hypothesised Model on three HIT systems.

3. Interpret the findings of the Hypothesised Model so as to predict end-users' acceptance as well as future utilisation of new technologies, and computer systems.

3.2 Participants Recruitment

The target population was limited to healthcare professionals who are also clinical researchers. More precisely, researchers who happened to be using innovative HIT systems which were planned and designed by the researchers and developers involved in this research study. The target samples for the three studies were comprised of a representative mix of male and female participants drawn from a wide range of clinical and professional specialties, aged between 20 and 65 (and above), and their experience in using clinical database systems varied.

3.3 Research Model and Hypothesis

The Hypothesised Model incorporates variables which we consider fundamental in the healthcare practice. We have introduced three new composite-variables to the existing direct determinants: *System-Specific Features*, *Technology Anxiety*, and *Adaptation Timeline*. We have also added *Specialty* to the existing key moderators. The adjustments are summarised in the following points and in [Table 3].

The Hypothesised Model [Figure 5]:

1. Retains the direct determinants of the original UTAUT: *Performance Expectancy*, *Effort Expectancy*, *Social Influence*, and *Facilitating Conditions*. However, it expands them by introducing *System-Specific Features, Technology Anxiety,* and *Adaptation Timeline.*
2. Retains the existing key moderators: *Gender*, *Age*, *Experience,* and *Voluntariness of Use.* However, it expands them by introducing *Specialty*.
3. Discards the non-direct determinants of the original UTAUT*: Attitude, Self-efficacy*, and *Anxiety;* they are more or less covered by the added direct determinants.
4. Examines the relationships between the direct determinants and *Behavioural Intention*.

System-Specific Features, Technology Anxiety, and *Adaptation Timeline* were added along with relevant questions as ordinal direct determinants measured by a seven-point Likert scale ranging from strongly disagree to strongly agree.

System-Specific Features obtains information on an end-users' level of satisfaction with the system and whether or not they believe it delivers what they need (i.e. added to validate the requirements of a given system). It is absolutely crucial that systems are efficient in terms of characteristics such as: the number of steps required to complete a given task, promptness and speed, and the overall output clarity. These features vary from one system to another, so they have to be identified and verified with particular reference or application to highly specialised systems.

The *System-Specific Features* core construct may be similar to *Performance Expectancy* and *Effort Expectancy*, however the latter two are general whereas *System-Specific Features* is more particular. Thus, most systems in general are expected to (fit the job well, be useful, increase productivity, improve work quality, and speed up completion of tasks); these attributes would be represented by *Performance Expectancy*. In addition, most systems in general are also expected to be user-friendly as in (not mentally exhausting, clear and understandable, easy to learn and use, and would facilitate work); these attributes would be represented by *Effort Expectancy*. However, highly specialised systems, like the ones used in healthcare, may require very specific features depending on the purpose that they were designed for. Without these features, their purpose would not be served, for example: one of the studied systems is required to produce a visual information map of the outcome. Such specific attributes would be represented by *System-Specific Features*. Consequently, these three core constructs together or a combination of two per study might be more effective at capturing a broader range of end-users' opinions. Good sources on computer attitudes, satisfaction, literacy, and aptitude could be found in [139] [140].

Technology Anxiety obtains information on an end-user's psychological and/or habitual readiness to adapt to change [141]. This was incorporated in order to examine whether there is a direct link between anxiety and the use of HIT in demanding settings. Nevertheless, Anxiety is not completely new to the technology acceptance models; it is originally a part of the SCT [142], and is also a non-direct determinant in the UTAUT. A good source on computer anxiety could be found in [143].

Adaptation Timeline obtains information on the importance of allowing enough time for an end-user to completely absorb change and master a new system, **particularly at the training period** [141]. Hence, *Adaptation Timeline* has the essence of Attitude and Self-efficacy which are core constructs in the SCT [114], and non-direct determinants in the UTAUT [17]. However, we would like to explore if an end-user's positive or negative feelings for a new system have anything to do with how efficient they think they can become when actually using it.

Specialty was added as a nominal key moderator based on a recommendation by Chimer and Wiley-Patton, 2003 [144]. However, we **do not** suggested that some end-users are more technology savvy and willing to use new technologies and computer systems than others, but we would like to have this information amongst the findings to better describe the samples and give extra details on the participants' backgrounds (see 4.1, 5.1, and 6.1).

Note that this research study did not visually represent the moderators in the Hypothesised Model, nor discuss their impact in the results. Instead, it used them as part of the participants' demographic profile to better describe the samples and give extra details on the participants' backgrounds (as detailed in 4.1, 5.1, and 6.1). This is not due to the lack of insight, however these moderators were extensively researched beforehand [135]. For that reason, we preferred to simplify the Hypothesised Model by only keeping the relevant core constructs [Figures 4 and 5], this in return will keep the findings focused on the studied systems' performance and measure it using a seven-point Likert scale. In fact, reducing or excluding the moderators was the opinion of other researchers who have previously tried to adapt UTAUT to the healthcare context too [18] [133] [134]. Moreover, from a managerial point of view, there is not much that could be done with regards to the moderators. However, the direct determinants could be certainly adjusted to facilitate the implementation of new technologies and computer systems in a specific work environment. For instance, plans could be made to reduce *Technology Anxiety* amongst employees or for better *Facilitating Conditions* to be available, regardless of the moderators. Furthermore, the target population members are likely to have very comparable skills to do the type of work they do (clinical research), in spite of their *Specialty, Gender, Age, Experience,* and *Voluntariness of Use*. Nevertheless, preliminary analysis was done on the moderators to assess whether there are any interesting findings that would add to the field of knowledge (Appendix F, G, and H). Although some of the findings were statistically significant, they were practically not useful, previously revealed, or difficult to interpret. For instance, Study 1 and Study 3 show that *Age* significantly correlates with *Experience* which is a given. Another example, in Study 1 and Study 2 *Specialty* significantly correlates with *Age* and *Gender* which is difficult to understand.

In line with the original UTAUT assumptions [17] [Figure 5], we hypothesise that:

H1: Performance Expectancy will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H2: Effort Expectancy will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H3: Social Influence will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H4: The System-Specific Features will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H5: Technology Anxiety will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H6: Adaptation Timeline will have an impact on healthcare professionals' Behavioural Intention to use HIT.

H7: Facilitating Conditions will have an impact on healthcare professionals' Behavioural Intention to use HIT. These could include: managerial involvement, sufficient training, helpdesk support, and/or the availability of a comprehensive manual.

Table 3: Definitions of Added Core Constructs

Core Construct	Theory	Definition
System-Specific Features*	Hypothesised Model	An end-user's level of satisfaction with the system and whether or not they believe it delivers what they need (i.e. added to validate a system's requirements).
Adaptation Timeline*	Hypothesised Model	An end-user's ability to develop the necessary skills for using a new technology given a certain level of complexity, appropriate training, and a limited period of time.
Technology Anxiety*	Hypothesised Model	Emotional reactions and readiness for changing an end-user's work habits to a certain extent within a demanding environment; provided that they have access to appropriate facilitating conditions.
* New Variables		

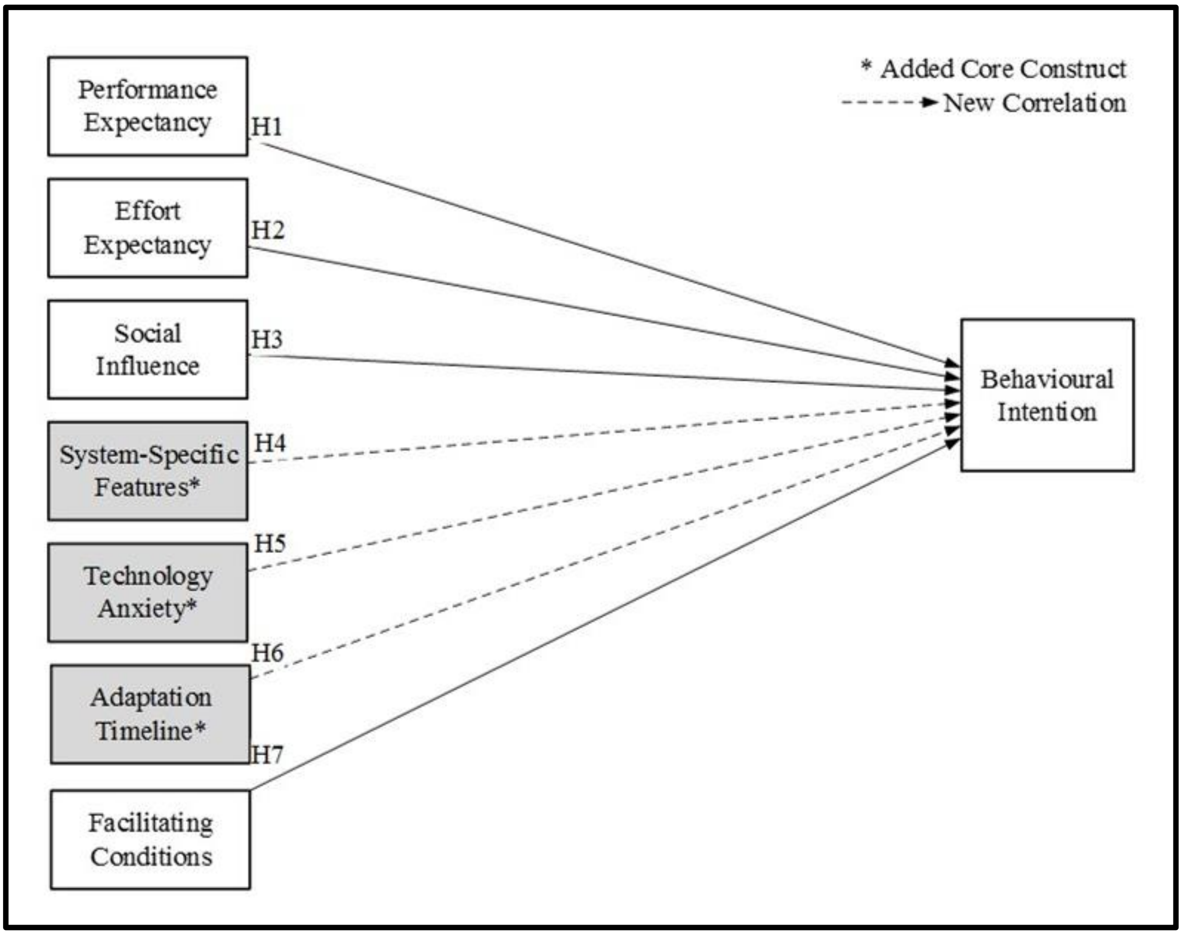


Figure 5: The Hypothesised Model

3.4 Questionnaire Instrument

The questionnaire instrument was based on validated core constructs and questions [17], yet expanded with three new core constructs: *System-Specific Features, Technology Anxiety,* and *Adaptation Timeline* along with relevant questions. Nevertheless, it should be noted that simply adding questions to a validated questionnaire **does not** guarantee that the validity will be preserved or that the new questions will be equally valid. The addition of questions, in effect, creates a new questionnaire which requires further validation. So, it is worth asking whether the additional questions load on their own unique factors, or load on the existing factors that inform UTAUT. Furthermore, as mentioned earlier, since no two healthcare systems are identical, the core constructs included and questions asked will be adjusted to suit the specific circumstances of each study. A number of the questions might be of the same idea, but expressed differently depending on what end-users would find clearer as detailed in [Table 4]. Moreover, all decisions regarding which core constructs to include and which questions to ask were made in agreement with the involved stakeholders in each study, and in anticipation of yielding the best possible results. The final questionnaire of each study was also double checked mostly by the system developers who know both the system they developed and the end-users they dealt with to a great extent [Appendix B, D, and E].

Table 4: Core Constructs and Questions Asked

Questions Asked	Study 1	Study 2	Study 3
Performance Expectancy			
I expect the system to improve my work performance	X		
I expect the system to be efficient	X		
I expect the system to increase my productivity	X		
I expect the system to help me acquire transferable skills	X		
I expect the system to give me better control over my work	X		
Overall, I expect the system to technically perform well	X		
OR			
I find the system useful in my job, especially when entering and searching data		X	X
Using the system enables me to complete tasks at a quicker pace		X	X
Using the system increases my productivity		X	X
Using the system improves the quality of my work		X	X
Overall, the system fits well with the way I work and the service I provide		X	X
Effort Expectancy			
I found it easy to access data through the system	X		
I found the available data format clear	X		
I was able to easily identify relevant data	X		
I found it smooth to interact with the system	X		
I think the system has a good presentation and outline	X		
Overall, the system is easy to use	X		
OR			
Interacting with the system has been user-friendly, clear, and understandable		X	X
Learning to operate the system has been easy for me and did not take a long time		X	X
I found it easy to become skilful at using the system (for example: applying extensive and/or particular search enquiries)		X	X

Questions Asked	Study 1	Study 2	Study 3
The system facilitates my daily job		X	X
I believe that interacting with the system does not mentally exhaust me		X	X
Social Influence			
I was encouraged to use the system by my superiors	X		
I was pressurised to use the system by my superiors	X		
There has been good communication with my superiors/colleagues to try the system	X		
I was given a demonstration on how the system works	X		
There is an "open door" policy to discuss aspects related to the system	X		
Overall, my organization supports this change initiative	X		
OR			
My managers/supervisors encourage me to use the system		X	X
The long-term benefits of using the system inspire me to use it		X	X
Within my organization, the management usually communicates their plans of introducing new systems to the staff		X	X
Within my organization, the management usually offers sufficient training when new systems are introduced		X	X
Overall, the use of healthcare information technology in my workplace is very important		X	X
Facilitating Conditions			
The manual and/or training session was comprehensive enough	X		
I could imagine using the system to conduct my routine work	X		
The availability of more complex and extensive search criteria was mentioned	X		
The steps which the system follows were logical to use, apply, and recall	X		
The offered manual and/or training session covered all essential tasks and provided help on how to overcome difficult ones	X		
Overall, the facilitating conditions to use the system were sufficient	X		

Questions Asked	Study 1	Study 2	Study 3
OR			
The manual **or** training/help option was/is comprehensive enough		X	X
The use of the system is smooth (no technical errors)		X	X
The steps followed by the system are logical to use, apply, and recall		X	X
If I got stuck, a sufficient reference or resource is available to help me out		X	X
The system is easily accessible, responds to queries promptly, and does not disturb my daily routine		X	X
Technology Anxiety			
I am open for -dramatic- changes in my work habits if necessary	X	X	X
I am likely to become (**or** I consider myself) technology-oriented due to the nature of my field	X	X	X
I had prior knowledge of the need to use health Information Technology in my job	X		
My computer experience will help me put this system into use	X		
Generally, I would be more comfortable with new systems if trained in advanced	X		
Overall, I am not that anxious about using technology	X	X	X
AND / OR			
Generally, I like to keep up with new information technology		X	X
If I were given enough time and sufficient resources to absorb change, I am likely to accept it		X	X
Adaptation Timeline			
I had adequate time to get trained on using the system	X		X
I received sufficient information and/or training during this time	X		X
I had enough time to get used the system environment	X		X
If the system became available, I think I would be able to improve the quality of my work immediately	X		X
I think I would be confident enough to carry out clinical trials by the help of this system right away if it becomes available	X		X

Questions Asked	Study 1	Study 2	Study 3
Overall, I think I will be allowed enough time to get into the habit of using this system if it becomes available	X		X
System-Specific Features			
RDE forms: the number of steps to enter clinical data into forms is reasonable		X	
Data entry into RDE forms: it is important to enter complete and reliable data		X	
RDE edit: editing data on the system is more consistent than editing it on paper		X	
RDE dynamic search: searching the system is better and quicker than searching papers		X	
RDE dynamic search: querying clinical data is prompt enough		X	
RDE querying function: querying DICOM data is prompt enough		X	
Data viewing: the system is better than the paper forms; it gives a holistic view of patients' data as well as specific records		X	
RDE upload function: the upload of files is quick enough		X	
OR			
DQT system: the number of steps to select practices fit for purpose is reasonable			X
DQT login: logging into the system is quick enough			X
DQT information map: there is enough information about available databases, their country of origin, and owner contact details			X
DQT specific database: for a database of interest, some further general requirements can be selected such as: whether the database is linkable to generic data, to a cancer registry, to drug registry, etc.			X
DQT data quality: the system assesses the completeness of available data in a visual output which is helpful to interpret			X
DQT defining use case: querying data for a certain study using use case, population, and time period is prompt enough			X
DQT specifying use cases: after a use case is defined, further specification can be applied using slide bars on predefined data elements			X

Questions Asked	Study 1	Study 2	Study 3
DQT output: the practice ID given for a specified use case is the right output			X
Behavioural Intention			
I intend to learn as much as I can about the system (**or** I intend to learn how to use the system to the best of my abilities)	X	X	X
I intend to use the system as often as needed (to perform my work)	X	X	X
I intend to promote the system to my colleagues (if it became available for broader use)	X	X	X
I intend to suggest ideas for further improvements (**or** to further enhance) the system to the developers if I thought of any	X	X	X
I intend to do more research studies if the system proved to substantially facilitate so	X		
Overall, I intend to put this system into full use if it became available	X		
AND / OR			
I prefer to use the system because data can be better preserved, archived, shared, manipulated, and searched electronically		X	X
Table Indications			
X = the question is included in the marked study/studies. **AND** = the question is included in this exact format in the study/studies marked with an X. **OR** = the question is of the same idea, but was expressed differently for the study/studies marked with an X. **Added Core Constructs:** Study 1 (ePCRN): Technology Anxiety and Adaptation Timeline. Study 2 (RDE): System-Specific Features and Technology Anxiety. Study 3 (DQT): System-Specific Features, Technology Anxiety, and Adaptation Timeline.			

3.5 Pilot Study

To validate the questionnaire instrument, a pilot study was conducted on two healthcare professionals who were keen on trying one of the tested systems (ePCRN). The participants were given a brief training session, where they were given a simple ePCRN Workbook [Appendix C]. The researcher then introduced the first few steps, yet encouraged the participants to explore the rest of the Workbook and system's features on their own and sat to observe whether there were any difficulties in the system interface/design or ambiguity in the provided Workbook. Next, the questionnaire was handed to the participants to be filled [Appendix B]. Finally, both participants were interviewed and asked the following questions:

1. What do you think of the questionnaire's length?
2. Do you think the questionnaire is comprehensive enough to cover the important aspects of the system?
3. What do you think of "phrasing the questions"? Please give your suggestions if there is ambiguity anywhere.

In terms of length and comprehensiveness, they both agreed that it was of an appropriate length and that every question was of importance. However, a few suggestions were given to better phrase some of the questions for clarity purposes. All suggestions were taken into consideration and incorporated in the final version of the questionnaire.

3.6 Data Analysis

A number of statistical measures were needed to analyse the whole set of data, each measure was used to extract explicit findings. For each study, a summary of participants' demographics, a set of core construct frequency tables, a summary of scale reliability, and an overall correlation analysis were calculated and presented. Moreover, each study had Principal Components Analysis (PCA) done, followed by reliability and correlation calculations of the resulting factors.

3.6.1 Descriptive Statistics

Two measures of descriptive analysis were calculated:

1. Percentages were calculated on the nominal variables to depict the participants' demographics. Particularly of: the participants' gender, age group, background/specialty, how many of them had previous experience in clinical research, and whether or not they were keen on trying to use the offered system [Tables 6, 19, and 29].
2. Frequencies were calculated for each of the core constructs to examine the end-users' level of satisfaction with the system, and whether or not they believe it delivers what they need. The core constructs are essentially ordinal numerical variables measured by a seven-point Likert scale ranging from (strongly disagree) to (strongly agree). So, having frequency tables to represent their findings is a simple yet efficient way to validate and/or modify the desired functionality. These were turned to percentages for simplicity [Tables 7, 20, and 30].

3.6.2 Structural Model Assessment

To assess the structural model and test the hypothesis, two steps were necessary:

1. To assess the reliability of the core constructs, a Cronbach's Alpha reliability test was calculated to examine the consistency of the Likert scales. It is widely-accepted in the

social sciences that Alpha should be ≥ 0.7 for a set of items to be considered a valid scale [145].

Reliability is a measure of internal consistency. Hence, a consistent scale is one that would very likely produce similar results every time it is used, and all the questions that come under it are relevant to, and representative of that particular scale. For example: to measure the reliability of the Performance Expectancy scale (which is represented by more than one question, typically five to six), the resulting Alpha should be ≥ 0.7 for it to be internally consistent. To be precise, these questions together express Performance Expectancy well, and would give similar results every time they are asked [Tables 8, 21, and 31].

2. To examine the relationships amongst the Hypothesised Model's core constructs, a Spearman's correlation analysis was completed. Only the reliable constructs were included.

   Spearman's correlation coefficient (P or r_s) measures the strength of association between two ranked variables which are assumed to have a monotonic relationship. Namely, if the value of one variable increases, the value of the other variable increases too, **or** if the value of one variable increases, the value of the other variable decreases. However, the significance of Spearman correlation does not provide information about the strength of the relationship at all. Thus, a value of $P = 0.001$, for example, does not mean that the relationship is stronger than a value of $P = 0.04$. Instead, **to assess the strength of the relationship,** we could either look up the P value in special Spearman t-statistics tables in accordance to the available sample size, or IBM SPSS automatically does so and mark the significant values as (**Correlation is significant at the 0.01 level, and *Correlation is significant at the 0.05 level).

For example, we used a seven-point Likert scale ranging from (strongly disagree) to (strongly agree) to measure Effort Expectancy and Facilitating Conditions. These are ranked variables, where (1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree). Therefore, we could use the Spearman's correlation measure to explore how these two variables relate to each other. In other words, would the availability of certain Facilitating Conditions (such as: managerial involvement, sufficient training, helpdesk support, and/or the availability of a comprehensive manual) make the end-users think of the offered system as easy to use?

To illustrate this in numbers, in one of the studies, Facilitating Conditions has a significant relationship with Effort Expectancy (r_s=.502**, p=.0). This means, if the right facilitating conditions were provided, the end-users would indeed perceive the system as effortless. Ultimately, this would have an impact on their intention to use and accept the system [Tables 9, 22, and 32].

3.6.3 Principal Components Analysis (PCA)

A PCA measure was applied to test whether the hypothesised factor structure, in fact, fits the initial set of data. The PCA method was chosen **because** it is psychometrically comprehensive, but less complex than Factor Analysis [145]. PCA seeks to define clusters in the data (without making assumptions as to why these clusters might exist). In other words, it forms linear components within the data, and displays how a particular variable might contribute to that cluster [145].

Principle components are the underlying structure in the data. They are the directions where there is most variance, or where the data is most spread out. It produces clusters which can be deconstructed into eigenvalues (eigenvalues are numbers that indicate how much variance there is in the data cluster). Hence, the bigger the variation, the more information provided by the cluster.

What does PCA do? Assume there is a Hypothesised Model with a relevant questionnaire, these would be structured in a certain way to measure a certain outcome. They are usually arranged to meet the research purpose from a certain angle. But, what if these could be arranged differently? In other words, what if there is another viewpoint? This is the job of PCA; it just looks at the outcome from a different point of view, without changing the data.

Is UTAUT truly as structured as it looks like in the diagram? Is it surely composed of separate core constructs that are placed in their own boxes, or is there a different logic to it? To answer such questions, PCA would be very useful. For example, we understand why there is a core construct called Performance Expectancy, another called Effort Expectancy, and so on [Figure 5]. However, PCA could statistically rearrange all of these core constructs/data in a different order. There is usually a good reason why, but it needs to be worked out. Thus, PCA will produce eigenvalues, but it is up to the researcher to find and understand the underlying structure in the data (or the alternative logic).

This research study believes that a more holistic and inclusive approach should be embraced when designing and evaluating complex healthcare systems, and that social and technical factors are complementary to each other, if not inseparable. Therefore, PCA was applied to examine whether or not the UTAUT's core constructs would merge if statistically deconstructed in order to support this believe.

PCA is not one value, it is rather a multistep process. A few PCA Passes were needed for each study; the number of passes was actually guided by the percent of explained variance and the number of cross loadings needed to be discarded (this is detailed in 4.4, 5.4, and 6.4). The Kaiser-Mayer-Olkin (KMO) statistic is a value between 0 and 1, the closer to 1, the more distinct and reliable the cluster/factor is. For KMO to determine whether the PCA is useful, Kaiser, 1974 suggests to only accept values that are ≥ 0.6 [146]. While Hutcheson and Sofroniou, 1999 suggest that values between 0.5 and 0.7 are average, between 0.7 and 0.8 are good, between 0.8 and 0.9 are great, and above 0.9 are superb [147]. This research study considers Eigenvalues values that are ≥ 0.5.

To start with, the KMO values of the Hypothesised Model scales were calculated, and Eigenvalues values ≥ 0.5 were considered.

Next, the variables were reduced on the basis of their Eigenvalues, values < 0.5 were discarded. Yet, competing values which could be part of more than one cluster/factor, were considered part of the bigger one (i.e. taking their construct validity or the variable's strength of association to a specific factor into consideration).

After that, a reliability test was calculated to check the internal consistency of the resulting clusters/factors. Scale improvements were made, where necessary, in preparation to calculate the Spearman's correlations of the final outcome (hence, only the reliable scales were included) in addition to the remaining single variables (if any).

Finally, Spearman's correlations amongst the resulting clusters/factors were calculated.

3.6.4 Qualitative Data Analysis

We could only use a questionnaire instrument to collect data, however an open-ended question was added at the end of it for end-users to freely express their opinions, concerns, and suggestions with regards to the system itself. It also aimed to seek participants' feedback on the training session and the user-guide in an attempt to collect qualitative data for added value. However, only one study yielded a good amount of qualitative data on how the system could be improved. When analysed, three main themes emerged: Technical Aspects, Training and User-Guide Aspects, and Socio-Technical Aspects. For each theme, the comments were categorised as Supportive Opinions, Uncertain Opinions, and Recommendations (as presented in 4.5).

3.6.5 Other Possible Measures

Some technology acceptance studies used Partial Least Squares (PLS), which is part of the Structural Equation Modelling (SEM), for measuring the reliability of their model's constructs and then form correlations amongst them.

This measure is slightly more robust as detailed by Falk and Miler, 1992 [148], nevertheless it is still a comparable alternative to using Cranach's Alpha reliability and Spearman's correlations. Examples of using PLS are found in, but not limited to [136] [149]. However, this research study preferred the latter measures for the availability of expertise and guidance to confidently apply them.

3.7 Tested Systems Overview

The Hypothesised Model was tested on three allocated HIT systems, this section gives an overview of them.

3.7.1 Electronic Primary Care Research Network (ePCRN)

Recruiting patients into clinical research trials is a challenging task; a sufficient number of participants is required to establish a statistically adequate sample size for any interventional research study [150]. This is particularly challenging in the growing emphasis on double blind experimental designs to ensure that the findings are actually results of the trial and not of other factors. This need had initially led to the development of EHR, an example of a leading EHR project is the NPfIIT [64] [65] (as defined and discussed in Chapter 1 - 1.5.2).

EHR systems which are implemented in health science centres have been supporting research and generating greater evidence successfully (for example: Mayo Clinic). However, there has been a lack for systems that facilitate research in community practice settings [151].

Primary care and specialist centres differ in the type of potential research that they undertake, and consequently in the type of participants that they need to recruit. For example, individuals who are at risk of disease, with new diagnosis, or with complex co-morbidities are more likely to be found in primary care than specialist centres [152]. Moreover, the process of identifying study participants, recruiting them, following up with their progress, maintaining data about them, and standardizing interventions has been daunting for the small, scattered community practices that provide primary care [153]. Therefore, considerable efforts have been made across countries to organise groups of primary care practices into practice-based research networks [152] [154]. In addition, considerable efforts have been made to create standards for exchanging clinical information as well as facilitating its integration and aggregation **in both the US and Europe**. These developments have occurred in parallel to the rapid development of Internet technical standards and web services [155]. This implies that the technological challenges that relate to data sharing are, if not solved, then at least addressable using contemporary web-based technologies.

There are, of course, economic and technical issues which might prevent the widespread adoption of such technology, but this study is concerned with the perceived benefits that these technologies might provide to clinical researchers. I.e. if it is likely that clinical researchers do not perceive the benefit of having it, regard it as something which creates additional work for them without suitable return, or regard it as a threat to their work; then it is unlikely that they will accept it.

Despite the availability of EHR systems, accessing healthcare data for research purposes is not directly possible, there are tremendous issues with regards to systems integration and interoperability that have to be determined still.

This need had led to the development of the electronic Primary Care Research Network (ePCRN) in 2005. It is still a software prototype, actually one of twelve pilot projects funded by the US National Institutes of Health to develop clinical research [156] [157]. The project was a collaboration between the University of Minnesota, the University of Chicago, the University of California, the University of Birmingham (UK), and a number of practice-based research networks [Table 5]. It was built around open standards and open-source software, and piloted methods that could be operated internationally. Furthermore, an international consortium and model for sharing further ePCRN developments in the US and Europe was created [158]. In the West Midlands, UK, it specifically utilises the available EHRs to support searches, i.e. the patient records of the NHS GP systems at the primary care practice [151]. Such a system should have sophisticated tools that capture and preserve the rich medical context in the form of coded data, as well as business models in order to encourage stakeholders to use it [151]. It should also be secure and prevent any unauthorised access to medical data by registered end-users or external parties [151]; because patients' have a right to privacy and confidentiality.

This software prototype enables researchers to find patients who serve as potential recruits in clinical trials, over a secure infrastructure that links separate geographical sites for larger-scale research projects [159]. Yet, to preserve patients' privacy and confidentiality, it performs anonymous record counting and remote flagging without transferring any patient-level data out of the EHR system.

Table 5: ePCRN Collaborating Practice-Based Research Networks

Collaborating Networks
• American Academy of Family Physicians National Research Network (AAFP NRN) • Alabama Practice Based Research Network (APBRN) • Indiana Family Practice Research Network (INET) • USC Department of Family Medicine PBRN (LA Net) • Minnesota Academy of Family Physicians Research Network (MAFPRN) • Oklahoma Physicians Resource/Research Network (OKPRN) • Penn State Ambulatory Research Network (PSARN) • State Network of Colorado Ambulatory Practices & Partners (SNOCAP) • South Florida Primary Care Practice-Based Research Network (SoFlaPBRN) • South Texas Ambulatory Research Network (STARNET) • Upstate New York Practice Based Research Network (UNYNET)

Then, the EHR system reminds the onsite staff to approach the potentially eligible participants. It was built on the basis of requirements found to be necessary to conduct clinical studies through distributed electronic network coupled with EHRs [151]. A researcher can identify potential trial participants who have a specific eligibility criteria through a friendly Graphical User Interface (GUI). They could define clinical trial inclusion and exclusion measures such as: age, gender, clinical problems, lab tests, vital signs, and prescribed drugs [Figure 6]. In addition, there is currently a work agreement with the Heart of Birmingham Teaching Primacy Care Trust (HoB PCT) for the first set of patient records to be used by ePCRN. Nonetheless, technology acceptance has always been an issue, and a software prototype on the scale of ePCRN might face acceptance challenges. Would end-users trust it enough to run enquires given the sensitivity of the data they work with? Would they easily understand and embrace its innovative design? [Appendix A, B, and C].

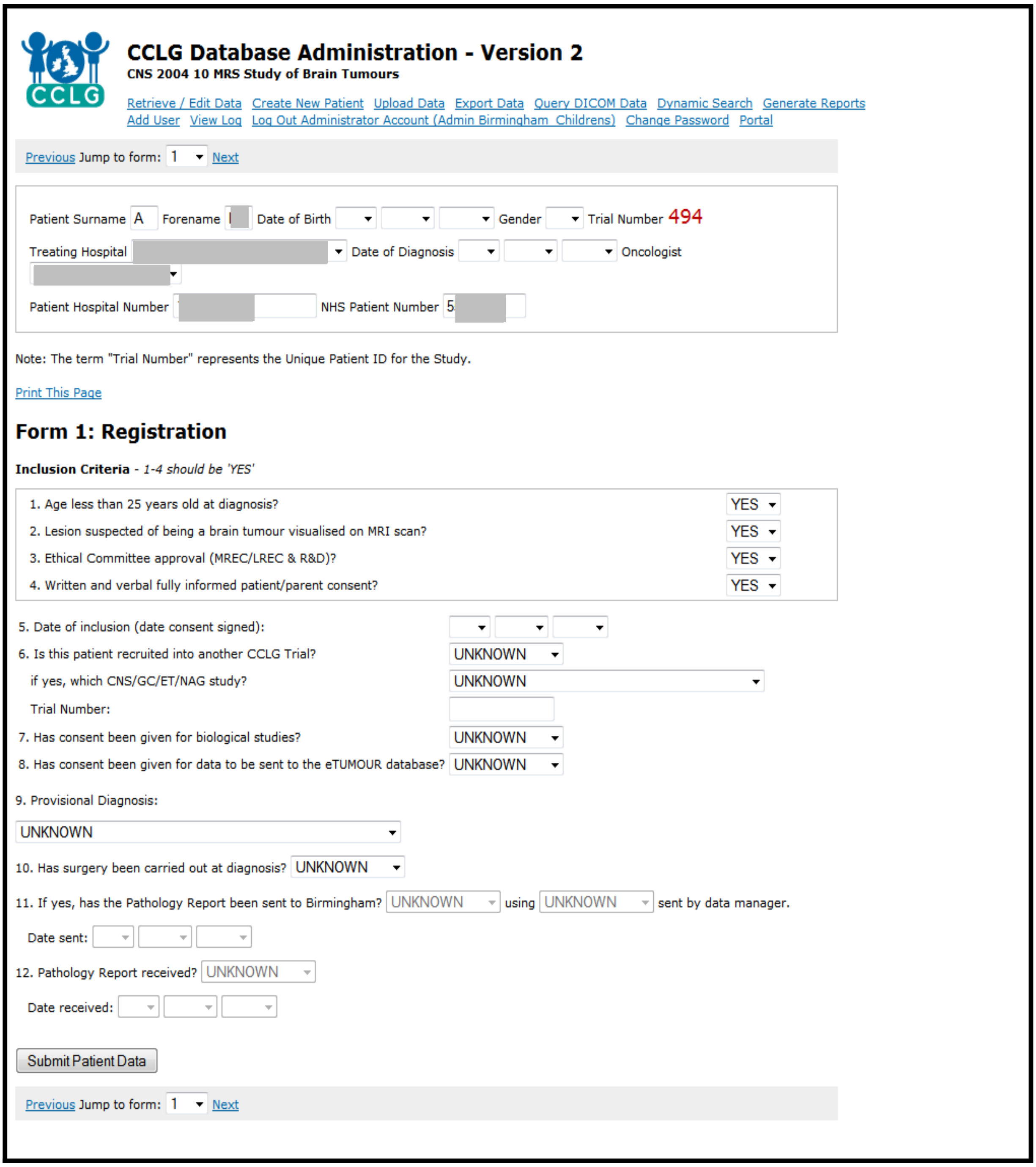
Figure 6: ePCRN Screenshot Sample

3.7.2 Remote Data Entry (RDE)

Despite the availability of EHR, accessing healthcare data for research purposes is **only** possible via a “middle system” because of the lack of interoperability. The Remote Data Entry system (RDE) was one of these middle systems, sponsored by Birmingham and the Black Country Comprehensive Local Research Network (BBC CLRN). Its aim is to provide a research-focused web-based electronic health record system, within the West Midlands (UK), for the Chronic Obstructive Pulmonary Diseases (COPD).

The main purpose of the system is for patients to be identified and enrolled into studies quicker. Moreover, it records episodes of patients’ care delivery such as: demographics, baseline data, clinic data, and data on other visits. This information was made more interoperable amongst the involved researchers and specialty areas by using standardised lists, terminology, and data items [Figure 7]. Version 1.0 went live in December 2012 and the final version was delivered in January 2013. A user-guide is available in the system itself, however the end-users were trained individually before using the live system [160] [161].

Even though RDE seems to be very helpful in concept, it would be favourable to assess it for acceptance in the early stages to make sure that it indeed delivers what it was developed for.


CCLG Database Administration - Version 2
CNS 2004 10 MRS Study of Brain Tumours
Retrieve / Edit Data Create New Patient Upload Data Export Data Query DICOM Data Dynamic Search Generate Reports
Add User View Log Log Out Administrator Account (Admin Birmingham Childrens) Change Password Portal

Previous Jump to form: 1 Next

Patient Surname A Forename Date of Birth Gender Trial Number 494
Treating Hospital Date of Diagnosis Oncologist
Patient Hospital Number NHS Patient Number 5

Note: The term "Trial Number" represents the Unique Patient ID for the Study.

Print This Page

Form 1: Registration

Inclusion Criteria - *1-4 should be 'YES'*

1. Age less than 25 years old at diagnosis?	YES
2. Lesion suspected of being a brain tumour visualised on MRI scan?	YES
3. Ethical Committee approval (MREC/LREC & R&D)?	YES
4. Written and verbal fully informed patient/parent consent?	YES

5. Date of inclusion (date consent signed):	
6. Is this patient recruited into another CCLG Trial?	UNKNOWN
if yes, which CNS/GC/ET/NAG study?	UNKNOWN
Trial Number:	
7. Has consent been given for biological studies?	UNKNOWN
8. Has consent been given for data to be sent to the eTUMOUR database?	UNKNOWN

9. Provisional Diagnosis:
UNKNOWN

10. Has surgery been carried out at diagnosis? UNKNOWN

11. If yes, has the Pathology Report been sent to Birmingham? UNKNOWN using UNKNOWN sent by data manager.

Date sent:

12. Pathology Report received? UNKNOWN

Date received:

Submit Patient Data

Previous Jump to form: 1 Next

Figure 7: RDE Screenshot Sample

3.7.3 Data Quality Tool (DQT)

Similar to the previous systems, the problems associated with recruiting patients into clinical research trials had led to the start of **a vast multimillion project in Europe called TRANSFoRm** [162]. The project started on 1st March 2010 and was completed by 31 May 2015. It is mostly sponsored by the European Union (EU), and will benefit twenty-two establishments, mostly educational and research focused in the UK, Ireland, Germany, Malta, Netherlands, Sweden, Poland, Belgium, France, and Greece*.

TRANSFoRm utilises the existing international foundations in clinical trial information models such as: BRIDG and PCROM; data standards and semantic interoperability approaches that are service-based such as: ISO11179 and controlled vocabulary, data discovery, machine learning, and open-standards electronic health records (openEHR) [162]. This technology should support the identification and follow up of research participants in primary care settings. It should also preserve patients' safety while improving the European conduct and volume of clinical research [163].

One of TRANSFoRm's deliverables is the Data Quality Tool System (DQT). The difficulty of recruiting patients into clinical research trials is well-known, however this is not the only hurdle that stands in the way of a successful study. There is also the quality of the available raw data on which the findings and conclusions are based. Not all available databases contain research-worthy data to begin with, therefore a great amount of time and effort could be wasted, sometimes before a researcher stumbles on this issue. As a result, the DQT was created to give information that would help a researcher decide whether or not a particular study is feasible depending on the quality of the available database itself. Feasibility

* For more information about TRANSFoRm, please visit the referenced website. It is very extensive and covers the project's overview, objectives, work packages and their lead persons, advisory board, beneficiaries, management, disseminations, demonstration videos, ontologies and models, news, and contact details.

is measured in terms of the source's data content (i.e. does this database contain data which is complete, correct, accurate, and consistent to run a specific study?).

The functionality of the DQT could be summarised in the following steps:

1. At logging in, a map of all available databases in their respective countries is displayed along with background information including: contact and database owner details. At this stage , databases can be chosen based on very general requirements, including the availability of: patient consent, physical examination data, lifestyle data, medication data, lab results, genetic markers, linkability to genetic data, linkability to cancer registry, linkability to drug registry, linkability to hospital registry, and/or linkability to population registry. Based on these requirements, a collection of databases is displayed on the next screen.
2. A collection of obtainable databases is displayed along with information on the quality of their basic data elements with regards to their completeness, correctness, accuracy, and consistency (if available). This information is still general and about the database itself, separate from any predefined study.
3. Practices that satisfy the needs of an end-user can now be selected. Then, the study can be defined along with the population and time period specifications. For example: Diabetes and GORD.
4. A visual output of the data elements associated with that specific study will be displayed on the monitor, giving the end-user an overall idea about the quality of the data that they will be working with [Figure 8]. These data elements are predefined, but there are slide bars for the researcher to apply quality criteria more or less strictly.

Hence, end-users could be informed immediately about the number of available practices and patients available.

5. The task concludes with one of three options*: Save Search Query, Save Selection,* or *Request Patients' Records.*

This methodology might seem very complicated to use, but actually it is not. However, end-users tend to adopt certain attitudes before they have even tried a given system (these could be positive or negative), and could influence behaviour accordingly. Therefore, it would be good practice to demonstrate the system, give them a chance to explore it, and assess it for acceptance in the early stages.

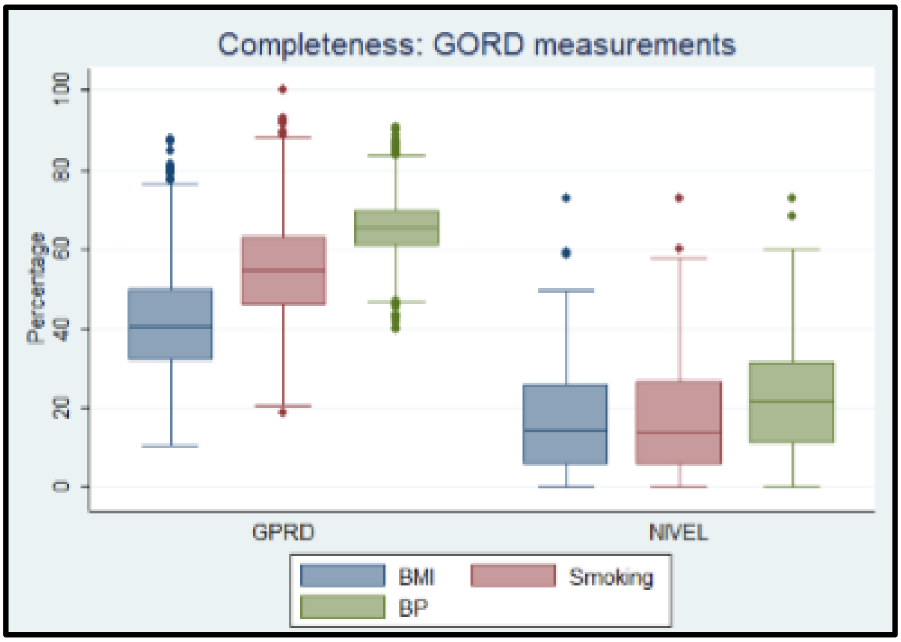


Figure 8: DQT Screenshot Sample (Tests and Lifestyle Measures for Different Coding Categories)

3.8 Conclusion

On the basis of the methodology discussed in this chapter, the three following chapters will present the detailed findings of this research study (Chapters 4, 5, and 6).

CHAPTER 4: STUDY 1

Electronic Primary Care Research Network (ePCRN)

This chapter discusses the research findings of the ePCRN study. It describes the collected data, as well as the application of descriptive statistics, structural model assessment, and PCA analysis in detail.

4.1 Data Collection

Data were collected through questionnaires submitted to participants after running a carefully designed ninety-minute training session [Appendix A and B]. The rationale for the time limit, it should be explained here that the session did not exceed ninety minutes owing to the participants' busy schedules; in addition, most participants needed permission to take part in the study. Nevertheless, the session had to be comprehensive enough to demonstrate the features of the software prototype.

The training session started with a very basic search enquiry, then it gradually progressed in terms of specificity [Appendix C]. For a start, the participants were asked to define **Age** and **Gender**. Next, they were asked to add **Clinical Problems** such as: "Diabetes" and they could choose a more specific condition such as: "Diabetes Mellitus". Finally, they were asked to add **Included Lab Tests** such as: "Blood Count" and they could choose a more specific test like: "Complete Blood Count".

Firstly, by introducing such a gradual scenario, the participants got to understand what the system is capable of whilst exploring its menus and buttons at the same time.

Secondly, the trainer went through the first few items of the user-guide, and then encouraged the participants to complete the rest of the exercise on their own. However, they were allowed to seek assistance throughout if / when necessary.

To test ePCRN, a total of five sessions took place between January and February 2012; one in Belgium and four in the UK[†]. The added core constructs in this study were: Technology Anxiety and Adaptation Timeline [Tables 3 and 4] [Figure 5]. Sixty-one questionnaires were collected, four were disregarded for being incomplete (i.e. n = 57). The Belgium participants were recruited through the University of Antwerp, and the UK participants were recruited through Queen Elisabeth Hospital Birmingham. Their backgrounds or specialities collectively covered: primary care (64.9%), epidemiology (3.5%), biomedical informatics (3.5%), primary care research (14%), and primary care clinical trials (14%).

4.2 Descriptive Statistics

Two measures of descriptive analysis were calculated. One to depict the participants' demographics, and another to examine the end-users' level of satisfaction with the system.

4.2.1 Participants' Demographics Profile

Data feedback was collected from a total of 57 participants, (37%) were Male and (63%) were Female. The participants' ages varied between (20 and 62+) years, yet the age group (38-43) had the highest rate at (23%) in comparison with the other age groups [Table 6].

[†] The ePCRN is a collaboration between the US and Europe.

Most participants were Primary Care specialists as they make up (65%) of the sample, but not everyone had experience in clinical research; in point of fact, only (79%) were experienced. Within the experienced group, (42%) had between (1 and 6) years of experience.

Most of the participants took part in the study voluntarily as (84%) answered that they were willing to try and explore the ePCRN system because it might be helpful for them in the future.

Table 6: Sample Demographics Profile (n=57)

Variable	Content	Frequency	Percent
Gender	Male	21	37%
	Female	36	63%
Age Group	(20-25)	3	5%
	(26-31)	11	19%
	(32-37)	6	11%
	(38-43)	13	23%
	(44-49)	3	5%
	(50-55)	8	14%
	(56-61)	12	21%
	(62+)	1	2%
Clinical Specialty or Background	Primary Care	37	65%
	Epidemiology	2	4%
	Biomedical Informatics	2	4%
	Primary Care Research	8	14%
	Primary Care Clinical Trials	8	14%
Previous Experience in Clinical Research	-	-	-
No	(0) Year(s)	12	21%
Yes	(1-6) Years	24	42%
	(7-12) Years	7	12%
	(13-18) Years	7	12%
	(19-24) Years	4	7%
	(25-30) Years	3	5%
Total No	-	12	21%
Total Yes	-	45	79%
Participant's Willingness to Use the System	Yes	48	84%
	No	2	4%
	To some extent	7	12%

4.2.2 Core Constructs' Frequency Tables

Frequencies were calculated to examine the end-users' level of satisfaction with the system. The frequency analysis provided a rich understanding of the participants' perceptions of ePCRN. The observed rates on the (Performance Expectancy, Effort Expectancy, Facilitating Conditions, Technology Anxiety, Adaptation Timeline, and Behavioural Intention) are in agreement with the Hypothesised Model. The participants answered "Agree" to at least five of the six questions asked within each core construct [Table 7]. Therefore, the overall outcome of the model indicates agreement with the future acceptance and utilisation of the system (as a tool of query generation and eligibility criteria capture for clinical trials). However, the reported frequency rates on Social Influence seemed to reflect uncertainty. The participants answered "Not Sure" to four out of the six questions asked within this core construct. This might indicate that the ePCRN concept might not be fully supported within the traditional clinical research settings. It might also indicate a lack of organisational encouragement [164].

Table 7: ePCRN Frequency Table

Questions Asked	Frequency in %							
Performance Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I expect the system to improve my work performance	4	0	4	19	**44**	21	9	100
I expect the system to be efficient	2	0	0	7	**40**	33	18	100
I expect the system to increase my productivity	2	0	7	23	**30**	26	12	100
I expect the system to help me acquire transferable skills	2	0	4	28	**51**	12	4	100
I expect the system to give me better control over my work	2	0	5	26	**42**	12	12	100
Overall, I expect the system to technically perform well	2	0	0	12	**39**	26	21	100
Effort Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I found it easy to access data through the system	0	0	2	12	**54**	28	4	100
I found the available data format clear	0	0	2	11	**63**	21	4	100

Questions Asked	Frequency in %							
I was able to easily identify relevant data	0	0	4	19	**54**	19	4	100
I found it smooth to interact with the system	0	0	7	21	**49**	21	2	100
I think the system has a good presentation and outline	0	0	7	11	**61**	16	5	100
Overall, the system is easy to use	0	2	2	21	**53**	19	4	100
Social Influence	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I was encouraged to use the system by my superiors	12	9	14	**40**	18	5	2	100
I was pressurized to use the system by my superiors	26	11	28	**32**	4	0	0	100
There has been good communication with my superiors/colleagues to try the system	4	2	18	**44**	23	11	0	100
I was given a demonstration on how the system works	2	0	9	7	**32**	19	32	100
There is an “open door” policy to discuss aspects related to the system	2	0	0	32	**44**	16	7	100
Overall, my organization supports this change initiative	2	0	5	**47**	19	14	12	100
Facilitating Conditions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
The manual and/or training session was comprehensive enough	0	0	9	16	**46**	21	9	100
I could imagine using the system to conduct my routine work	0	2	7	9	**53**	16	14	100
The availability of more complex and extensive search criteria was mentioned	0	0	4	12	**51**	25	9	100
The steps which the system follows were logical to use, apply, and recall	0	2	5	5	**54**	23	11	100
The offered manual and/or training session covered all essential tasks and provided help on how to overcome difficult ones	0	5	14	**33**	30	14	4	100
Overall, the facilitating conditions to use the system were sufficient	0	2	4	28	**47**	16	4	100
Technology Anxiety	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I am open for -dramatic- changes in my work habits if necessary	0	0	5	21	**56**	12	5	100
I am likely to become (or I consider myself) technology-oriented due to the nature of my field	0	2	9	19	**44**	16	11	100
I had prior knowledge of the need to use health Information Technology in my job	0	0	7	7	**42**	23	21	100
My computer experience will help me put this system into use	0	0	2	14	**35**	28	21	100
Generally, I would be more comfortable with new systems if trained in advanced	0	0	2	9	**37**	25	28	100

Questions Asked	Frequency in %							
Overall, I am not that anxious about using technology	5	0	4	5	35	**37**	14	100
Adaptation Timeline	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I had adequate time to get trained on using the system	5	0	**28**	26	**28**	11	2	100
I received sufficient information and/or training during this time	2	0	21	28	**37**	9	4	100
I had enough time to get used the system environment	2	4	19	**33**	30	7	5	100
If the system became available, I think I would be able to improve the quality of my work immediately	0	0	4	28	**42**	23	4	100
I think I would be confident enough to carry out clinical trials by the help of this system right away if it becomes available	0	2	2	25	**46**	19	7	100
Overall, I think I will be allowed enough time to get into the habit of using this system if it becomes available	0	2	2	26	**47**	16	7	100
Behavioral Intention	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I intend to learn as much as I can about the system (or I intend to learn how to use the system to the best of my abilities)	0	0	4	25	**54**	11	7	100
I intend to use the system as often as needed to perform my work	0	0	4	18	**53**	19	7	100
I intend to promote the system to my colleagues (if it became available for broader use)	2	0	2	26	**44**	18	9	100
I intend to suggest ideas for further improvements (or to further enhance) the system to the developers if I thought of any	0	0	0	21	**44**	19	16	100
I intend to do more research studies if the system proved to substantially facilitate so	4	0	4	28	**39**	18	9	100
Overall, I intend to put this system into full use if it became available	0	0	2	23	**44**	18	14	100
1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree.								

4.3 Structural Model Assessment

To assess the structural model and test the hypothesis, the reliability of the core constructs were assessed first. Then, the relationships amongst the Hypothesised Model core constructs were examined.

4.3.1 Scale Reliability

It is widely-accepted in the social sciences that Alpha should be ≥ 0.7 for a set of items to be considered a valid scale [145]. All of the Likert scales that represent the Hypothesised Model variables appear to have a good degree of reliability (their Cronbach's Alpha was ≥ 0.7), except for the Social Influence which scored 0.6 [Table 8]. However, this measure was improved to 0.7 by deleting question (4.4 I was given a demonstration on how the system works). It is proposed that removing this question is permitted because of the variation in the manner in which the system had been introduced to the participants in the different settings. Some participants had only been given one demonstration at the data collection session, while others had attended presentations before then.

Table 8: Reliability Analysis of the Likert Scales (n=57)

Model Construct	Cronbach's Alpha	Number of Items
Performance Expectancy	0.9	6
Effort Expectancy	0.9	6
[Social Influence	0.6	6]
Social Influence* (deleted 4.4)	0.7	5
Facilitating Conditions	0.8	6
Technology Anxiety	0.7	6

Model Construct	Cronbach's Alpha	Number of Items
Adaptation Timeline	0.8	6
Behavioural Intention	0.9	6
* Enhanced scale		

4.3.2 Spearman's Correlations

The values of the core constructs were calculated from the questionnaire according to a ranked seven-point Likert scale ranging from (strongly disagree) to (strongly agree), where (1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree). Then, Spearman's Correlations were calculated to assess the existing relationships amongst the scales, only the reliable scales were included (refer to 3.6.2 (2) for extra details). A summary of Spearman's Correlation analysis is shown in [Table 9] and demonstrated in [Figure 9].

A total of sixteen significant positive relationships were found. The UTAUT Model suggests a positive relationship between Behavioural Intention and Performance Expectancy, and the data supports this with significance (r_s=.600**, p=0). Behavioural Intention also has significant relationships with Facilitating Conditions (r_s=.298*, p=.025), Technology Anxiety (r_s=.394**, p=.002), and Adaptation Timeline (r_s=.509**, p=.0). This means that the Behavioural Intention to accept ePCRN and utilise it in the future potentially requires end-users who perceive it as useful, know that they will be allowed enough time to completely master it, and are not generally anxious about change. Moreover, the right facilitating conditions such as: the availability of a comprehensive manual and/or training sessions should be put in place.

Furthermore, interesting results were found relating to the newly introduced core constructs. The Adaptation Timeline construct displays remarkable results as it has significant relationships with all the other core constructs, including: Behavioural Intention (r_s=.509**, p=.0), Performance Expectancy (r_s=.527**, p=0), Effort Expectancy (r_s=.374**, p=.004), Social Influence (r_s=.443**, p=.001), Facilitating Conditions (r_s=.565**, p=0), and Technology Anxiety (r_s=.346**, p=.008). Besides that, the Technology Anxiety construct shows significant relationships with Behavioural Intention (r_s=.394**, p=.002), Performance Expectancy (r_s=.351**, p=.007), and Facilitating Conditions (r_s=.326*, p=.013). These correlations add to the understanding of healthcare professionals and give leads on the critical importance of the Adaptation Timeline and Technology Anxiety constructs when introducing new HIT systems. Consequently, these two constructs need to be balanced out. Creating a scenario where end-users who are already overwhelmed with work, and would have to deal with change at the same time should be avoided; it would potentially lead to increasing anxiety, and therefore increasing the risk of system underutilisation or rejection too. Instead, the management should make an effort to create suitable circumstances for end-users to receive sufficient ePCRN training.

In addition, the Facilitating Conditions construct has significant relationships with Performance Expectancy (r_s=.362**, p=.006), Effort Expectancy (r_s=.502**, p=.0), and Social Influence (r_s=.457**, p=.0). This means that besides the availability of the right facilitating conditions, having positive feelings for or a general positive attitude towards ePCRN by the leading individuals involved would potentially accentuate end-users' perception of its usefulness and effortlessness.

Likewise, the Social Influence construct has significant relationships with Performance Expectancy (r_s=.555**, p=.0) and Effort Expectancy (r_s=.407**, p=.002). This means that the Social Influence construct could potentially be used to inspire end-users' perception of ePCRN's usefulness and effortlessness.

Table 9: Spearman's Correlations of the Likert Scales (n=57)

		PE	EE	SI	FC	TA	AT	BI
PE	Correlation Coefficient	1						
	Sig. (2-tailed)	.						
EE	Correlation Coefficient	0.195	1					
	Sig. (2-tailed)	0.146	.					
SI	Correlation Coefficient	.555**	.407**	1				
	Sig. (2-tailed)	0	0.002	.				
FC	Correlation Coefficient	.362**	.502**	.457**	1			
	Sig. (2-tailed)	0.006	0	0	.			
TA	Correlation Coefficient	.351**	0.206	0.107	.326*	1		
	Sig. (2-tailed)	0.007	0.123	0.428	0.013	.		
AT	Correlation Coefficient	.527**	.374**	.443**	.565**	.346**	1	
	Sig. (2-tailed)	0	0.004	0.001	0	0.008	.	
BI	Correlation Coefficient	.600**	0.105	0.199	.298*	.394**	.509**	1
	Sig. (2-tailed)	0	0.436	0.137	0.025	0.002	0	.

**Correlation is significant at the 0.01 level (2-tailed); and *Correlation is significant at the 0.05 level (2-tailed).

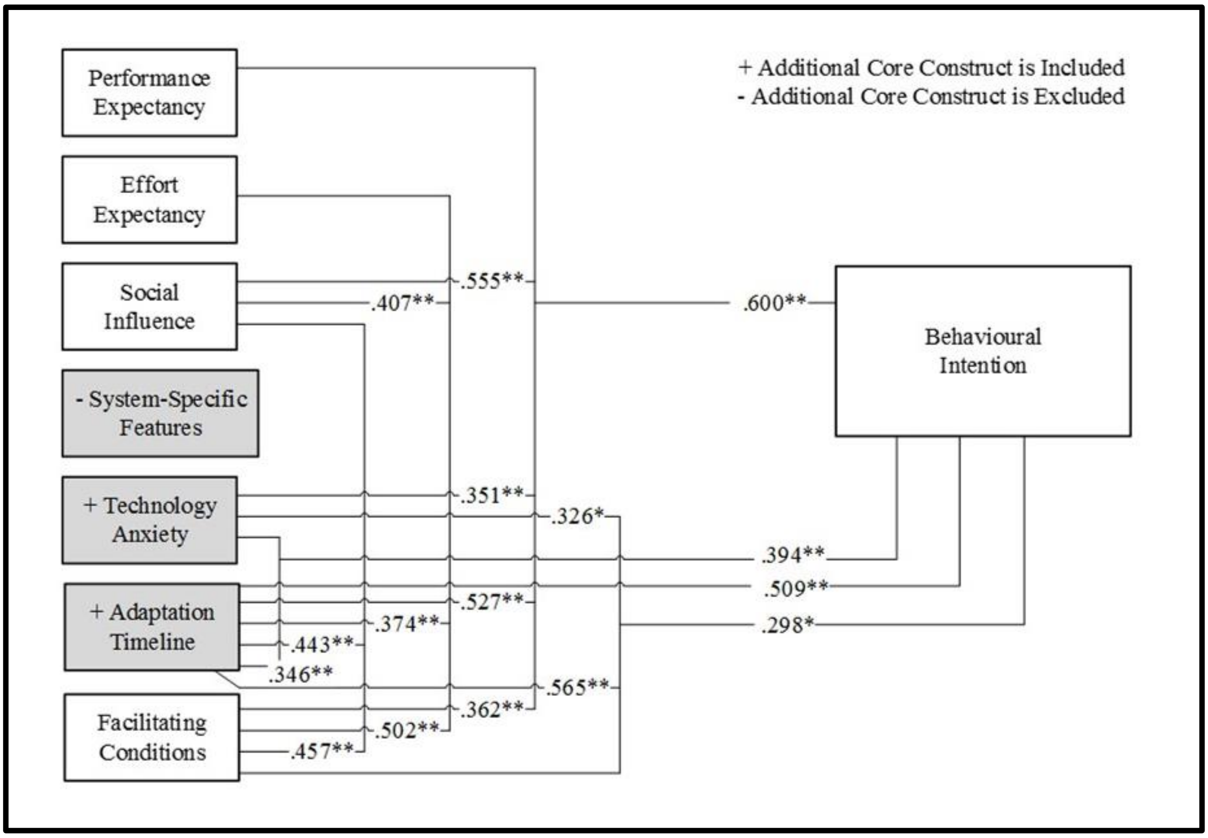


Figure 9: Spearman's Correlations of the Hypothesised Model (n=57)

4.4 PCA Analysis

PCA was applied to test whether the hypothesised factor structure, in fact, fits the initial set of data. Four steps were followed to complete the process as explained below. A number of passes was necessary, and Eigenvalues ≥ 0.5 were considered in each to statistically reduce the questions whilst maintaining a high percent of explained variance.

4.4.1 PCA of the Hypothesised Scales

In the first step, the KMO and Bartlett's values of the Hypothesised Model scales were calculated. The total cumulative variance in the Usage Intention explained by the Hypothesised Model has increased to (76%) in comparison with (70%) in the original UTAUT [2] [Table 10].

Table 10: PCA (KMO and Bartlett's Tests of the Hypothesised Model's Scales)

Model Construct	KMO	Bartlett's Test for Sphericity		
		Approx. Chi-square	df	Sig.
Performance Expectancy	.7	169.7	15	.000
Effort Expectancy	.8	186.6	15	.000
Social Influence	.5	85.2	15	.000
Facilitating Conditions	.7	116.8	15	.000
Technology Anxiety	.7	81.2	15	.000
Adaptation Timeline	.7	150.2	15	.000
Behavioural Intention	.8	164.4	15	.000
All Variables	.5	1962.5	861	.000
Variables (without Technology Anxiety and Adaptation Timeline)	.6	1222.0	435	.000
Total Cumulative Variance Explained	76%			
Total Cumulative Variance Explained (without Technology Anxiety and Adaptation Timeline)	76%			

4.4.2 Variable Reduction

In the second step, five PCA Passes were calculated in order to assess whether the ranked seven-point Likert scale questions asked can be statistically reduced in a way that maintains a high percent of explained variance. The number of passes was guided by the percent of explained variance in each pass, and by the number of cross loadings which needed to be discarded**. Pass 2** appears to have the highest total variance explained (it is only marginally higher than Pass 1) [Table 11].

Table 11: PCA Passes

Pass#	Total Variance Explained
Pass 1	75.696%
Pass 2	**75.751%**
Pass 3	71.290%
Pass 4	62.733%
Pass 5	65.410%

PCA had statistically rearranged all of the ranked seven-point Likert scale questions (into different member questions according to an alternative logic). It did so by tracing an alternative logic, different to that suggested by the Hypothesised Model, which depended on the collected data (without changing it). Thus, the reduction of member questions was completed on the basis of their Eigenvalues. Eigenvalues values ≥ 0.5 were considered, while Eigenvalues values < 0.5 as well as cross loadings were discarded. This process was repeated in five passes until 22 questions were arrived to. These are the questions which PCA suggests explain the biggest variance (the bigger the variation, the more information provided by the resulting factor) [Table 12].

Table 12: PCA Components Matrix of Pass 2

Discard	Question#	Factors							
		1	2	3	4	5	6	7	8
	2.2	0.585	0.089	0.032	-0.409	0.146	0.443	-0.305	-0.069
	2.3	0.581	0.385	-0.044	-0.491	0.201	0.199	0.01	-0.003
	2.5	0.618	0.292	0.045	-0.291	0.149	0.313	-0.008	-0.062
	3.1	0.689	-0.231	0.223	-0.01	0.241	-0.157	0.131	-0.204
	3.2	0.396	-0.674	0.319	0.117	-0.016	0.108	0.17	0.025
	3.3	0.419	-0.583	0.303	0.095	0.357	0.049	0.131	-0.258
X	3.4	0.523	-0.51	0.017	-0.142	0.159	-0.312	0.156	-0.024
X	3.5	0.522	-0.578	0.301	-0.015	0.08	-0.054	-0.228	0.263
	3.6	0.701	-0.424	0.216	0.019	0.117	-0.098	-0.185	0.213
	4.4	0.323	-0.011	0.028	0.016	-0.413	0.591	0.317	0.278
	4.5	0.543	-0.128	0.282	-0.269	-0.378	0.104	-0.02	-0.198
	4.6	0.669	-0.012	-0.024	-0.308	-0.361	-0.024	-0.134	-0.28
	5.1	0.724	-0.344	-0.015	-0.003	-0.244	-0.115	-0.151	0.081
	5.2	0.617	0.415	0.088	-0.055	-0.261	-0.346	0.138	-0.177
	5.4	0.696	-0.339	0.145	-0.012	-0.141	0.009	-0.224	0.109
	5.6	0.391	-0.214	-0.545	0.242	-0.18	0.038	-0.258	0.322
X	6.2	0.464	0.415	-0.028	0.483	0.094	0.063	-0.328	0.014
	6.3	0.461	0.219	0.272	0.573	-0.145	-0.039	0.084	-0.284
	6.4	0.476	0.377	0.152	0.546	-0.106	0.198	0.101	-0.052
X	6.6	-0.025	-0.044	0.432	0.417	0.482	0.297	0.114	0.102
X	7.1	0.508	-0.126	-0.678	0.025	0.243	-0.055	-0.087	-0.094
X	7.2	0.632	-0.244	-0.581	0.119	0.175	0.024	0.11	-0.1
X	7.3	0.502	-0.175	-0.689	0.175	0.134	0.143	0.21	0.041
X	7.4	0.434	0.475	0.052	-0.336	0.175	0.01	0.406	0.144
	7.5	0.526	0.434	0.321	0.077	-0.107	-0.214	0.002	0.373
	7.6	0.573	0.154	-0.091	0.094	-0.149	-0.115	0.4	0.225
	8.1	0.159	0.713	0.146	-0.126	0.305	-0.028	-0.082	0.147
	8.3	0.622	0.379	-0.121	-0.043	0.095	-0.328	0.255	0.095
	8.4	0.508	0.455	-0.123	0.31	-0.081	0.149	-0.122	-0.305
	8.5	0.356	0.57	0.101	0.048	0.17	-0.196	-0.396	0.073
Gray cells indicate member questions where Eigenvalues values ≥ 0.5 X indicate discarded questions where Eigenvalues values < 0.5 or have cross loadings									

Finally, the factors and their member questions were detailed [Table 13]. The ePCRN questionnaire originally had 42 ranked seven-point Likert scale questions [Appendix B]. However, at this particular step of the analysis, the PCA only reserved 22 questions, which we roughly grouped under 5 alternative factors. These might be further reduced in the following steps.

Table 13: Factors and Member Questions

Factors and Member Questions
Factor 1: Performance Expectancy
2.2 I expect the system to be efficient
2.3 I expect the system to increase my productivity
2.5 I expect the system to give me better control over my work
3.1 I found it easy to access data through the system
3.6 Overall, the system is easy to use
4.5 There is an “open door” policy to discuss aspects related to the system
4.6 Overall, my organization supports this change initiative
5.1 The manual and/or training session was comprehensive enough
5.2 I could imagine using the system to conduct my routine work
5.4 The steps which the system follows were logical to use, apply, and recall
7.5 I think I would be confident enough to carry out clinical trials by the help of this system right away if it becomes available
7.6 Overall, I think I will be allowed enough time to get into the habit of using this system if it becomes available
8.3 I intend to promote the system to my colleagues
8.4 I intend to suggest ideas for further improvements to the system developers if I thought of any
Factor 2: Effort Expectancy
3.2 I found the available data format clear
3.3 I was able to easily identify relevant data
8.1 I intend to learn as much as I can about the system
8.5 I intend to do more research studies if the system proved to substantially facilitate so
Factor 3: Facilitating Conditions
5.6 Overall, the facilitating conditions to use the system were sufficient
Factor 4: Technology Anxiety
6.3 I had prior knowledge of the need to use health Information Technology in my job
6.4 My computer experience will help me put this system into use
Factor 6: Social Influence
4.4 I was given a demonstration on how the system works

4.4.3 Factors' Reliability

In the third step, a reliability test was calculated to check the internal consistency of the factors produced by Pass 2. This was done in preparation to calculate the Spearman's correlations of the final outcome. Hence, only the reliable factors were included (where Cronbach's Alpha was ≥ 0.7), in addition to the remaining single-item ones (number 5.6 and 4.4) [Table 14].

Table 14: Reliability Analysis of the Factors (n=57)

Model Construct	Cronbach's Alpha	Number of Items	Improved Reliability
Factor 1 (Performance Expectancy)	.9	14	-
Factor 2 (Effort Expectancy)	.1	4	Cannot be Improved
Factor 3 (Facilitating Conditions)	Not Applicable	1	-
Factor 4 (Technology Anxiety)	.8	2	-
Factor 6 (Social Influence)	Not Applicable	1	-
Gray indicated excluded scale for being unreliable			

4.4.4 Factors' Correlations

In the fourth and final step, Spearman's correlations were calculated amongst the factors as summarised in [Table 15] and demonstrated in [Figure 10]. Factor 1 (Performance Expectancy) appears to be the biggest and most central one, as all the other factors have significant positive relationships with it. It correlates with Factor 3 (r_s=.313*, p=.018), Factor 4 (r_s=.484**, p=0), and Factor 6 (r_s=.394**, p=.002). This means that end-users' Behavioural

Intention to accept and utilise ePCRN is impacted by four vital factors, including: Performance Expectancy, Technology Anxiety, Facilitating Conditions, and Social Influence (although the latter two are single-item Factors).

Table 15: Spearman's Correlations of the Factors (n=57)

		Factor 1	**Factor 3 (5.6)**	**Factor 4**	**Factor 6 (4.4)**
Factor 1	Correlation Coefficient	1			
	Sig. (2-tailed)	.			
Factor 3 (5.6)	Correlation Coefficient	.313*	1		
	Sig. (2-tailed)	0.018	.		
Factor 4	Correlation Coefficient	.484**	0.173	1	
	Sig. (2-tailed)	0	0.199	.	
Factor 6 (4.4)	Correlation Coefficient	.394**	0.141	0.226	1
	Sig. (2-tailed)	0.002	0.295	0.091	.
**Correlation is significant at the 0.01 level (2-tailed); and *Correlation is significant at the 0.05 level (2-tailed).					

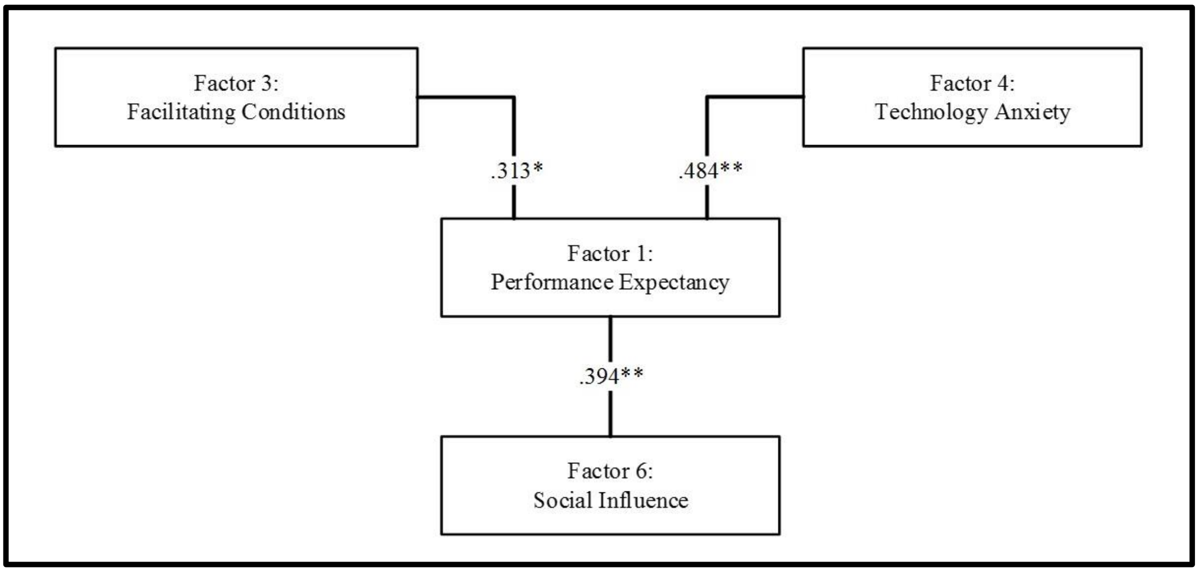


Figure 10: Spearman's Correlations of the Factors (n=57)

4.5 Qualitative Data Analysis

The open-ended question that was added at the end of the questionnaire collected some valuable qualitative data. When analysed, three main themes emerged: Training and User-Guide Aspects, Technical Aspects, and Socio-Technical Aspects. For each theme, the comments were categorised as Supportive Opinions, Uncertain Opinions, and Recommendations [Tables 16, 17, and 18].

Table 16: Training and User-Guide Aspects

	Training and User-Guide Aspects
Supportive Opinions	- The session was interesting, useful, and good as an overview of the system. - The trainers who delivered the session were helpful and had a friendly approach. - Using the system will become easier with more practice, but at the moment it is not making me feel anxious.
Uncertain Opinions	- One demonstration is not sufficient to answer the questionnaire reliably. - This is not a typical training session as it is not extensive. - Probably more training will be required for users to feel confident. - Not sure if further training will be available.
Recommendations	- The users would need a longer training session and a more detailed user-guide. - If this system became available, I would need more in depth training where I could bring examples of what I would like to search for. - In such sessions, feedback should be given to the GPs to prevent them from feeling over qualified over the other participants. - Include nurse students in the study.

Table 17: Technical Aspects

	Technical Aspects
Supportive Opinions	- The system has an excellent concept. The more populated it becomes, the more useful it will be. It is fairly simple, easy to use and follow, comprehensive, and would be a useful tool to identify patients who meet the inclusion/exclusion criteria of clinical trial studies. It would boost patients' recruitment in primary care research. - The user-interface was clear, well presented, and user-friendly. - The ability to type into all fields is helpful. - Defining queries is particularly interesting; actually the strength of the system lays in the controlled-vocabulary search option which looks into clinically coded data using different types of clinical coding systems. Nevertheless, further tweaking, expanding, and development is needed to achieve its full potential.
Uncertain Opinions	- The system is slow as it takes a long time to log on, run searches, and allocate results. - The layout is crowded and the main buttons do not stand out. - The system is not user-friendly, as it stands at the moment, which makes it difficult for busy end-users, such as GPs, to learn
Recommendations	- The system needs further tweaking and expansion so that it becomes more useful. - The navigation could become much better if included a "wizard" feature and showed instructions along the way. Add navigation buttons such as: **back**, **forward**, and **exit** on the main windows; in addition to **previous**, **next**, and **finish,** on each section. - The status bar could be more accurate in displaying progress and time left. - The buttons of the system should stand out and be clearly labelled. It would also be helpful if some "hover-on button descriptions" were given to remind the users which button does what. - When it comes to the "Age Field", typing a number should be allowed as it is quicker than scrolling up and down. Additionally, since there are some patients who are over 100 years of age these days, please permit entering numbers which are >100. - The system might benefit from the possibility to look for potential participants within a specific timeframe (as in between two dates). - For primary care, additional selection criteria might be of interest including: social background (for instance: low income), a non-medication therapy (such as: physiotherapy or dietary requirements), smoking and/or drinking habits, the availability of end of life testimony, incidents, prevalent conditions, signs, and symptoms. - It is important to implement a way which insures that all patients who are dead or no longer available at a practice are excluded. - When the search is complete, it would be interesting to see brief anonymous profiles or overviews of the available patients. - Once the system is ready for deployment, please do not make it become a pop-up system.

Table 18: Socio-Technical Aspects

	Socio-Technical Aspects
Supportive Opinions	- I can see that the system has a huge potential for primary care research. It can make it more feasible and turnaround time on all trials. However, all powers need to be on board for this to actually happen. - I am convinced of the possibilities. - I can see myself using the system for my studies as it would save time and lower costs. - I attended the session because I have an interest in knowing about new systems although I am not involved in research at the moment. - It looks like a fantastic system for countries with good clinical coding practice and informatics. - If the system could cope with more complex searches -other than those presented in the training session-, I would look forward to making use of it. - I had some issues, but nothing that I could not overcome. - Web-based tools do make the daily work easier in terms of transferring data and epidemiology information. However, all GPs must improve their clinical coding skills so that searching for conditions returns better results --especially since this system's strength is in the controlled-vocabulary search.
Uncertain Opinions	- Not sure if I will personally use this system, I need to think about it a bit. - I cannot see this becoming widely available in the near future. It would appear to have the same potential as EMIS Web which I find more user-friendly in comparison. - Not sure how it would work alongside the present system (EMIS Web) which is currently used at health centres. - This will only have added value for collaborating GPs. - In Belgium, the GPs tend to be very weak when it comes to the clinical coding of their diagnosis; therefore looking for coded criteria will be difficult for them.
Recommendations	- Excellent potential, but the practice side needs to be right too. - The quality of the input is the most important and delicate matter when it comes to using a system likes this one. Therefore, GPs who are taking part in research networks need support to improve their coding knowledge so their input of clinical data would be accurate.

4.6 Discussion

The correlation analysis of the added core constructs partially agrees with the Hypothesised Model [Figure 5]. The observed significant correlations between (Performance Expectancy, Facilitating Conditions, Technology Anxiety, and Adaptation Timeline) and (Behavioural Intention) are predicted by the Hypothesised Model. Hence, all of these core constructs have an impact on healthcare professionals' Behavioural Intention and therefore their actual use of HIT [Table 9] and [Figure 9]. Consequently, the decision makers should pay attention to putting the right facilitating conditions and training sessions in place in order to increase the likelihood of system acceptance and utilisation. However, Effort Expectancy and Social Influence did not indicate significant correlations with Behavioural Intention. Maybe these two core constructs are perceived as less important in the presence of a system that really delivers what healthcare professionals need. Therefore, they would not mind if it was slightly difficult to use nor pay too much attention to organisational encouragement. The individuals' drive to change seem to rather be a result of being positive about the system and willing to change the way things are done in favour of better outcomes. Perhaps it is all attributable to their own open-mindedness, flexibility, and skilfulness indeed.

A comparison was completed between the hypothesised scales and the PCA Factors to understand what they have in common, where they differ, and why there were dissimilarities. On one hand, it is argued that composite variables "measure complex concepts more adequately than single indicators, extend the range of scores available and are more efficient at handling multiple items" [165]. The Hypothesised Model in this study has seven hypothesised scales which are essentially Likert, independent, and composite variables (i.e. measured on the basis of multiple data items). Their member questions were balanced as they ranged between five and six items, the matter that makes them easy to interpret. In addition, when they were tested for reliability, they all scored ≥ 0.7, apart from Social Influence which was then improved to 0.7 [Table 8]. Moreover, there were sixteen significant correlations amongst these scales [Figure 9].

Conversely, the PCA revealed three Likert, independent, and composite factors and two single-item factors. Only two of the composite factors were reliable (Factor 1 and Factor 4), and one was unreliable (Factor 2) [Table 14]. The numbers of their member questions were not very balanced as they ranged between two and fourteen items [Table 13]. Nevertheless, Factor 1 (Performance Expectancy) showed significant correlations with all the other factors [Table 15] and [Figure 10]. No other significant correlations were found amongst the rest of the factors.

On the other hand, there is a striking similarity in principal between Factor 1 (Performance Expectancy) and most of the hypothesised core constructs (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and Adaptation Timeline). Unsurprisingly, Factor 1 captures the fundamental ideas which form most of the hypothesised core constructs at once, it actually includes between two and three questions of each construct (apart from Technology Anxiety which stands as a factor on its own). This observation calls into question the assumption of UTAUT that there are separate constructs/factors when, in fact, they all collapse into a single component. While it is not unusual for the first component of a PCA to contain many variables, the fact that the UTAUT's core constructs all correlate could be concerning. Therefore, having a diagram in which the separate components are presented in their own boxes with correlations shown on the links might be misleading, at least, in this particular study [Figures 9 and 10]. Nonetheless, the validated questions that inform UTAUT seem to be realistic and enlightening for the healthcare practice.

The discrepancy between the hypothesised scales and the PCA Factors might be explained by the nature of the health professionals' field of work, where using new technologies is mostly helpful and their computer skills are sufficient. Yet, the change process itself could be interruptive, and that is why Technology Anxiety and Adaptation Timeline were added in the Hypothesised Model. Moreover, the observed differences might be rooted at the modern end-users' holistic perception of useful change, and how it will be facilitated and supported.

Finally, although the total explained variance was exactly the same for both the original UTAUT and Hypothesised Models (76%) [Table 10], the initial PCA analysis contained ten out of twelve questions asked within the Technology Anxiety and Adaptation Timeline core constructs (6.2, 6.3, 6.4, 6.6, 7.1, 7.2, 7.3, 7.4, 7.5, and 7.6) [Table 12]. Even though the final member questions were statistically reduced further in the next step, the influence of the remaining questions was seamlessly incorporated within the final output (7.5, 7.6, 6.3, and 6.4) [Table 13]. This indicates the importance of these concepts for this particular study.

4.7 Conclusion

This research study has met its aim of presenting a Hypothesised Model that suits the healthcare practice. The Hypothesised Model was empirically tested using the ePCRN software prototype, and the added core constructs (Technology Anxiety and Adaptation Timeline) seem to have been a valuable addition. The explained total cumulative variance of the Hypothesised Model has improved to (76%), which is better than the original UTAUT's at (70%). **In other words,** the Hypothesised Model has the capacity to predict end-users' intentions as to whether or not they would want to use the ePCRN prototype (up to 76%).

CHAPTER 5: STUDY 2

Remote Data Entry (RDE)

This chapter discusses the research findings of the RDE study. It describes the collected data, as well as the application of descriptive statistics, structural model assessment, and PCA analysis in detail.

5.1 Data Collection

Prior to data collection, e-mail correspondence was established with the potential participants about the evaluation study and its purposes. Then, data were collected through online questionnaires uploaded on Survey Monkey [166] [Appendix D]. The participants have already been individually trained and using the RDE system for approximately nine months. Moreover, a detailed user-guide was already written by the system developers.

The user-guide started with a basic “form filling” task, followed by a few “data editing” suggestions. Then, a number of “dynamic searching” scenarios were presented so that end-users get to know the main features of the system. The dynamic searching task led to trying a range of “viewing patients’ records” options afterwards. Finally, the user-guide concluded by explaining the “file uploading” feature in detail.

The added core constructs in this study were: RDE-Specific Features and Technology Anxiety [Tables 3 and 4] [Figure 5]. Thirty questionnaires were collected, nine of them were disregarded for being incomplete (i.e. n = 21). The participants of the RDE Study were recruited through Queen Elisabeth Hospital Birmingham. Their backgrounds or specialities covered: study or trial coordinator (19%), data manager (28.6%), researcher or research fellow (33.3%), data analyst (4.8%), neuroradiologist (4.8%), oncologist (4.8%), and psychologist (4.8%).

5.2 Descriptive Statistics

Two measures of descriptive analysis were calculated. One to depict the participants' demographics, and another to examine the end-users' level of satisfaction with the system.

5.2.1 Participants' Demographics Profile

Data feedback was collected from a total of 21 participants. Their ages varied from (20 to 55) years; yet the age groups (32-37) and (44-49) reported the highest rate at (23.8%) with five participants in each, compared to the other age groups.

The Female participants represented (71.4%) of the sample size in comparison with the male participants (28.6%). Moreover, the majority of participants were either Researchers / Research Fellows as they make up (33.3%) of the sample. In addition, most of the participants had previous experience in conducting clinical research (66.7%). Within the experienced group (52.4%) had between (1 and 5) years of experience, and (14.3%) had between (6 and 10) years of experience.

Most of the participants were using RDE voluntarily because they thought it might improve their work performance (81.0%) [Table 19].

Table 19: Sample Demographics Profile (n=21)

Variable	Content	Frequency	Percent
Gender	Male	6	28.6%
	Female	15	71.4%
Age Group	20-25	2	9.5%
	26-31	3	14.3%
	32-37	5	23.8%
	38-43	3	14.3%
	44-49	5	23.8%
	50-55	3	14.3%
Clinical Specialty or Background	Study/Trial Coordinator	4	19.0%
	Data Manager	6	28.6%
	Research Fellow/Researcher	7	33.3%
	Data Analyst	1	4.8%
	Neuroradiology	1	4.8%
	Oncologist	1	4.8%
	Psychologist	1	4.8%
Previous Experience in Clinical Research	-	-	-
No	0	7	33.3%
Yes	1-5	11	52.4%
	6-10	3	14.3%
Total Yes	-	14	66.7%
Participant's Willingness to Use the System	Yes	17	81.0%
	No	0	0.0%
	To Some Extent	2	9.5%
	Not Sure	2	9.5%

5.2.2 Core Constructs' Frequency Tables

Frequencies were calculated to examine the end-users' level of satisfaction with the system. The frequency analysis provided a rich understanding of the participants' perceptions of RDE. The observed rates on the (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, System-Specific Features, Technology Anxiety, and Behavioural Intention) are in agreement with the Hypothesised Model. The participants answered "Agree" or "Very Much Agree" to at least three out of the five (or eight) questions asked within each core construct [Table 20]. Therefore, the overall outcome of the model indicates agreement with the future acceptance and utilisation of the system (as a tool of electronic archiving and querying medical data to conduct clinical trials). It is also worth to stress the reported frequency rates on the System-Specific Features, these seemed to reflect strong support for RDE, where the participants answered “Very Much Agree” to four out of the eight questions asked within this core construct, and “agree” to another two questions.

Table 20: RDE Frequency Table

Questions Asked	Frequency in %							
Performance Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I find the system useful in my job, especially when entering and searching data	5	0	0	14	**57**	10	14	100
Using the system enables me to complete tasks on a quicker pace	5	0	10	**33**	29	14	10	100
Using the system increases my productivity	5	0	5	**43**	19	19	10	100
Using the system improves the quality of my work	5	0	5	33	**38**	5	14	100
Overall, the system fits well with the way I work and the service I provide	5	0	10	19	**43**	14	10	100
Effort Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Interacting with the system has been user-friendly, clear, and understandable	0	10	5	5	**52**	24	5	100
Learning to operate the system has been easy for me and did not take a long time	0	0	14	5	**43**	29	10	100
I found it easy to become skilful at using the system (for example: applying extensive and/or particular search enquiries)	0	0	19	**33**	29	14	5	100
The system facilitates my daily job	5	0	19	24	**38**	5	10	100
I believe that interacting with the system does not mentally exhaust me	0	0	5	19	**48**	14	14	100
Social Influence	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
My managers/supervisors encourage me to use the system	5	0	10	14	**43**	10	19	100
The long-term benefits of using the system inspire me to use it	0	0	5	29	**43**	19	5	100
Within my organization, the management usually communicates their plans of introducing new systems to the staff	0	0	5	19	**57**	14	5	100

Questions Asked	Frequency in %							
Within my organization, the management usually offers sufficient training when new systems are introduced	0	0	14	19	**52**	10	5	100
Overall, the use of healthcare information technology in my workplace is very important	0	0	0	5	33	**38**	24	100
Facilitating Conditions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
The manual or training/help option was/is comprehensive enough	0	0	10	14	**52**	19	5	100
The use of the system is smooth (no technical errors)	5	5	5	14	**38**	33	0	100
The steps followed by the system are logical to use, apply, and recall	0	0	5	14	**52**	19	10	100
If I got stuck, a sufficient reference or resource is available to help me out	0	0	5	14	**43**	29	10	100
The system is easily accessible, responds to queries promptly, and does not disturb my daily routine	5	5	5	5	**48**	24	10	100
System-Specific Features	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
RDE forms: the number of steps to enter clinical data into forms is reasonable	0	0	10	**38**	29	19	5	100
Data entry into RDE forms: it is important to enter complete and reliable data	0	0	0	19	19	**33**	29	100
RDE edit: editing data on the system is more consistent than editing it on paper	0	0	0	**33**	24	19	24	100
RDE dynamic search: searching the system is better and quicker than searching papers	0	0	0	24	24	**29**	24	100
RDE dynamic search: querying clinical data is prompt enough	0	0	5	24	24	**29**	19	100
RDE querying function: querying DICOM data is prompt enough	0	0	5	29	**33**	19	14	100
Data viewing: the system is better than the paper forms; it gives a holistic view of patients' data as well as specific records	0	0	0	24	24	**33**	19	100
RDE upload function: the upload of files is quick enough	0	0	0	38	**43**	14	5	100
Technology Anxiety	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Generally, I like to keep up with new information technology	0	0	10	5	29	**43**	14	100
I am open for -dramatic- changes in my work habits if necessary	0	0	0	0	33	**43**	24	100
I am likely to become (or I consider myself) technology-oriented due to the nature of my field	0	0	0	5	**38**	**38**	19	100

Questions Asked	Frequency in %							
If I were given enough time and sufficient resources to absorb change, I am likely to accept it	0	0	0	0	33	**38**	29	100
Overall, I am not that anxious about using technology	0	0	5	0	24	**38**	33	100
Behavioural Intention	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I intend to learn as much as I can about the system (or I intend to learn how to use the DQT System to the best of my abilities)	0	0	0	0	**57**	19	24	100
I intend to use the system as often as needed (to perform my work)	0	0	0	0	**57**	19	24	100
I intend to promote the system to my colleagues (if it became available for broader use)	0	0	0	14	**48**	19	19	100
I intend to suggest ideas for further improvements (or to further enhance) the system to the developers if I thought of any	0	0	0	10	**57**	14	19	100
I prefer to use the system because data can be better preserved, archived, shared, manipulated, and searched electronically	0	0	0	10	**48**	33	10	100
1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree.								

5.3 Structural Model Assessment

To assess the structural model and test the hypothesis, the reliability of the core constructs were assessed first. Then, the relationships amongst the Hypothesised Model core constructs were examined.

5.3.1 Scale Reliability

All of the Likert scales that represent the Hypothesised Model variables appear to have a good degree of reliability (their Cronbach's Alpha was ≥ 0.7) [Table 21].

Table 21: Reliability Analysis of the Likert Scales (n=21)

Model Construct	Cronbach's Alpha	Number of Items
Performance Expectancy	1	5
Effort Expectancy	0.9	5
Social Influence	0.7	5
Facilitating Conditions	0.9	5
System-Specific Features	0.9	8
Technology Anxiety	0.9	5
Behavioural Intention	1	5

5.3.2 Spearman's Correlations

The values of the core constructs were calculated from the questionnaire according to a ranked seven-point Likert scale ranging from (strongly disagree) to (strongly agree), where (1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree). Then, Spearman's correlations were calculated to examine the relationships amongst the scales (refer to 3.6.2 (2) for extra details). A summary is shown in [Table 22] and demonstrated in [Figure 11].

A total of seventeen significant positive relationships were found. **Behavioural Intention has significant relationships with all the core constructs**: Performance Expectancy (r_s=.741**, p=.000), Effort Expectancy (r_s=.813**, p=.000), Social Influence (r_s=.678**, p=.001), Facilitating Conditions (r_s=.606**, p=.004), System-Specific Features (r_s=.692**, p=.001), and Technology Anxiety (r_s=.665**, p=.001). This supports the Hypothesised Model as all of the core constructs appear to have an impact on the Behavioural Intention of the healthcare professionals to use RDE.

Furthermore, interesting results were found relating to all the newly introduced core constructs. The System-Specific Features construct displays remarkable results as it has significant relationships with all the other core constructs, including: Performance Expectancy (r_s=.447*, p=.042), Effort Expectancy (r_s=.784**, p=.000), Social Influence (r_s=.517*, p=.016), and Facilitating Conditions (r_s=.705**, p=.000). Besides that, the Technology Anxiety construct has one significant relationship with Effort Expectancy (r_s=.468*, p=.032), indicating that the more anxious the end-user is, the more difficult they perceive the system to be. These correlations add to the understanding of the healthcare professionals' attitude towards custom designed HIT systems like RDE, especially when they are satisfied with the system and believe that it delivers what they need.

In addition, the Facilitating Conditions construct has significant relationships with Performance Expectancy (r_s=.651**, p=.001), Effort Expectancy (r_s=.849**, p=.000), and Social Influence (r_s=.641**, p=.002). This means that having the right Facilitating Conditions would help the end-users to perceive the system as useful, effortless, and potentially make them more open to get inspired by their colleagues.

Likewise, the Social Influence construct has significant relationships with both Performance Expectancy (r_s=.620**, p=.003) and Effort Expectancy (r_s=.534*, p=.013). This means that the effect of Social Influence could possibly be useful to inspire end-users' perception of RDE's usefulness and effortlessness.

Finally, the Effort Expectancy construct has one significant relationship with Performance Expectancy (r_s=.754**, p=.000). This might be an indication that if the end-users' perceive the system as useful, then they are likely to think of it as effort free compared to having no system at all.

Table 22: Spearman's Correlations of the Likert Scales (n=21)

		PE	EE	SI	FC	SF	TA	BI
PE	Correlation Coefficient	1.000						
	Sig. (2-tailed)	.						
EE	Correlation Coefficient	.754**	1.000					
	Sig. (2-tailed)	.000	.					
SI	Correlation Coefficient	.620**	.534*	1.000				
	Sig. (2-tailed)	.003	.013	.				
FC	Correlation Coefficient	.651**	.849**	.641**	1.000			
	Sig. (2-tailed)	.001	.000	.002	.			
SF	Correlation Coefficient	.447*	.784**	.517*	.705**	1.000		
	Sig. (2-tailed)	.042	.000	.016	.000	.		
TA	Correlation Coefficient	.259	.468*	.266	.207	.371	1.000	
	Sig. (2-tailed)	.258	.032	.243	.367	.098	.	
BI	Correlation Coefficient	.741**	.813**	.678**	.606**	.692**	.665**	1.000
	Sig. (2-tailed)	.000	.000	.001	.004	.001	.001	.

**Correlation is significant at the 0.01 level (2-tailed); and *Correlation is significant at the 0.05 level (2-tailed).

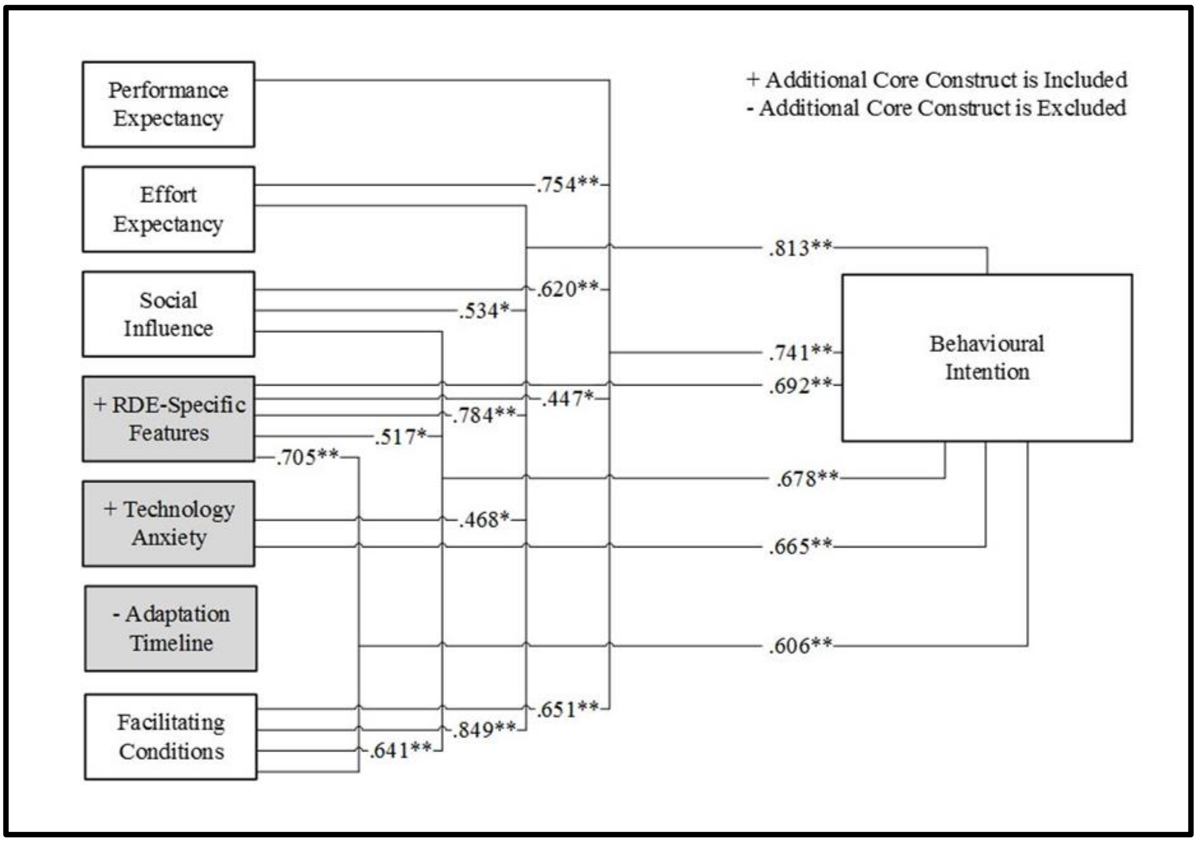


Figure 11: Spearman's Correlations of the Hypothesised Model (n=21)

5.4 PCA Analysis

PCA was applied to test whether the hypothesised factor structure, in fact, fits the initial set of data. Four steps were followed to complete the process as explained below. A number of passes was necessary, and Eigenvalues ≥ 0.5 were considered in each to statistically reduce the questions whilst maintaining a high percent of explained variance.

5.4.1 PCA of the Hypothesised Scales

In the first step, the KMO and Bartlett's values of the Hypothesised Model scales were calculated. The total cumulative variance in the Usage Intention explained by the Hypothesised Model has increased to (86%) in comparison with (70%) in the original UTAUT [2] [Table 23].

Table 23: PCA (KMO and Bartlett's Tests of the Hypothesised Model's Scales)

Model Construct	**KMO**	**Bartlett's Test for Sphericity**		
		Approx. Chi-square	**df**	**Sig.**
Performance Expectancy	.8	137.9	10	.000
Effort Expectancy	.7	74.2	10	.000
Social Influence	.5	24.7	10	.006
Facilitating Conditions	.7	58.9	10	.000
RDE-Specific Features	.7	135.2	28	.000
Technology Anxiety	.8	63.0	10	.000
Behavioural Intention	.9	105.1	10	.000
Total Cumulative Variance Explained	86%			
Total Cumulative Variance Explained (without RDE-Specific Features and Technology Anxiety)	83%			

5.4.2 Variable Reduction

In the second step, three PCA Passes were calculated in order to assess whether the ranked seven-point Likert Scale questions asked can be statistically reduced in a way that maintains a high percent of explained variance. The number of passes was guided by the percent of explained variance in each pass, and by the number of cross loadings needed to be discarded. **Pass 1** appears to have the highest total variance explained [Table 24].

Table 24: PCA Passes

Pass#	Total Variance Explained
Pass1	**86.172%**
Pass2	84.626%
Pass3	85.314%

PCA had statistically rearranged all of the ranked seven-point Likert scale questions (into different member questions according to an alternative logic). It did so by tracing an alternative logic, different to that suggested by the Hypothesised Model, which depended on the collected data (without changing it). Thus, the reduction of member questions was completed on the basis of their Eigenvalues. Eigenvalues values ≥ 0.5 were considered, while Eigenvalues values < 0.5 as well as cross loadings were discarded. This process was repeated in three passes until 30 questions were arrived to. These are the questions which PCA suggests explain the biggest variance (the bigger the variation, the more information provided by the resulting factor) [Table 25].

Table 25: PCA Components Matrix of Pass 1

Discard	Question#	Factors						
		1	2	3	4	5	6	7
	2.1	0.805		-0.478				
X	2.2	0.744		-0.513				

Discard	Question#	Factors						
	2.3	0.784		-0.421				
	2.4	0.83		-0.462				
	2.5	0.871						
	3.1	0.841	-0.319			-0.314		
	3.2	0.89						
	3.3	0.679			-0.384		-0.313	
	3.4	0.774		-0.435				
	3.5	0.755			0.416			
	4.1	0.497				0.684		
	4.2	0.675		-0.337				0.358
	4.3	0.414			0.411		0.63	
X	4.4	0.469			0.486	0.418	0.408	
	4.5	0.456	0.476					-0.5
	5.1	0.781						
	5.2	0.726						
	5.3	0.885						
X	5.4	0.402	-0.385		0.415	0.347	-0.388	
X	5.5	0.779	-0.534					
X	6.1	0.555			0.552			
X	6.2	0.624		0.624				
	6.3	0.715		0.397				
	6.4	0.781		0.425				
	6.5	0.674		0.466	-0.397			
X	6.6	0.585		0.5	-0.477			
	6.7	0.748		0.425				
	6.8	0.58			0.372	-0.351		0.424
X	7.1	0.614	0.4		-0.313	-0.509		
	7.2	0.455	0.658					
	7.3		0.843					
	7.4		0.802					
	7.5	0.338	0.84					
	8.1	0.791	0.377	0.305				
	8.2	0.818						
	8.3	0.859	0.304					
	8.4	0.824						
	8.5	0.884						
Gray cells indicate member questions where Eigenvalues values ≥ 0.5 X indicate discarded questions where Eigenvalues values < 0.5 or have cross loadings								

Finally, the factors and their member questions were detailed [Table 26]. The RDE questionnaire originally had 38 ranked seven-point Likert scale questions [Appendix D]. However, at this particular step of the analysis, the PCA only reserved 30 questions, which we roughly grouped under 5 alternative factors. These might be further reduced in the following steps.

Table 26: Factors and Member Questions

Factors and Member Questions
Factor 1: Performance Expectancy
2.1 I find the RDE System useful in my job, especially when entering and searching data
2.3 Using the RDE System increases my productivity
2.4 Using the RDE System improves the quality of my work
2.5 Overall, the RDE System fits well with the way I work and the service I provide
3.1 Interacting with the RDE System has been user-friendly, clear, and understandable
3.2 Learning to operate the RDE System has been easy for me and did not take a long time
3.3 I found it easy to become skilful at using the RDE System (for example: applying extensive and/or particular search enquiries)
3.4 The RDE System facilitates my daily job
3.5 I believe that interacting with the RDE System does not mentally exhaust me
4.2 The long-term benefits of using the RDE System inspire me to use it
5.1 The manual is comprehensive enough
5.2 The use of the RDE System is smooth (no technical errors)
5.3 The steps followed by the system are logical to use, apply, and recall
6.3 RDE edit: editing data on the system is more consistent than editing it on paper
6.4 RDE dynamic search: searching the system is better and quicker than searching papers
6.5 RDE dynamic search: querying clinical data is prompt enough
6.7 Data viewing: the system is better than the paper forms; it gives a holistic view of patients’ data as well as specific records
6.8 RDE upload function: the upload of files is quick enough
8.1 I intend to learn how to use the RDE System to the best of my abilities
8.2 I intend to use the RDE System as often as needed to perform my work
8.3 I intend to promote the RDE System to my colleagues if it became available for broader use
8.4 I intend to suggest ideas to further enhance the RDE System if I had any
8.5 I prefer to use the RDE System because data can be better preserved, archived, shared, manipulated, and searched electronically

Factors and Member Questions
Factor 2: Technology Anxiety
7.2 I am open to change my work habits if necessary
7.3 I consider myself technology-oriented due to the nature of my job
7.4 If I were given enough time and sufficient resources to absorb change, I am likely to accept it
7.5 Overall, I am not anxious about using information technology
Factor 5: Social Influence
4.1 My managers/supervisors encourage me to use the RDE System
Factor 6: Communication
4.3 Within my organization, the management usually communicates their plans of introducing new systems to the staff
Factor 7: HIT Importance
4.5 Overall, the use of healthcare information technology in my workplace is very important

5.4.3 Factors' Reliability

In the third step, a reliability test was calculated to check the internal consistency of the factors produced by Pass 1. This was done in preparation to calculate the Spearman's correlations of the final outcome. Hence, only the reliable factors were included (where Cronbach's Alpha was ≥ 0.7), in addition to the remaining single-item ones (number 4.1, 4.3, and 4.5) [Table 27].

Table 27: Reliability Analysis of the Factors (n=21)

Model Construct	Cronbach's Alpha	Number of Items
Factor 1 (Performance Expectancy)	1	23
Factor 2 (Technology Anxiety)	.9	4
Factor 5 (Social Influence)	Not Applicable	1
Factor 6 (Communication)	Not Applicable	1
Factor 7 (HIT Importance)	Not Applicable	1

5.4.4 Factors' Correlations

In the fourth and final step, Spearman's correlations were calculated amongst the factors as summarised in [Table 28] and demonstrated in [Figure 12]. Only two significant positive relationships were found. Factor 1 (Performance Expectancy) correlates with Factor 6 (Communication) (r_s=.463*, p=.035). This means that good communication amongst the stakeholders would help the end-users perceptions of the system's usefulness. Moreover, Factor 2 (Technology Anxiety) correlates with Factor 7 (HIT Importance) (r_s=.471*, p=.031). This indicates that the more important a specific piece of technology to a workplace is perceived to be (RDE in this study), the more anxious the end-users will be about utilising it.

Table 28: Spearman's Correlations of the Factors (n=21)

		F1	F2	F5 (4.1)	F6 (4.3)	F7 (4.5)
F1	Correlation Coefficient	1				
	Sig. (2-tailed)	.				
F2	Correlation Coefficient	0.388	1			
	Sig. (2-tailed)	0.082	.			
F5 (4.1)	Correlation Coefficient	0.426	0.22	1		
	Sig. (2-tailed)	0.054	0.338	.		
F6 (4.3)	Correlation Coefficient	.463*	-0.024	0.052	1	
	Sig. (2-tailed)	0.035	0.918	0.823	.	
F7 (4.5)	Correlation Coefficient	0.428	.471*	0.419	0.107	1
	Sig. (2-tailed)	0.053	0.031	0.059	0.643	.
**Correlation is significant at the 0.01 level (2-tailed); and *Correlation is significant at the 0.05 level (2-tailed).						

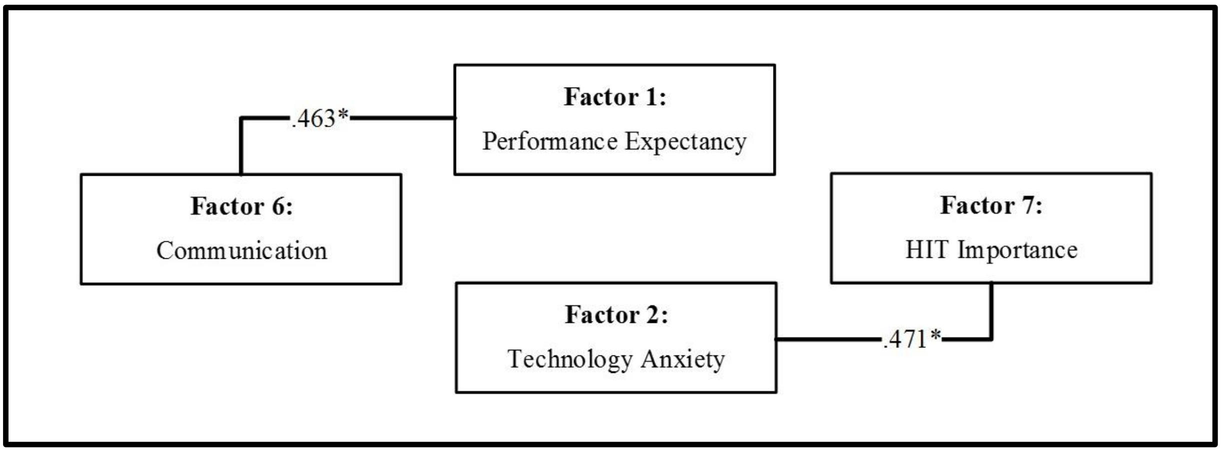


Figure 12: Spearman's Correlations of the Factors (n=21)

5.5 Discussion

The correlation analysis of the added core constructs fully agrees with the Hypothesised Model [Figure 5]. The observed significant correlations between all of the core constructs, including (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, RDE-Specific Features, and Technology Anxiety) and (Behavioural Intention) are predicted by the Hypothesised Model. Hence, all of the core constructs have an impact on healthcare professionals' Behavioural Intention and therefore their actual use of HIT [Table 22] and [Figure 11]. Consequently, the decision makers should pay attention to this range of aspects when planning to acquire a new HIT such as RDE. These core constructs are not purely technical, they are rather socio-technical. So, there is a need to understand the technical, social, and organisational aspects within a given environment before putting any facilitating conditions and training sessions in place. It is through this understanding that the transition from old work habits to new ones would be smoothly facilitated.

A comparison was done between the hypothesised scales and the PCA Factors to understand what they have in common, where they differ, and why there were dissimilarities.

On one hand, the Hypothesised Model has seven hypothesised scales which are essentially Likert, independent, and composite variables (i.e. measurements based on multiple data items). Their member questions were balanced as they ranged between five and eight items, the matter that makes them easy to interpret. In addition, when they were tested for reliability, they were all reliable as they scored ≥ 0.7 [Table 21]. Moreover, there were seventeen significant correlations amongst these scales [Figure 11].

Conversely, the PCA Factors revealed two likert, independent, and composite factors and three single-item factors. Both composite factors were reliable (Factor 1 and Factor 2) [Table 27], however their correlations showed only two significant relationships [Figure 12].

On the other hand, there is a striking similarity in principal between Factor 1 (Performance Expectancy) and most of the hypothesised core constructs (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and RDE-Specific Features). Unsurprisingly, Factor 1 captures the fundamental ideas which form most of the hypothesised core constructs at once, it actually includes between one and five questions of each construct (apart from Technology Anxiety which stands as a factor on its own) [Table 26]. This observation disproves of UTAUT in terms of it assuming that there are separate constructs/factors when, in fact, they all collapse into a single component. Therefore, having a diagram in which the separate components are presented in their own boxes with correlations shown on the links might be misleading, at least, in this particular study [Figures 11 and 12]. The discrepancy between the hypothesised scales and the PCA Factors might be explained by the nature of the health professionals' field of work, where using new technologies is mostly helpful and their computer skills are sufficient. Nonetheless, the validated questions that inform UTAUT seem to be realistic and enlightening for the healthcare practice, and they have served this study very well.

In other words, new technologies and/or computer systems **will not** necessarily be always resisted. Instead, if their functionality was highly needed to deliver demanding daily tasks more efficiently, then they are likely to be welcomed. The Hypothesised Model appears to have pinpointed two additional and very relevant scales for assessing end-users' system acceptance and predicting their future use (RDE-Specific Features and Technology Anxiety).

Finally, the total explained variance was (83%) for the original UTAUT Model and (86%) for the Hypothesised Model [Table 23]. Moreover, the initial PCA analysis contained all of the thirteen questions asked within the RDE-Specific Features and Technology Anxiety core constructs (6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 7.1, 7.2, 7.3, 7.4, and 7.5) [Table 25]. Even though the final member questions were statistically reduced to nine in the next step, the influence of the remaining questions was seamlessly incorporated within the final output (6.3, 6.4, 6.5, 6.7, 6.8, 7.2, 7.3, 7.4, and 7.5) [Table 26]. This indicates the importance of these concepts for this particular study.

5.6 Conclusion

This research study has met its aim of presenting a Hypothesised Model that suits the healthcare practice. The Hypothesised Model was empirically tested using the RDE system, and the added core constructs (RDE-Specific Features and Technology Anxiety) seem to have been a valuable addition. The explained total cumulative variance of the Hypothesised Model has improved to (86%), which is better than the original UTAUT's at (70%). **In other words,** the Hypothesised Model has the capacity to predict end-users' intentions as to whether or not they would want to use the RDE system (up to 86%).

It is important to note a limitation in the RDE study as it has a low sample size. The response time was extremely problematic, in fact, the sample size was supposed to include approximately 40-50 participants. However, the data collection phase had suffered severe delays when more than half the participants failed to meet the study's deadline (which was extended several times). For that reason, the sample size is lower than expected, yet the results analysis and documentation had to be done in spite.

CHAPTER 6: STUDY 3

Data Quality Tool (DQT)

This chapter discusses the research findings of the DQT study. It describes the collected data, as well as the application of descriptive statistics, structural model assessment, and PCA analysis in detail.

6.1 Data Collection

Similar to the RDE study in Chapter 5, prior to data collection, e-mail correspondence was established with potential participants about the evaluation study and its purposes. Then, data were collected through online questionnaires uploaded on Survey Monkey [166] [Appendix E].

The Participants have already been trained and using a prototype of the DQT system when the study took place. They were actually awaiting deployment of the final version in a few months. Moreover, a detailed user-guide was already written by the system developers. It went step by step from start to finish, illustrating simple instructions to create a sample study (known as a use case). Every step was followed by a screenshot to demonstrate the displayed screen and/or resulting output.

The added core constructs in this study were: DQT-Specific Features, Technology Anxiety, and Adaptation Timeline [Tables 3 and 4] [Figure 5]. Twenty-six questionnaires were collected, four of them were disregarded for being incomplete i.e. (n = 22). The participants of the DQT Study were recruited through the Netherlands Institute for Health Services

Research (Nivel). Their backgrounds or specialities covered: clinical researcher (50%), database designer (18.2%), data collector (13.6%), and data manager (18.2%).

6.2 Descriptive Statistics

Two measures of descriptive analysis were calculated. One to depict the participants' demographics, and another to examine the end-users' level of satisfaction with the system.

6.2.1 Participants' Demographics Profile

Data feedback was collected from a total of 22 participants. Their ages varied from (20 to 61) years; yet the age groups (26-31) and (32-37) reported the highest rate at (27.3%) with six participants in each compared to the other age groups.

The male participants represented (54.5%) of the sample size in comparison with the female participants (45.5%). Moreover, the majority of participants were Clinical Researchers as they make up (50%) of the sample. In addition, most of the participants had previous experience in conducting clinical research (77.3%). Within the experienced group (31.8%) had between (1 and 5) years of experience, followed by (27.3%) who had between (6 and 10) years of experience.

Most of the participants were using DQT voluntarily because they thought it might improve their work performance (63.6%) [Table 29].

Table 29: Sample Demographics Profile (n=22)

Variable	Content	Frequency	Percent
Gender	Male	12	54.5%
	Female	10	45.5%
Age Group	20-25	4	18.2%
	26-31	6	27.3%
	32-37	6	27.3%
	38-43	0	0.0%
	44-49	3	13.6%
	50-55	2	9.1%
	56-61	1	4.5%
Clinical Specialty or Background	-	-	-
	Clinical Researcher	11	50.0%
	Database Designer	4	18.2%
	Data Manager	3	13.6%
	Other	4	18.2%
Previous Experience in Clinical Research	-	-	-
No	0	5	22.7%
Yes	1-5	7	31.8%
	6-10	6	27.3%
	11-15	2	9.1%
	16-20	2	9.1%
Total Yes	-	17	77.3%
Participant's Willingness to Use the System	Yes	14	63.6%
	No	1	4.5%
	To Some Extent	5	22.7%
	Not Sure	2	9.1%

6.2.2 Core Constructs' Frequency Tables

Frequencies were calculated to examine the end-users' level of satisfaction with the system. The frequency analysis provided a rich understanding of the participants' perceptions of DQT. The observed rates on the (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, System-Specific Features, Technology Anxiety, Adaptation Timeline, and Behavioural Intention) are in agreement with the Hypothesised Model. The participants answered "Agree", "Very Much Agree", or "Strongly Agree" to at least four out of between (five and eight) of the questions asked within each core construct [Table 30]. Therefore, the overall outcome of the model indicates agreement with the future acceptance and utilisation of the system. It is also worth to stress the reported frequency rates on the System-Specific Features, these seemed to reflect strong support for DQT, where the participants answered "Agree" to all of the eight questions asked within this core construct.

Table 30: DQT Frequency Table

Questions Asked	**Frequency in %**							
Performance Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I find the system useful in my job, especially when entering and searching data	0	5	5	18	32	**36**	5	100
Using the system enables me to complete tasks on a quicker pace	0	0	14	9	**55**	18	5	100
Using the system increases my productivity	0	5	0	32	**46**	18	0	100
Using the system improves the quality of my work	0	5	0	36	**50**	9	0	100
Overall, the system fits well with the way I work and the service I provide	0	0	9	23	**46**	14	9	100
Effort Expectancy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Interacting with the system has been user-friendly, clear, and understandable	0	0	23	14	**32**	27	5	100
Learning to operate the system has been easy for me and did not take a long time	0	0	14	9	**46**	18	14	100
I found it easy to become skilful at using the system (for example: applying extensive and/or particular search enquiries)	0	0	5	18	**59**	18	0	100
The system facilitates my daily job	0	0	23	27	**41**	9	0	100
I believe that interacting with the system does not mentally exhaust me	0	0	5	18	**41**	23	14	100
Social Influence	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
My managers/supervisors encourage me to use the system	0	5	14	**59**	18	0	5	100
The long-term benefits of using the system inspire me to use it	0	5	0	18	**59**	18	0	100
Within my organization, the management usually communicates their plans of introducing new systems to the staff	5	5	0	23	**46**	9	14	100
Within my organization, the management usually offers sufficient training when new systems are introduced	0	0	0	32	**55**	5	9	100
Overall, the use of healthcare information technology in my workplace is very important	0	0	5	5	**41**	18	32	100

Questions Asked	Frequency in %							
Facilitating Conditions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
The manual or training/help option was/is comprehensive enough	0	0	5	32	**36**	18	9	100
The use of the system is smooth (no technical errors)	0	0	0	5	**55**	32	9	100
The steps followed by the system are logical to use, apply, and recall	0	0	5	9	**55**	18	14	100
If I got stuck, a sufficient reference or resource is available to help me out	0	0	14	**41**	36	9	0	100
The system is easily accessible, responds to queries promptly, and does not disturb my daily routine	0	0	0	18	**50**	18	14	100
System-Specific Features	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
DQT system: the number of steps to select practices fit for purpose is reasonable	0	0	0	9	**64**	14	14	100
DQT login: logging into the system is quick enough	0	0	5	0	**50**	27	18	100
DQT information map: there is enough information about available databases, their country of origin, and owner contact details	0	5	9	9	**50**	23	5	100
DQT specific database: for a database of interest, some further general requirements can be selected such as: whether the database is linkable to generic data, to a cancer registry, to drug registry, etc.	0	0	9	18	**46**	18	9	100
DQT data quality: the system assesses the completeness of available data in a visual output which is helpful to interpret	0	0	14	14	**50**	9	14	100
DQT defining use case: querying data for a certain study using use case, population, and time period is prompt enough	0	0	5	0	**73**	5	18	100
DQT specifying use cases: after a use case is defined, further specification can be applied using slide bars on predefined data elements	0	0	5	5	**64**	9	18	100
DQT output: the practice ID given for a specified use case is the right output	0	0	5	36	**41**	5	14	100
Technology Anxiety	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Generally, I like to keep up with new information technology	0	0	0	9	**41**	27	23	100
I am open for -dramatic- changes in my work habits if necessary	0	0	0	0	**55**	23	23	100

Questions Asked	Frequency in %							
I am likely to become (or I consider myself) technology-oriented due to the nature of my field	0	0	0	9	**41**	27	23	100
If I were given enough time and sufficient resources to absorb change, I am likely to accept it	0	0	0	9	36	**41**	14	100
Overall, I am not that anxious about using technology	0	0	0	0	27	**36**	**36**	100
Adaptation Timeline	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I had adequate time to get trained on using the system	0	5	14	14	**50**	9	9	100
I received sufficient information and/or training during this time	0	5	14	23	**36**	14	9	100
I had enough time to get used the system environment	0	5	14	9	**55**	9	9	100
If the system became available, I think I would be able to improve the quality of my work immediately	0	0	18	27	**41**	9	5	100
I think I would be confident enough to carry out clinical trials by the help of this system right away if it becomes available	0	0	5	**32**	**32**	27	5	100
Overall, I think I will be allowed enough time to get into the habit of using this system if it becomes available	0	0	0	23	**46**	23	9	100
Behavioural Intention	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
I intend to learn as much as I can about the system (or I intend to learn how to use the DQT System to the best of my abilities)	0	0	5	18	**46**	23	9	100
I intend to use the system as often as needed (to perform my work)	0	0	9	23	**46**	14	9	100
I intend to promote the system to my colleagues (if it became available for broader use)	0	0	0	18	**41**	27	14	100
I intend to suggest ideas for further improvements (or to further enhance) the system to the developers if I thought of any	0	0	0	23	**41**	14	23	100
I prefer to use the system because data can be better preserved, archived, shared, manipulated, and searched electronically	0	0	0	27	**41**	14	18	100
1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree.								

6.3 Structural Model Assessment

To assess the structural model and test the hypothesis, the reliability of the core constructs were assessed first. Then, the relationships amongst the Hypothesised Model core constructs were examined.

6.3.1 Scale Reliability

All of the Likert scales that represent the Hypothesised Model variables appear to have a good degree of reliability (their Cronbach's Alpha was ≥ 0.7) [Table 31].

Table 31: Reliability Analysis of the Likert Scales (n=22)

Model Construct	Cronbach's Alpha	Number of Items
Performance Expectancy	0.9	5
Effort Expectancy	0.8	5
Social Influence	0.7	5
Facilitating Conditions	0.8	5
DQT-Specific Features	0.9	8
Technology Anxiety	0.9	5
Adaptation Timeline	0.9	6
Behavioural Intention	0.9	5

6.3.2 Spearman's Correlations

The values of the core constructs were calculated from the questionnaire according to a ranked seven-point Likert scale ranging from (strongly disagree) to (strongly agree), where (1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree). Then, Spearman's correlations were calculated to examine the relationships amongst the scales (refer to 3.6.2 (2) for extra details). A summary is shown in [Table 32] and demonstrated in [Figure 13].

A total of seventeen significant positive relationships were found. **Behavioural Intention has significant relationships with most of the core constructs**: Performance Expectancy (r_s=.665**, p=.001), Effort Expectancy (r_s=.457*, p=.032), Social Influence (r_s=.435*, p=.043), Facilitating Conditions (r_s=.547**, p=.008), and Adaptation Timeline (r_s=.628**, p=.002). This mostly supports the Hypothesised Model indicating that these core constructs have an impact on the Behavioural Intention of the healthcare professionals to use DQT.

Furthermore, interesting results were found relating to the newly introduced core constructs. The Adaptation Timeline construct has four significant relationships with: Performance Expectancy (r_s=.711**, p=.000), Effort Expectancy (r_s=.656*, p=.001), Facilitating Conditions (r_s=.765**, p=.000), and DQT-Specific Features (r_s=.554**, p=.007). Besides that, the Technology Anxiety construct has one significant relationship with Effort Expectancy (r_s=.536*, p=.010), indicating that the more anxious the end-user is, the more difficult they perceive the system to be. The DQT-Specific Features construct also has one significant relationship with Facilitating Conditions (r_s= .562**, p=.006), indicating the importance of allocating the right resources (such as: training sessions, help option, and/or sufficient reference) would help the end-users to engage with a highly specialised system like DQT. These correlations add to the understanding of the healthcare professionals' attitude towards custom designed HIT systems, especially when they are satisfied with the system and believe that it delivers what they need.

In addition, the Facilitating Conditions construct has significant relationships with Performance Expectancy (r_s=.732**, p=.000), Effort Expectancy (r_s=.806**, p=.000), and Social Influence (r_s=.534*, p=.010). This means that having the right Facilitating Conditions would help the end-users to perceive the system as useful, effortless, and potentially make them more open to get inspired by their colleagues.

Likewise, the Social Influence construct has significant relationships with both Performance Expectancy (r_s=.567**, p=.006) and Effort Expectancy (r_s=.601**, p=.003). This means that the effect of Social Influence could possibly be useful to inspire end-users' perception of DQT's usefulness and effortlessness.

Finally, the Effort Expectancy construct has one significant relationship with Performance Expectancy (r_s=.755**, p=.000). This might be an indication that if the end-users' perceive the system as useful, then they are likely to think of it as effort free compared to having no system at all.

Table 32: Spearman's Correlations of the Likert Scales (n=22)

		PE	EE	SI	FC	SF	TA	AT	BI
PE	Correlation Coefficient	1.000							
	Sig. (2-tailed)	.							
EE	Correlation Coefficient	.755**	1.000						
	Sig. (2-tailed)	.000	.						
SI	Correlation Coefficient	.567**	.601**	1.000					
	Sig. (2-tailed)	.006	.003	.					
FC	Correlation Coefficient	.732**	.806**	.534*	1.000				
	Sig. (2-tailed)	.000	.000	.010	.				
SF	Correlation Coefficient	.417	.415	.337	.562**	1.000			
	Sig. (2-tailed)	.054	.055	.125	.006	.			
TA	Correlation Coefficient	.370	.536*	.303	.301	.193	1.000		
	Sig. (2-tailed)	.090	.010	.171	.173	.389	.		
AT	Correlation Coefficient	.711**	.656**	.400	.765**	.554**	.271	1.000	
	Sig. (2-tailed)	.000	.001	.065	.000	.007	.223	.	
BI	Correlation Coefficient	.665**	.457*	.435*	.547**	.298	.388	.628**	1.000
	Sig. (2-tailed)	.001	.032	.043	.008	.179	.075	.002	.

** 2-tailed Correlation is significant at the 0.01 level; * 2-tailed Correlation is significant at the 0.05 level

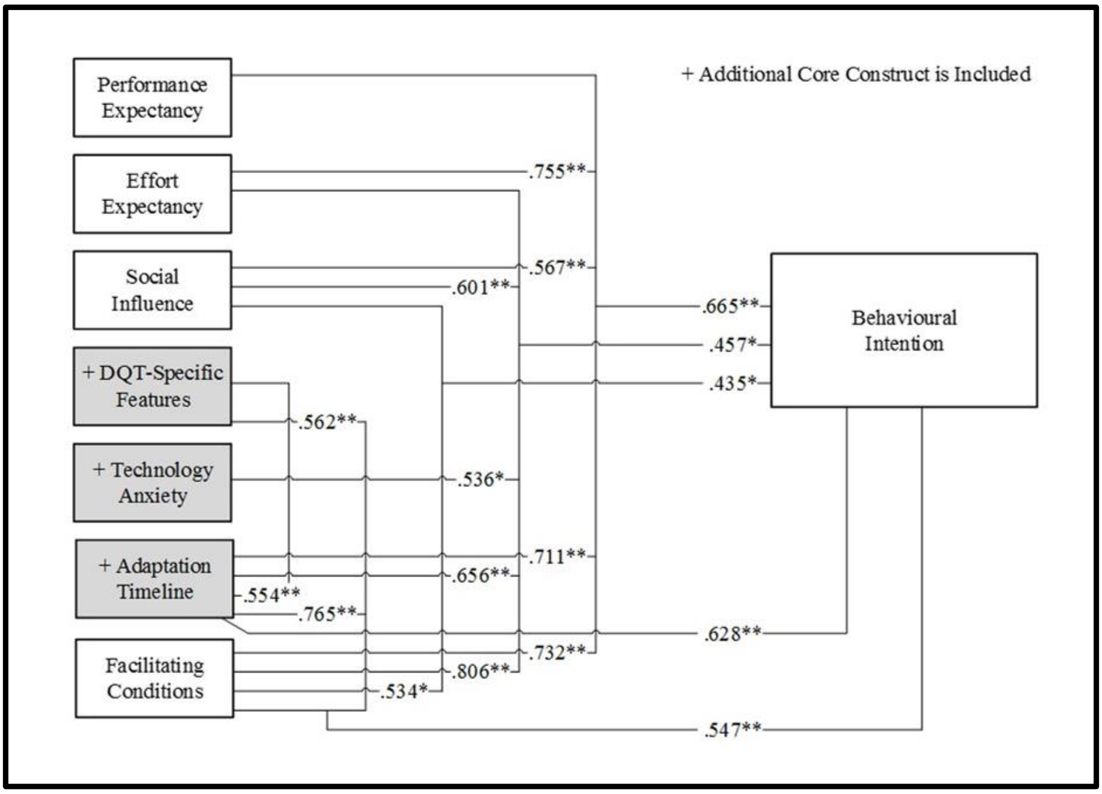


Figure 13: Spearman's Correlations of the Hypothesised Model (n=22)

6.4 PCA Analysis

PCA was applied to test whether the hypothesised factor structure, in fact, fits the initial set of data. Four steps were followed to complete the process as explained below. A number of passes was necessary, and Eigenvalues ≥ 0.5 were considered in each to statistically reduce the questions whilst maintaining a high percent of explained variance.

6.4.1 PCA of the Hypothesised Scales

In the first step, the KMO and Bartlett's values of the Hypothesised Model scales were calculated. The total cumulative variance in the Usage Intention explained by the Hypothesised Model has increased to (87%) in comparison with (70%) in the original UTAUT [2] [Table 33].

Table 33: PCA (KMO and Bartlett's Tests of the Hypothesised Model's Scales)

Model Construct	KMO	Bartlett's Test for Sphericity		
		Approx. Chi-square	df	Sig.
Performance Expectancy	.8	56.0	10	.000
Effort Expectancy	.7	39.5	10	.000
Social Influence	.5	38.4	10	.000
Facilitating Conditions	.6	37.6	10	.000
DQT-Specific Features	.7	108	28	.000
Technology Anxiety	.6	74.8	10	.000
Adaptation Timeline	.7	105.1	15	.000
Behavioural Intention	.8	79.7	10	.000
Total Cumulative Variance Explained	87%			
Total Cumulative Variance Explained (without DQT-Specific Features, Technology Anxiety, and Adaptation Timeline)	81%			

6.4.2 Variable Reduction

In the second step, three PCA Passes were calculated in order to assess whether the ranked seven-point Likert scale questions asked can be statistically reduced in a way that maintains a high percent of explained variance. The number of passes was guided by the percent of explained variance in each pass, and by the number of cross loadings needed to be discarded. **Pass 1** appears to have the highest total variance explained [Table 34].

Table 34: PCA Passes

Pass#	Total Variance Explained
Pass1	**86.567%**
Pass2	84.841%
Pass3	83.741%

PCA had statistically rearranged all of the ranked seven-point Likert scale questions (into different member questions according to an alternative logic). It did so by tracing an alternative logic, different to that suggested by the Hypothesised Model, which depended on the collected data (without changing it). Thus, the reduction of member questions was completed on the basis of their Eigenvalues. Eigenvalues values ≥ 0.5 were considered, while Eigenvalues values < 0.5 as well as cross loadings were discarded. This process was repeated in three passes until 35 questions were arrived to. These are the questions which PCA suggests explain the biggest variance (the bigger the variation, the more information provided by the resulting factor) [Table 35].

Table 35: PCA Components Matrix of Pass 1

Discard	Q#	Factors								
		1	2	3	4	5	6	7	8	9
	2.1	0.793				0.375				
	2.2	0.527	-0.46			0.488				
	2.3	0.628		0.462						
	2.4	0.607								-0.337
	2.5	0.75					-0.309		-0.336	
	3.1	0.582	-0.365		0.424	-0.309				
	3.2	0.513		0.441	0.409			-0.41		
	3.3	0.592			0.491			-0.381		
	3.4	0.652				0.494		-0.383		
	3.5	0.617	0.382	0.373						
X	4.1	0.604	-0.323			0.579				
	4.2	0.768			-0.337					
	4.3		-0.618	0.409	0.331		0.32	0.319		
X	4.4	0.386			0.492	0.383				
X	4.5	0.571								0.527
	5.1	0.813								
	5.2	0.472	0.566					-0.301	-0.409	
	5.3	0.592	-0.441						-0.401	
	5.4	0.572		-0.469			-0.348			
	5.5	0.627	0.478							-0.311
	6.1	0.426	0.566				0.345		-0.4	
	6.2		0.572	-0.382					0.349	
	6.3	0.616	0.313	-0.341						
	6.4	0.434	0.601	-0.377			0.302			
X	6.5	0.506					-0.712			
	6.6	0.717	0.321		0.405					
X	6.7	0.689	0.556							

Discard	**Q#**	**Factors**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
X	6.8	0.622					-0.537	0.308		
X	7.1	0.572		0.473		-0.546				
	7.2	0.529	0.329	0.44	-0.428					
	7.3	0.446		0.474		-0.617				
X	7.4		0.58	0.568						
	7.5	0.626		0.326						
	8.1	0.679		-0.412	0.379					
	8.2	0.765		-0.356	0.394					
	8.3	0.641		-0.455	0.335					
	8.4	0.649					-0.443			
	8.5	0.7								-0.379
	8.6	0.698						0.474		
	9.1	0.617		-0.442		-0.328				
	9.2	0.588		-0.486	-0.498					
	9.3	0.823			-0.312					
	9.4	0.647					0.358			
X	9.5	0.658			-0.527					
Gray cells indicate member questions where Eigenvalues values ≥ 0.5 X indicate discarded questions where Eigenvalues values < 0.5 or have cross loadings										

Finally, the factors and their member questions were detailed [Table 36]. The DQT questionnaire originally had 44 ranked seven-point Likert scale questions [Appendix E]. However, at this particular step of the analysis, the PCA only reserved 35 questions, which we roughly grouped under 3 alternative factors. These might be further reduced in the following steps.

Table 36: Factors and Member Questions

Factors and Member Questions
Factor 1: Performance Expectancy
2.1 I find the DQT System useful in my job, especially when entering and searching data
2.2 Using the DQT System enables me to complete tasks on a quicker pace
2.3 Using the DQT System increases my productivity
2.4 Using the DQT System improves the quality of my work
2.5 Overall, the DQT System fits well with the way I work and the service I provide
3.1 Interacting with the DQT System has been user-friendly, clear, and understandable
3.2 Learning to operate the DQT System has been easy for me and did not take a long time
3.3 I found it easy to become skilful at using the DQT System (for example: applying extensive and/or particular search enquiries)
3.4 The DQT System facilitates my daily job
3.5 I believe that interacting with the DQT System does not mentally exhaust me
4.2 The long-term benefits of using the DQT System inspire me to use it
5.1 The training/help option was/is comprehensive enough
5.3 The steps followed by the system are logical to use, apply, and recall
5.4 If I got stuck, a sufficient reference or resource is available to help me out
5.5 The DQT System is easily accessible, responds to queries promptly, and does not disturb my daily routine
6.3 DQT information map: there is enough information about available databases, their country of origin, and owner contact details
6.6 DQT defining use case: querying data for a certain study using use case, population, and time period is prompt enough
7.2 I am open to change my work habits if necessary
7.5 Overall, I am not anxious about using information technology
8.1 I had adequate time to get trained on using the system
8.2 I received sufficient information and/or training during this time
8.3 I had enough time to get used the system environment
8.4 If the system became available, I think I would be able to improve the quality of my work immediately
8.5 I think I would be confident enough to carry out clinical trials by the help of this system right away if it becomes available
8.6 Overall, I think I will be allowed enough time to get into the habit of using this system if it becomes available
9.1 I intend to learn how to use the DQT System to the best of my abilities
9.2 I intend to use the DQT System as often as needed to perform my work
9.3 I intend to promote the DQT System to my colleagues if it became available for broader use
9.4 I intend to suggest ideas to further enhance the DQT System if I had any
Factor 2: DQT-Specific Features
4.3 Within my organization, the management usually communicates their plans of introducing new systems to the staff
5.2 The use of the DQT System is smooth (no technical errors)
6.1 DQT system: the number of steps to select practices fit for purpose is reasonable
6.2 DQT login: logging into the system is quick enough

Factors and Member Questions
6.4 DQT specific database: for a database of interest, some further general requirements can be selected such as: whether the database is linkable to generic data, to a cancer registry, to drug registry, etc.
Factor 5: Technology Anxiety
7.3 I consider myself technology-oriented due to the nature of my job

6.4.3 Factors' Reliability

In the third step, a reliability test was calculated to check the internal consistency of the factors produced by Pass 1. This was done in preparation to calculate the Spearman's correlations of the final outcome. Hence, only the reliable factors were included (where Cronbach's Alpha was ≥ 0.7), in addition to the remaining single one (7.3: I consider myself technology-oriented due to the nature of my job). Factor 2 (DQT-Specific Features) was unreliable, but it was then enhanced by deleting Question (4.3: Within my organization, the management usually communicates their plans of introducing new systems to the staff). It is proposed that removing this question is permitted as it represents management communication, whereas the other four questions represent DQT-Specific Features. Therefore, it does not fit very well as it stands [Table 37].

Table 37: Reliability Analysis of the Factors (n=22)

Model Construct	Cronbach's Alpha	Number of Items	Enhanced Scale
Factor 1 (Performance Expectancy)	1	29	-
[Factor 2] (DQT-Specific Features)	.2	5	-
Factor 2* (DQT-Specific Features)	.8	4	Deleted Question (4.3)
Factor 5 Technology Anxiety	Not Applicable	1	-
* Enhanced Scale			

6.4.4 Factors' Correlations

In the fourth and final step, Spearman's correlations were calculated amongst the factors as summarised in [Table 38] and demonstrated in [Figure 14]. Only one significant positive relationships was found. Factor 1 (Performance Expectancy) correlates with Factor 5 (Technology Anxiety) at (r_s=.426*, p=.048). This indicates that, in a given workplace, the higher the performance expectations of a specific piece of technology are (DQT in this study), the more anxious the end-users will be to utilise it.

Table 38: Spearman's Correlations of the Factors (n=22)

		F1	F2	F5 (7.3)
F1	Correlation Coefficient	1		
	Sig. (2-tailed)	.		
F2	Correlation Coefficient	0.285	1	
	Sig. (2-tailed)	0.199	.	
F5 (7.3)	Correlation Coefficient	.426*	-0.042	1
	Sig. (2-tailed)	0.048	0.852	.
**Correlation is significant at the 0.01 level (2-tailed); and *Correlation is significant at the 0.05 level (2-tailed				

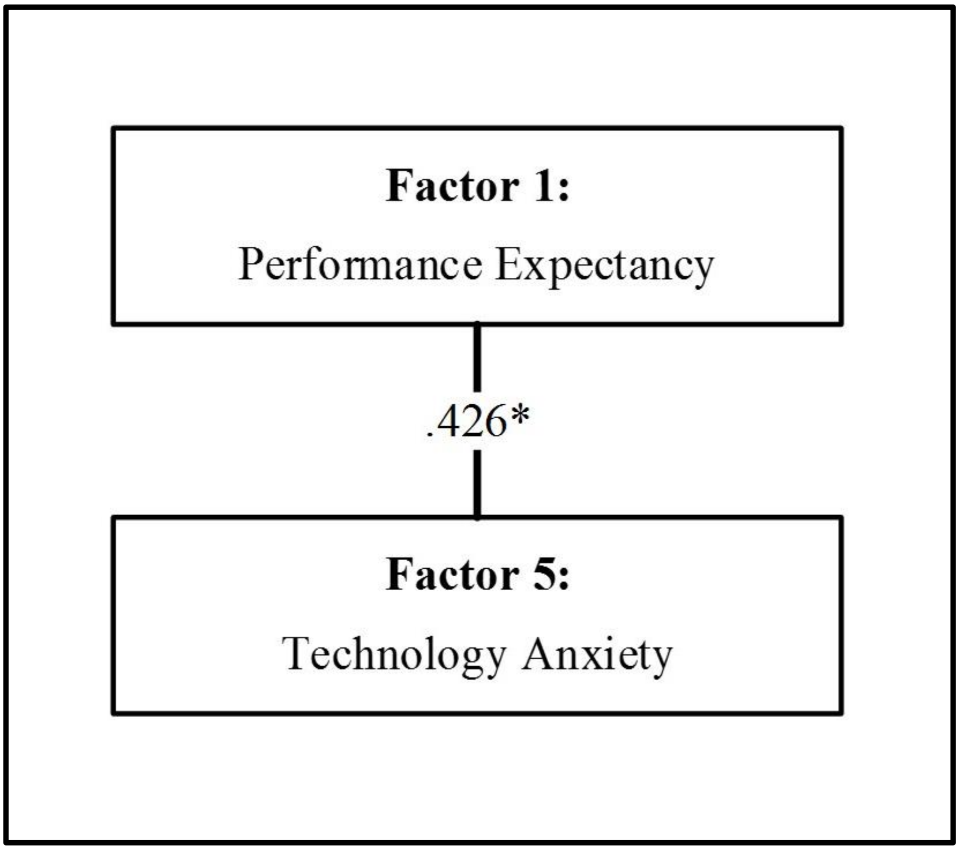


Figure 14: Spearman's Correlations of the Factors (n=22)

6.5 Discussion

The correlation analysis of the added core constructs partially agrees with the Hypothesised Model [Figure 5]. The observed significant correlations between (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and Adaptation Timeline) and (Behavioural Intention) are predicted by the Hypothesised Model. Hence, all of these core constructs have an impact on healthcare professionals' Behavioural Intention and therefore their actual use of HIT [Table 32] and [Figure 13]. Consequently, the decision makers should pay attention to this range of aspects when planning to acquire a new HIT such as DQT. These core constructs are not purely technical, they are rather socio-technical. So, there is a need to understand the technical, social, and organisational aspects within a given environment before putting any facilitating conditions and training sessions in place. It is through this understanding that the transition from old work habits to new ones would be smoothly facilitated.

A comparison was done between the hypothesised scales and the PCA Factors to understand what they have in common, where they differ, and why there were dissimilarities.

On one hand, the Hypothesised Model has eight hypothesised scales which are essentially Likert, independent, and composite variables (i.e. measurements based on multiple data items). Their member questions were balanced as they ranged between five and eight items, the matter that makes them easy to interpret. In addition, when they were tested for reliability, they were all reliable as they scored ≥ 0.7 [Table 31]. Moreover, there were seventeen significant correlations amongst these scales [Figure 13].

Conversely, the PCA Factors revealed two Likert, independent, and composite factors (Factors 1 and 2), and one single-item factor (Factor 5). One of the composite variables was reliable (Factor 1), while the other one needed to be improved (Factor 2) [Table 37]. However, their correlations showed only one significant relationship between (Factor 1 and Factor 5) [Figure 14].

On the other hand, there is a striking similarity in principal between Factor 1 (Performance Expectancy) and most of the hypothesised core constructs (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, DQT-Specific Features, Technology Anxiety, and Adaptation Timeline). Unsurprisingly, Factor 1 captures the fundamental ideas which form most of the hypothesised core constructs at once, it actually includes between one and six questions of each construct [Tables 36]. This observation disproves of UTAUT in terms of it assuming that there are separate constructs/factors when, in fact, they all collapse into a single component. Therefore, having a diagram in which the separate components are presented in their own boxes with correlations shown on the links might be misleading, at least, in this particular study [Figures 13 and 14]. The discrepancy between the hypothesised scales and the PCA Factors might be explained by the nature of the health professionals' field of work, where using new technologies is mostly helpful and their computer skills are sufficient. Nonetheless, the validated questions that inform UTAUT seem to be realistic and enlightening for the healthcare practice, and they have served this study very well.

In other words, new technologies and/or computer systems **will not** necessarily be always resisted, instead if their functionality was highly needed to deliver demanding daily tasks more efficiently, then they are likely to be welcomed. The Hypothesised Model appears to have pinpointed three additional and very relevant scales for assessing end-users' system acceptance and predicting their future use (DQT-Specific Features, Technology Anxiety, and Adaptation Timeline).

Finally, the total explained variance was (81%) for the original UTAUT Model and (87%) for the Hypothesised Model [Table 33]. Moreover, the initial PCA analysis contained all of the nineteen questions asked within the DQT-Specific Features, Technology Anxiety, and Adaptation Timeline core constructs (6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 7.1, 7.2, 7.3, 7.4, 7.5, 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6) [Table 35]. Even though the final member questions were statistically reduced to fourteen in the next step, the influence of the remaining questions was seamlessly incorporated within the final output (6.1, 6.2, 6.3, 6.4, 6.6, 7.2, 7.3, 7.5, 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6) [Table 36]. This indicates the importance of these concepts for this particular study.

6.6 Conclusion

This research study has met its aim of presenting a Hypothesised Model that suits the healthcare practice. The Hypothesised Model was empirically tested using the DQT system, and the added core constructs (DQT-Specific Features. Technology Anxiety, and Adaptation Timeline) seem to have been a valuable addition. The explained total cumulative variance of the Hypothesised Model has improved to (87%), which is better than the original UTAUT's at (70%). **In other words,** the Hypothesised Model has the capacity to predict end-users' intentions as to whether or not they would want to use the DQT system (up to 87%).

It is important to note a limitation in the DQT study as it has a low sample size, similar to the RDE study. In fact, the data collection phase had also suffered severe delays when more than half the participants failed to meet the study's deadline (which was extended several times).

For that reason, the sample size is lower than expected, yet the results analysis and documentation had to be done in spite.

CHAPTER 7: DISCUSSION

This chapter summarises the research findings of the three studies which were detailed in Chapters 4, 5, and 6. Then, it presents collective observations and comments about them. Finally, it goes on to make comparisons with similar work.

7.1 General Remarks on the Results

As discussed in Chapter 1, this research study was an attempt to formulate better verdicts for engineering or procuring technologies used in healthcare. More specifically, it was conducted to assess whether a given piece of technology is totally desirable in a given situation/department/organisation, before devoting valuable time, resources, and effort developing/acquiring it in the first place. Consequently, if its concept and preliminary requirements were found suitable, then it was judged prudent to proceed. If not, a better choice should and could be made early on.

The research objective, was to identify and measure some of the critical socio-technical factors which may influence the acceptance of new technologies, and computer systems, by healthcare professionals, in their field of practice. This was viewed as particularly crucial, at the early stages of the system's development lifecycle while, taking into consideration their complexity as socio-technical systems needing to achieve joint optimisation [96]. Exploring some of these factors was further viewed as helpful to understand the attitudes of contemporary end-users towards the introduction of new technologies and computer systems. The investigation focuses on the end-users' point of view by considering that a successful deployment of a given piece of technology means that it is indeed accepted and utilised by the group to whom in was intended.

The tool to achieve this objective was the creation of a Hypothesised Model, designed to specifically suit the healthcare context. It was derived from the UTAUT literature which is a validated and dependable theoretical model. However, the Hypothesised Model had to have a certain degree of flexibility to accommodate predefined socio-technical factors which are situation-specific, especially given that this research study posits the non-existence of a single model that might fit each and every situation [92] [93]. In other words, the Hypothesised Model had to adhere to the practicality of real life situations in an evolving environment such as the one represented by healthcare. Therefore, three slightly different questionnaires were developed and used to best suit each of the three individual studies as detailed in Chapter 3 [Tables 3 and 4] and [Figure 5]. Firstly, the added core constructs in Study 1 (ePCRN) were: Technology Anxiety and Adaptation Timeline. Secondly, the added core constructs in Study 2 (RDE) were: RDE-Specific Features and Technology Anxiety. Thirdly, the added core constructs in Study 3 were: DQT-Specific Features, Technology Anxiety, and Adaptation Timeline.

The literature related that the total explained variance in the Behavioural Intention to use technology by the original UTAUT is (70%) [2]. However, the Hypothesised Model revealed a higher total explained variance [Table 39]. Moreover, a comparison of the total explained variances of the original UTAUT and the Hypothesised Model revealed an equivalent value in Study 1 (76%), and higher values in Studies 2 and 3, (86%) and (87%) respectively. In addition, comparison of the total explained variances of the Hypothesised Model and the PCA analysis revealed **approximately** equal values in the three studies: (76%), (86%), and (87%) respectively [Table 39].

In summary, this research study has met its aim of presenting a Hypothesised Model that suits the healthcare practice. The Hypothesised Model was tested in three studies, and the reported results indicate the following [Table 39]:

1. Study 1 - ePCRN: the Hypothesised Model improved the explained total variance up to (76%). **In other words,** the Hypothesised Model has the capacity <u>to predict</u> end-users' intentions as to whether or not they would want to use the ePCRN prototype (up to 76% of the variance in the results is attributed to and explained by the asked questions).
2. Study 2 – RDE: The Hypothesised Model improved the explained total variance up to (86%). **In other words,** the Hypothesised Model has the capacity <u>to predict</u> end-users' intentions as to whether or not they would want to use the RDE system (up to 86% of the variance in the results is attributed to and explained by the asked questions).
3. Study 3 – DQT: The Hypothesised Model improved the explained total variance up to (87%). **In other words,** the Hypothesised Model has the capacity <u>to predict</u> end-users' intentions as to whether or not they would want to use the DQT system (up to 87% of the variance in the results is attributed to and explained by the asked questions).

In practical terms, applying such a flexible Hypothesised Model approach appears to have improved the final outcome. It yielded specific and meaningful information about the systems which are being developed to fit very specific needs, in turn that will assist the relevant stakeholders. Furthermore, this endeavour has emphasised the importance of the implicated socio-technical factors throughout. It has also helped in validating the all-important system specifications with potential end-users by measuring their initial level of satisfaction, and assessing whether or not they believe that these systems, in fact, deliver what they need, as shown in the frequency tables [Tables 7, 20, and 30].

Generally, the Hypothesised Model pinpointed three additional and very relevant core constructs for assessing end-users' system acceptance and predicting their future use of HIT systems. These include: System-Specific Features, Technology Anxiety, and Adaptation Timeline. For example, the initial PCA analysis of the **Technology Anxiety** core construct added in Studies 1, 2 and 3, contained all of the five questions asked within this construct in Study 2 and 3, and four out of six questions in Study 1 [Tables 12, 25, and 35]. Likewise, the initial PCA analysis of the **System-Specific Features** core construct added in Studies 2 and 3, contained all of the eight questions asked within this core construct in both studies [Tables 25 and 35]. Finally, the initial PCA analysis of the **Adaptation Timeline** core construct added in Studies 1 and 3, contained all of the six questions asked within this construct in both studies [Tables 12 and 35]. Even though the final member questions were statistically reduced in the next step, the influence of the remaining questions was seamlessly incorporated within the final output [Tables 13, 26 and 36]. This observation indicates the importance of these concepts for the relevant studies. It also reflects positively on the Hypothesised Model's explanatory power.

Table 39: Summary of the Total Explained Variance

Study	Sample Size	Total Variance Explained		
		Original UTAUT	Hypothesised Model	PCA
Study 1: ePCRN	57	76% (Without Technology Anxiety and Adaptation Timeline).	76%	Pass 2: 75.751%
Study 2: RDE	21	83% (Without RDE-Specific Features and Technology Anxiety).	86%	Pass1: 86.172%
Study 3: DQT	22	81% (Without DQT-Specific Features, Technology Anxiety, and Adaptation Timeline).	87%	Pass1: 86.567%

7.2 The Joint Models

The PCA Factors are a calculated reduction of the hypothesised core constructs. This section illustrates their significance simultaneously. The following figures serve as a quick and simple reference as to which core constructs were included or excluded in each study, and demonstrate their significant correlations according to the Hypothesised Model and to the PCA Factors [Figures 15, 16, and 17].

In line with the original UTAUT, the Hypothesised Model assumes that there are separate core constructs/factors. However, the PCA analysis shows that, in fact, they mostly collapse into a single main component (Factor 1) and a few supporting ones. Therefore, having a diagram in which the separate components are presented in their own boxes with correlations shown on the links might be misleading, at least, in these particular studies. Note that the final member questions have regrouped differently in each study [Tables 13, 26, and 36]. This observation supports the argument that new technologies and computer systems become unique when incorporated as part of a bigger information system. However, this depends on factors which include, but are not limited to workflow, end-users' skills and motivation, and used functionality (refer to 1.6). Nonetheless, the validated questions that inform UTAUT seem to be realistic and illuminating for the healthcare practice. Also, it is concluded that they have served the three studies very well as reflected by the Hypothesised Model's explanatory power.

Essentially, the observed differences might be rooted at the modern end-users' holistic perception of useful change, and how it will be facilitated and supported. In contemporary healthcare settings, there is a need when designing organisational processes that there exists the possibility that they may evolve over time, in order to enhance the overall socio-technical system. Moreover, there seems to be more to the overall functionality of emerging or newly deployed HIT systems -as an integral part of organisations- than the already recognised technical aspects. More specifically, understanding the technical, social, and organisational aspects can no longer be separated when engineering or procuring technologies in healthcare. Elements such as: logical workflow, technology introduction methods, quality of information, training and support, depth of use, and end-users' motivation need to be incorporated [40].

7.2.1 The ePCRN Joint Model

An ePCRN Joint Model was illustrated to show the significant correlations amongst both, the hypothesised core constructs and the final PCA Factors. Four core constructs were shared, including: Performance Expectancy, Facilitating Conditions, Technology Anxiety, and Social Influence [Figure 15].

7.2.2 The RDE Joint Model

An RDE Joint Model was illustrated to show the significant correlations between both, the hypothesised core constructs and the final PCA Factors. Two core constructs were shared including: Performance Expectancy and Technology Anxiety. It was observed that two single-item Factors emerged including: Communication and HIT Importance [Figure 16].

7.2.3 The DQT Joint Model

A DQT Joint Model was illustrated to show the significant correlations between both, the hypothesised core constructs and the final PCA Factors. Two core constructs were shared including: Performance Expectancy and Technology Anxiety (although it should be mentioned that Technology Anxiety is a single-item factor in this case) [Figure 17].

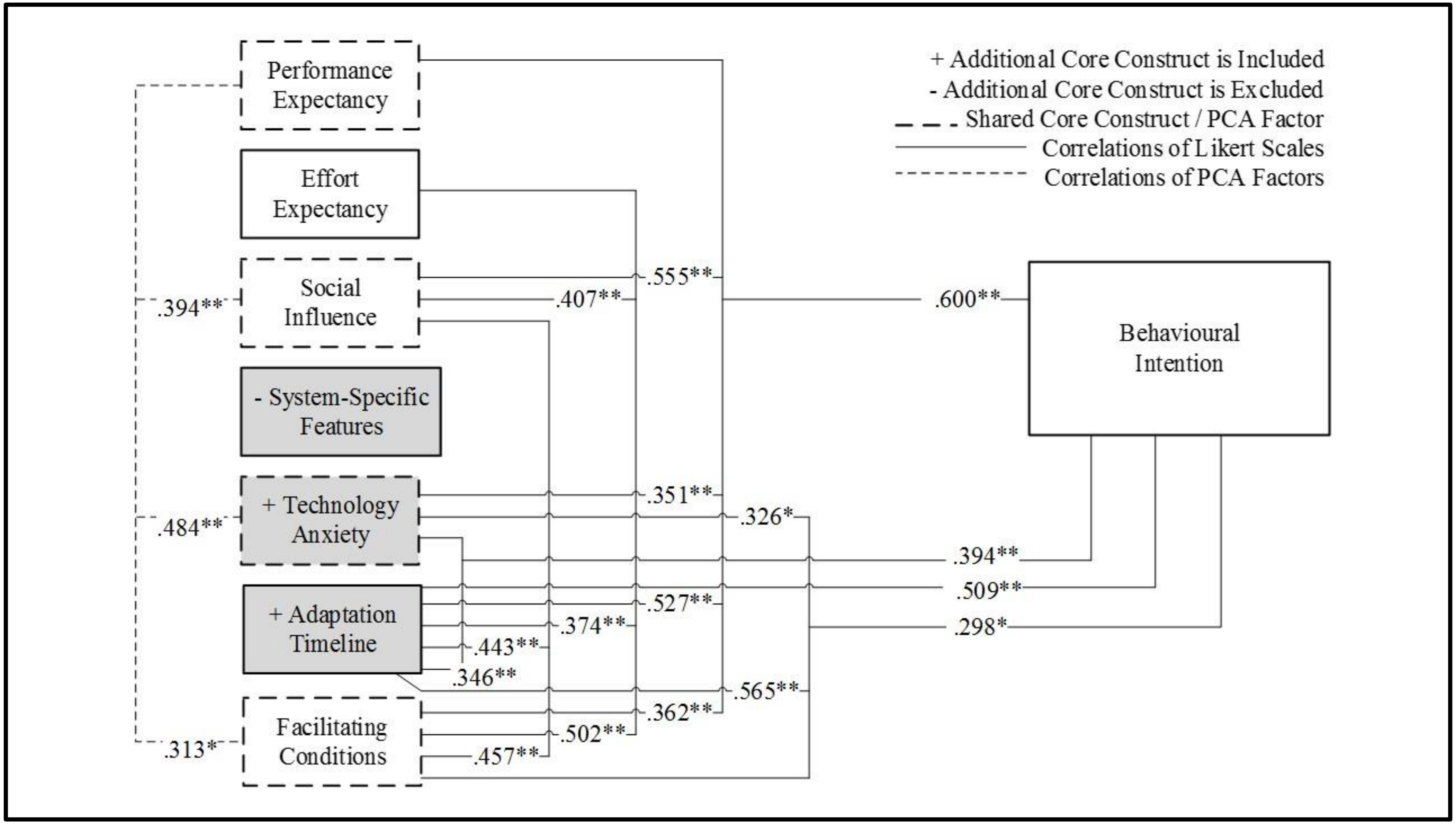


Figure 15: The ePCRN Joint Model

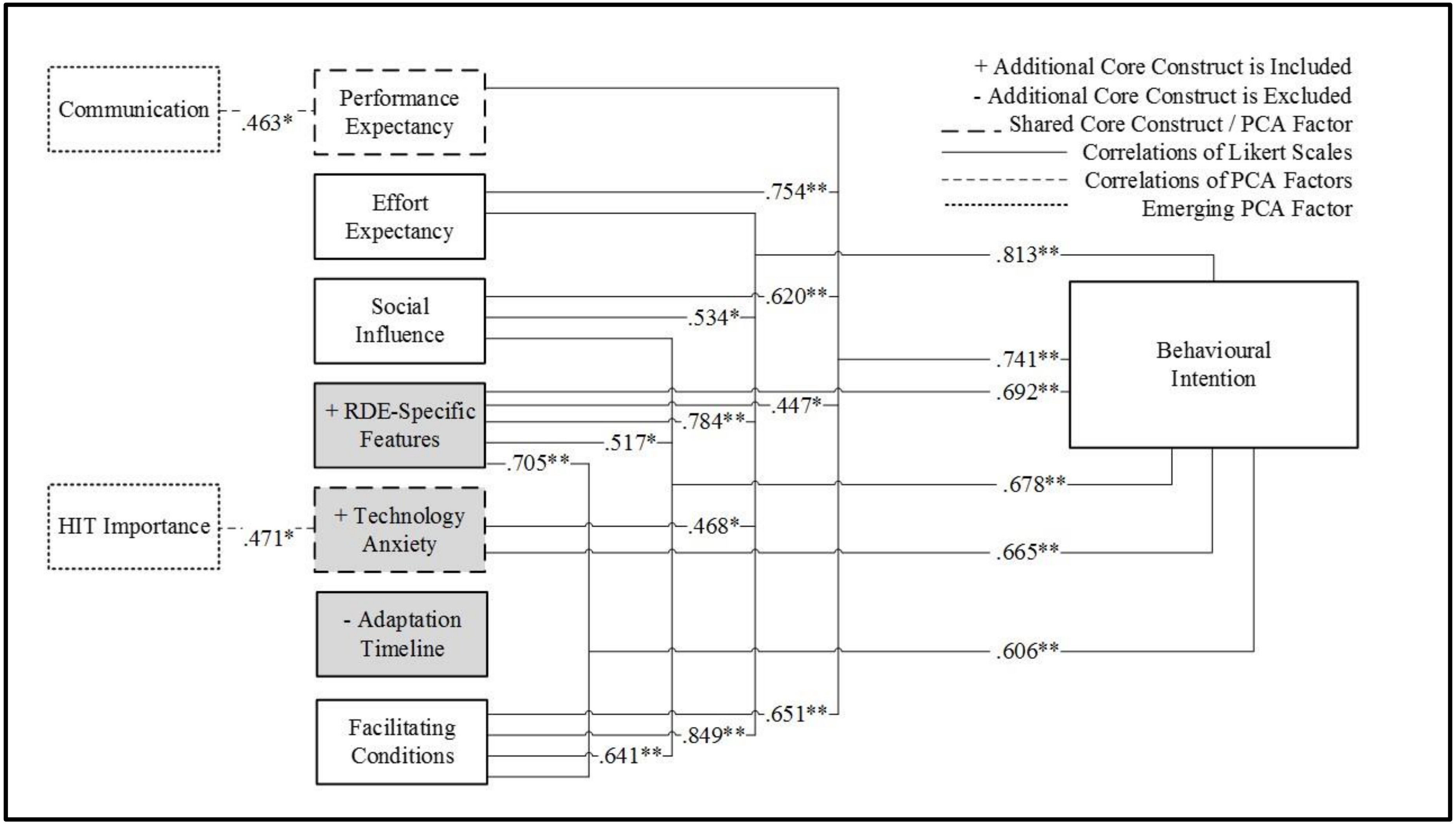


Figure 16: The RDE Joint Model

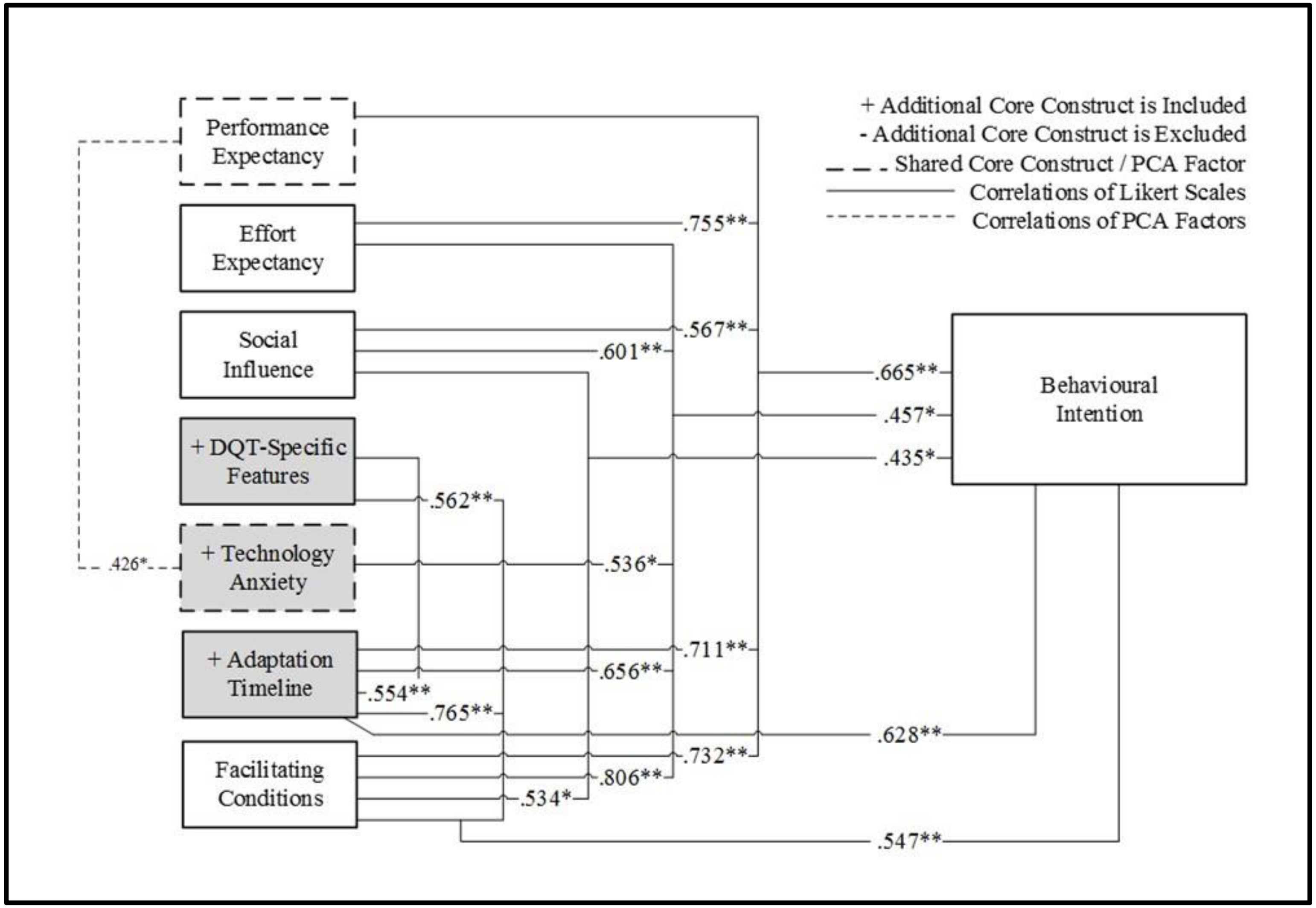


Figure 17: The DQT Joint Model

7.3 Summary of the Results

This section compares the findings of the Hypothesised Model with the actual results. Very importantly, it also answers the research questions in light of the findings.

7.3.1 The Hypothesised Model versus the Actual Results

The correlation analysis results were the means by which comparison of the Hypothesised Model's predictions were compared with the actual ones. Studies 1 and 3 showed partial agreement, while Study 2 showed full agreement.

Hence, in Study 1, the correlation analysis of the core constructs partially agrees with the Hypothesised Model [Figures 5 and 9]. The observed significant correlations between (Performance Expectancy, Facilitating Conditions, Technology Anxiety, and Adaptation Timeline) and (Behavioural Intention) are predicted by the Hypothesised Model. Similarly, in Study 3, the correlation analysis of the core constructs partially agrees with the Hypothesised Model [Figures 5 and 13]. The observed significant correlations between (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and Adaptation Timeline) and (Behavioural Intention) are also predicted by the Hypothesised Model. Finally, in Study 2, the correlation analysis of the core constructs fully agrees with the Hypothesised Model [Figures 5 and 11]. The observed significant correlations between (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, RDE-Specific Features, and Technology Anxiety) and (Behavioural Intention) are predicted by the Hypothesised Model. Therefore, it may be concluded that all of the core constructs have some impact on the healthcare professionals' Behavioural Intention and as a consequence their actual Use Behaviour of HIT.

7.3.2 Answering the Research Questions

This research study has been keen on answering the following questions:

Question 1: How do contemporary healthcare professionals respond to new technologies and computer systems at the workplace? In other words, is their general attitude positive or negative?

Frequencies were calculated to examine the end-users' level of satisfaction with the system [Tables 7, 20, and 30]. The answer code for the Likert scale is: (1 = Strongly Disagree, 2 = Very Much Disagree, 3 = Disagree, 4 = Not Sure, 5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree). Collectively, the answers (5 = Agree, 6 = Very Much Agree, and 7 = Strongly Agree) reflect a positive attitude/reaction towards the system being offered, and agreement with its concept and preliminary requirements. They also reflect that the participants want to have that specific system.

The observed rates on the (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Technology Anxiety, Behavioural Intention, and/or System-Specific Features, and/or Adaptation Timeline) are mostly in agreement with the Hypothesised Model. The participants agreed with majority of the questions asked within each of these core constructs. Therefore, it may be inferred that the overall outcome of the model indicates agreement with the future acceptance and utilisation of these specific system. If there had been no agreement with a specific system's concept and/or any of the preliminary requirements, then the project would have needed to be revisited and refined further. Alternatively, a better system choice could have been made in a timely manner.

Only in Study 1, were the participants unsure about the role of Social Influence as they answered "Not Sure" to four out of the six asked questions asked within this core construct.

The latter result potentially indicates a lack of support for the ePCRN concept within traditional clinical research settings, or a lack of organisational encouragement [164].

It is worth stressing the reported frequency rates on the System-Specific Features in Studies 2 and 3, these seemed to reflect strong support for the RDE and DQT systems.

Question 2: Which factors (attributes and skills) do healthcare professionals rely on if they were to change the way they do things in favour of better outcomes? In other words, is it all attributable to open-mindedness, flexibility, and skilfulness?

The answer to this question is not clear-cut. The healthcare settings typically mandate a complex interaction between socio-technical factors and end-users, alongside organizational processes and the influence of cultures in a multidimensional context [8] [Figure 1]. So, there are many indicators to consider, such as: individual characteristics, system features, and work environment. In the final analysis, the motivational factors that influence the intention of contemporary healthcare professionals to use new technologies and computer systems seem to be a combination of these factors.

With reference to the hypothesised core constructs, the frequency tables [Tables 7, 20, and 30] and the correlation tables [Tables 9, 22, 32] are the main areas where a number of these factors could be identified. These two sets of findings could potentially help the stakeholders concerned, in making appropriate adjustments in a timely and efficient manner, particularly with regards to how these factors interact and influence one another. For example, plans could be made for reducing Technology Anxiety amongst employees, or for better Facilitating Conditions to be available, if necessary.

However, the first step in embracing any change might be influenced by mental notions or experience, such as: open-mindedness, flexibility, and skilfulness. The participants studied did not seem to be resistant to changing the way they do things in favour of better outcomes. It would seem that they actually view using technology as mostly helpful because their computer skills are sufficient for that purpose. Nonetheless, the change process itself could be disruptive. Therefore, introducing new technologies to the work place needs to be planned carefully in order for end-users to adopt these technologies as part of their routine.

Question 3: How can the success of introducing a specific piece of technology into the healthcare practice be predicted? In other words, can the UTAUT be extended to fit within the healthcare context and offer predictions on the future deployment of new technologies and computer systems?

Thus far, this research study has conducted three evaluations with specific aims in mind, including, to:

1. Present a Hypothesised Model that fits soundly within the healthcare context.
2. Empirically test the Hypothesised Model on three HIT systems.
3. Interpret the findings of the Hypothesised Model so as to predict end-users' acceptance, as well as future utilisation of new technologies and computer systems.

The evidence gathered and discussed in Chapters 4, 5, and 6 was found to be either partially or fully supportive of the Hypothesised Model. Studies 1 and 3 showed partial agreement, while Study 2 showed full agreement. Moreover, the Hypothesised Model revealed a higher total explained variance of the Behavioural Intention to use technology than the reported one at (70%) [2] [Table 39]. In summary, this indicates that UTAUT can indeed be extended with situation-specific factors to evaluate systems within the healthcare context.

7.4 Comparable Results

This section discusses the use of UTAUT as a tool to assess end-users' intentions with regard to using new technologies and computer systems in healthcare. It compares the findings of this research study with ones available in the literature, focusing on the explanatory power and performance viewpoints of diverse extensions.

7.4.1 Comparable Explanatory Power

Similar studies have reported their explanatory power rates on a multitude of HIT systems in order to either explain the variance in Behavioural Intention, or actual Use Behaviour. However, the recommendations of these studies with reference to whether or not they support the use of UTAUT in the healthcare practice, varied [Table 40].

On the one hand, one study reported only (20-44%) of the total variance in doctors' actual Use Behaviour of a newly implemented EHR system. As a result, it concluded that UTAUT was not useful in the healthcare context [18]. This finding disagrees with the findings of this research, it should be noted.

On the other hand, a study reported approximately (> 50%) of the total variance in the adoption and actual Use Behaviour of many HIT systems used by healthcare professionals in a developing country, and concluded that UTAUT was useful for that specific context and that its constructs are comprehensive enough [132]. Moreover, another study reported between

(28.2% and 51.1%) of the total variance in nurses' and doctor assistants' adoption of implemented and upcoming EHR systems, and also concluded that UTAUT was reasonably useful in the healthcare context [133]. Both of these findings agree with the findings of this research study in spite of the lower rates. Yet, these rates might reflect the lack of situation-specific UTAUT extensions, in comparison with this research study's Hypothesised Model. It is worth noting here that, the three studies mentioned earlier have either used UTAUT in its generic form or with minor changes, whereas this research study used situation-specific extensions.

A similar study to this endeavour was found. It essentially extended UTAUT with socio-technical factors, similar to the ones we used, had reported (63%) of the total variance in the adoption and actual Use Behaviour of many HIT systems used by occupational therapists in Australia. As a result, it had likewise concluded that their model was useful in the healthcare context [136].

Finally, a single study which used UTAUT with minor changes was found, and reported a reasonably high rate. It reported (76.8%) of the total variance in doctors' and nurses' Behavioural Intention to adopt EHR systems, and concluded that the minor changes made to the UTAUT model were useful in the healthcare context [134]. This rate is speculated to have been a coincidence, as the study's circumstances might have happened to be very common for such a generic model to perform that well.

Table 40: Total Explained Variance Reported by Similar Studies

Study's Reference #	Sample Size	Total Explained Variance
[127]	256 Doctors	Unreported
[18]	141 Doctors	- UTAUT (20%) -Reduced UTAUT (44%)
[128]	8 Doctors	Unreported
[129]	92 Healthcare Managers and Supervisors	Unreported
[126]	23 Nurses	Unreported
[130]	196 Doctors	Unreported
[132]	1323 Healthcare Professionals	Approximately (> 50%)
[133]	52 Nurses and Doctor Assistants	Between (28.2% and 51.1%)
[134]	113 Doctors and Nurses	UTAUT with minor changes (76.8%)
[135]	Unspecified (used doctors' EHR system logs)	Inapplicable
[137]	1605 Occupational Therapists	UTAUT direct-effect only (63%)

7.4.2 Comparable UTAUT Extensions

The literature presented a number of attempts to adapt UTAUT to the healthcare practice. However, each extension of the model was unique, in the sense that it was designed to serve a specific objective, which makes comparing them difficult [Table 41]. For comparisons to make sense, they cannot overlook a given study's context, which includes: technology or system studied, study objective, time and duration of study, sample size and description, type of data collected, research methods used, statistical measures chosen, theoretical model or framework applied (if any), and desired outcomes. Otherwise, the comparisons would not be fair nor make much sense. Examples of added socio-technical factors were uncommon or inexplicit. Thus, Kok et al., 2011, wanted to identify the main technological and organisational factors affecting doctors' adoption of HER, so they used UTAUT with four additional variables (organisational characteristics, system characteristics, external factors, and interdependency) [128]. Their extended model was able to report that end-users were dissatisfied with some features, and concluded that adopting a system becomes more likely when it meets the end-user' requirements. Similarly, Whitten et al., 2010, wanted to identify key organisational characteristics that make a successful telemedicine programme, so they used a combination of UTAUT and OCR assessment [129]. Their extended model was able to report the features that make a successful telemedicine programme accurately, and their conclusion described several important organisational characteristics to start new programmes. In addition, Hennington and Janz, 2007, wanted to explore doctors' adoption of EHR systems, so they used UTAUT with EHR-relevant questions covering three variables (financial performance, alignment with business processes, and improvement in the quality of care provided) [135]. Their extended model was found to be a good start to explaining doctors' adoption of EHR systems. These three studies are particularly similar to this endeavour in two ways: 1- although they have not used the term socio-technical factors, they have effectively incorporated them; 2- they pinpointed some System-Specific Features which either needed to be improved or were validated [Table 41].

Moreover, the relevance of context is important to adapt and extend theoretical models, as much as it is important to correctly interpret their results. In spite of the variances noticed in the literature, once studies are positioned into their own context or compared with similar studies as a whole (not just as reported numbers); the ambiguity starts to fade away. For instance, the Venkatesh et al., 2011, study mentioned earlier for its lack of support to use UTAUT in the healthcare context [18]. When it was scrutinised, it became obvious that the model was not adapted to suit the complex environment in which it was applied, and that is a complete disregard of the all-important socio-technical aspects involved. Yet, this finding is useful so that future researchers take such factors into consideration. In fact, the Schaper and Pervan, 2007 study recommendations had explicitly warned against the inadequacy of using generic Technology Acceptance Models in the healthcare environment without appropriate adaptations [136], and proposed a framework with socio-technical aspects (covering technical, social, and organisational factors), these were originally suggested by Chau and Hu, 2002 [138]. In addition, this study had also recommended embracing a more holistic and inclusive view of such complex systems, and so did the Hennington et al., 2009 study [126]. This is also the opinion of other experienced researchers who are heavily involved with sizable healthcare projects [47] [66]. Consequently, the model extension applied in this research study seems to outperform the ones described in the literature, principally because it took these points into consideration and acted upon them.

Table 41: Summary of UTAUT Applications in Healthcare

Study's Reference #	UTAUT, Extension, and/or Reduction
[127]	- UTAUT + medical specialty, personality traits, and general openness to change in the work place. - Included Variables: age, gender, computer self-efficacy, job role, medical specialty, personality traits, and general openness to change in the work place.
[18]	- UTAUT. - Reduced UTAUT (only age as a moderator).
[128]	- UTAUT + organisational characteristics, system characteristics, external factors, and interdependency. - Included Variables: quality of care, sharing, medical history, time saving, archiving, search ability, user interface, and data preservation.
[129]	- A combination of UTAUT and OCR assessment.
[126]	- UTAUT + time spent using the system, timing of use, and mode of use.
[130]	- UTAUT + culture. - Culture was measured according to four dimensions: power versus distance, individualism versus collectivism, masculinity versus femininity, and uncertainly versus avoidance. These were originally suggested by Hofstede, 1980 [131].
[132]	- UTAUT
[133]	- UTAUT with two minor changes: excluded the moderators and (Social Influence) became a direct determinant of Behavioural Intention.
[134]	- UTAUT with two minor changes: excluded the moderators and (Facilitating Conditions) became a direct determinant of Behavioural Intention.
[135]	- UTAUT + HER-relevant questions covering three variables: financial performance, alignment with business processes, and improvement in the quality of care provided.
[137]	- UTAUT + socio-technical factors covering social, technical, and organisational aspects. These were originally suggested by Chau and Hu, 2002 [138].

7.5 Conclusion

The literature offered a number of Technology Acceptance Models that could be useful to evaluate technology in healthcare, and this research study was guided by them from the beginning. The suitability as to applying them has been thoroughly evaluated and discussed in Chapter 2. As a result, a Hypothesised Model was developed with the flexibility to accommodate predefined socio-technical factors which are situation-specific, on the basis of one of these valid theoretical models. The Hypothesised Model was built on the basis of UTAUT as a validated and dependable theoretical model, yet it was extended and simplified in a way that would help future evaluation studies yield more meaningful results. Accordingly, the Hypothesised Model seems to have performed better than most of the available attempts found in similar healthcare contexts.

Moreover, the suitability of adapting UTAUT to the healthcare context has been validated by applying the Hypothesised Model to evaluate three allocated HIT systems which are still at the “designing/prototyping/demonstrating” phase. The reported evidence reflects its competence for assessing end-users’ system acceptance and predicting the future use of these systems. Hence, the suggested seven to eight core constructs together seem to explain majority of the healthcare professionals’ Behavioural Intention to use the tested HIT systems [Figure 5] [Table 39].

Consequently, having a Hypothesised Model that has the ability to answer particular questions, at a particular point in time, relevant to a particular situation, appear to outperform the use of generic models within the healthcare context [Tables 40 and 41]. This finding is a contribution to the general phenomena of understanding professional end-users’ acceptance and utilisation of technology, as much as it is a contribution to the understanding of what the complex healthcare environment entails. Thus, the acquisition of HIT systems makes them part of bigger and evolving socio-technical systems which cannot be studied separately from their environments. Finally, it is this researcher's strong conviction that future studies should definitely embrace a holistic approach when introducing technology in healthcare.

CHAPTER 8: Research Conclusions

This chapter concludes the research study by mentioning the challenges encountered and how they impacted the presented sample sizes. Then, it provides some thought-provoking theoretical contributions and a concise guidance to mangers about the impotence of conducting evaluation studies. Finally, it offers some suggestions for future work.

8.1 Limitations

There were some challenges associated with the data collection phase. The balance between establishing a statistically adequate sample size, and the response time was extremely problematic in this research study. Primarily, the target population was exceptionally rare and highly specialised. Mostly healthcare professionals who are also clinical researchers, and happened to be using one of the three innovative HIT systems allocated for evaluation. Besides this, only some of these professionals were willing to participate in each study. Consequently, three studies were carried out involving fifty-seven, twenty-one, and twenty-two participants, respectively (comparable samples were listed in [Table 40]).

Moreover, the response time at the data collection phase had suffered severe delays. In spite of unbroken communication with the involved stakeholders, each study took a lot longer than planned. Hence, the target participants were extremely preoccupied with their work responsibilities and that had naturally taken priority over any additional tasks, like filling questionnaires. Perhaps bigger samples could have been collected if some kind of incentive was available, such as: a financial compensation, half a day off for participants, or maybe additional staffing to back up the endeavour [1]. However, this was not feasible, so the duration of each study was increased by several months instead. Even then, the RDE and DQT studies did not achieve their target sample sizes (another twenty participants in each study were supposed to respond, but failed to meet the deadline despite extending it four times over a period of twelve months).

8.2 Theoretical Contributions

Carrying out three evaluation studies on similar HIT systems has been a step towards comprehending the reason why the UTAUT and extensions of it tend to produce different results. Thinking of how unique technologies and systems become when incorporated as part of bigger socio-technical systems could unravel this mystery. Even the same technology or system could behave differently when integrated with bigger socio-technical systems [1]. This trend depends on an array of dynamics like: the relevant department's/organisation's workflow, end-users' skills and motivation, and used functionalities [5].

At first, the literature available on the uses of UTAUT within the healthcare context seemed to present conflicting opinions with regards to its fit appropriateness and future prediction accuracy [Tables 40 and 41]. However, with closer scrutiny, it had become clear that understanding each study involves its entire context, including: objective, time or stage of evaluation, sample size, type of data collected, research method, investigated technology or system, model or framework (if applicable), and desired findings. Subsequently, understanding a study as a whole could explain the conflicting opinions. Each of these studies is unique, and therefore the problem might not necessarily be associated with the UTAUT's capacity of explaining the variance in Behavioural Intention or actual Use Behaviour. Rather, it might be associated with the lack of extending it appropriately to fit a specific context well.

This reflection might be a very valuable contribution to unravelling the opposing UTAUT results and recommendations, not only within the healthcare literature but also within the information systems literature. In brief, UTAUT extensions need to be based on solid and thorough understanding of both, the technology or system being evaluated, and the context in which it will be deployed.

Moreover, it has become obvious that UTAUT is not as structured as it was once believed to be. This has been confirmed by applying both, correlations and PCA analysis to the three datasets gathered for this research study. The findings collectively demonstrate that **Performance Expectancy is the strongest determinant of Behavioural Intention by a large margin**, yet it encompasses elements of all (or most of) the other core constructs [Figures 15, 16, and 17]. Interestingly, the contemporary investigated HIT end-users seem to take a given piece of technology or system as a complete package (or as one unit). For example, its Performance Expectancy is not perceived to be separate from its Effort Expectancy or System-Specific Features. Likewise, the offered Facilitating Conditions also cover the Adaptation Timeline allowed for them to develop the necessary skills for using it. Furthermore, the effect of Social Influence in the workplace, might work for or against end-users' Technology Anxiety. These core constructs overlap and regroup slightly differently, but collectively they indicate that when change is emerging, they do indeed complement one another.

8.3 Guidance to Managers

The likelihood of HIT systems acceptance and utilisation increases when their concept and preliminary requirements meet the end-users' needs.

Knowing, managing, and adjusting the socio-technical factors which influence the intention of contemporary healthcare professionals to use HIT systems, would help in maximising their impact. It would also help in engineering or procuring the most suitable product for the end-users' needs, and in achieving the planned goals. This is particularly true with the availability of cutting edge technologies and systems that are capable of delivering what is needed, and supporting professionals in their work. However, these technologies and systems need to be designed and evaluated with joint optimisation in mind.

It is recommended that project managers execute an evaluation study (or an exploratory study), similar to this research study, in order to ascertain whether a given piece of technology is definitely desirable in a given department or organisation before spending valuable time, resources, and efforts engineering or procuring it in the first place. This author's view is that the earlier the better, and the rationale is that, pointing projects in the right direction is usually easily managed in the early stages. If the results come out in support of the technology's concept and preliminary requirements, then proceed. If not, a better choice could be made early on. This might seem like an extra chore in most healthcare projects, but it is definitely much better than putting forward a technology that will be underutilised or rejected for not being suitable to begin with. Such a study will also help developers in communicating with and getting feedback from their clients, especially when it comes to essential matters, such as: whether they correctly understood their client's needs, whether the project is progressing in the right direction, and whether their design is user-friendly. It is through this communication and feedback that the gap between healthcare professionals and IT teams could be bridged.

8.4 Future Work

It is proposed that it would be sensible that future researchers become more attentive to the fact that most Technology Acceptance Models and their extensions are usually done to study technologies or systems within a specific situation. In other words, their uses are context-specific. This is especially true for healthcare, because with all the socio-technical factors involved, the reported evidence is usually associated with the extended model's applicability to the specific situation in which it was applied. Therefore, tendencies to "standardise" and "generalise" them should be avoided. Instead, researchers could benefit from these models as effective tools to evaluate technologies and systems at the early stages of projects, in order to support their design and facilitate their deployment, as well as reduce the risk of underutilisation or rejection.

Although these models are very practical to validate and/or give indicators to modify a given system's concept and preliminary requirements, they need to be adapted with suitable factors in order for them to produce meaningful results. Nevertheless, competent core constructs (or determinants) should be considered and made use of if relevant, otherwise exploring and investigating new ones is a good alternative. Hence, this is what this research study has done with regards to the added core constructs: (System-Specific Features, Technology Anxiety, and Adaptation Timeline) [Table 42]. Overall, the added core constructs proved to be very relevant to the Clinical Trial Management Systems context. Whether they would be applicable for other contexts needs to be investigated in future studies.

Table 42: Summary of the Added Core Constructs' Reliability

Study	Added Constructs	Cronbach's Alpha
ePCRN	Technology Anxiety	0.7
	Adaptation Timeline	0.9
RDE	RDE-Specific Features	0.9
	Technology Anxiety	0.9
DQT	DQT-Specific Features	0.9
	Technology Anxiety	0.9
	Adaptation Timeline	0.9

Appendix A: Informed Consent

Appendix B: ePCRN Questionnaire

Appendix C: ePCRN Workbook 1.2

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Appendix D: RDE Questionnaire

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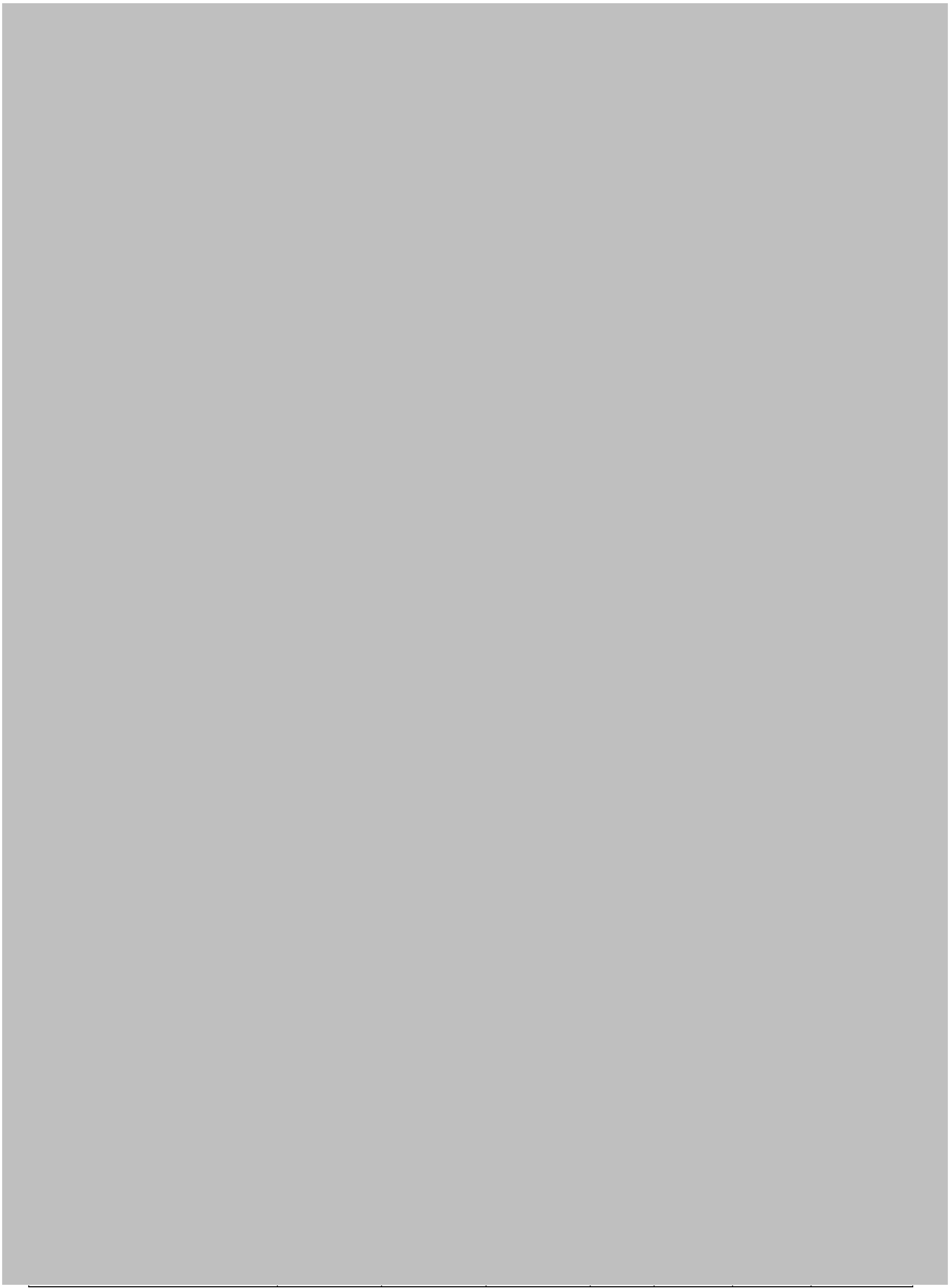
Appendix E: DQT Questionnaire



Appendix F: ePCRN Spearman's Correlations (+ Moderators)

		Age	Gender	Exp.	Specialty	Vol.	PE	EE	SI	FC	TA	AT	BI
Age	Correlation Coefficient	1.000											
	Sig. (2-tailed)	.											
Gender	Correlation Coefficient	-0.152	1.000										
	Sig. (2-tailed)	0.260	.										
Exp.	Correlation Coefficient	.402**	0.014	1.000									
	Sig. (2-tailed)	0.002	0.918	.									
Specialty	Correlation Coefficient	-.267*	.422**	-0.038	1.000								
	Sig. (2-tailed)	0.045	0.001	0.781	.								
Vol.	Correlation Coefficient	0.198	0.052	0.020	-0.186	1.000							
	Sig. (2-tailed)	0.140	0.699	0.885	0.165	.							
PE	Correlation Coefficient	-.428**	0.057	-0.027	.349**	-.402**	1.000						
	Sig. (2-tailed)	0.001	0.676	0.845	0.008	0.002	.						
EE	Correlation Coefficient	-0.108	0.084	0.052	-0.051	-0.083	0.195	1.000					
	Sig. (2-tailed)	0.424	0.536	0.701	0.706	0.541	0.146	.					
SI	Correlation Coefficient	-.382**	0.120	-0.051	0.159	-0.169	.548**	.394**	1.000				
	Sig. (2-tailed)	0.003	0.374	0.707	0.236	0.209	0.000	0.002	.				
FC	Correlation Coefficient	-0.104	-0.006	-0.023	-0.138	-0.157	.362**	.502**	.534**	1.000			
	Sig. (2-tailed)	0.440	0.967	0.866	0.305	0.243	0.006	0.000	0.000	.			
TA	Correlation Coefficient	0.015	-0.129	0.245	0.029	-0.186	.351**	0.206	0.176	.326*	1.000		
	Sig. (2-tailed)	0.912	0.340	0.066	0.830	0.166	0.007	0.123	0.190	0.013	.		
AT	Correlation Coefficient	-.411**	0.198	0.037	.312*	-.269*	.527**	.374**	.451**	.565**	.346**	1.000	
	Sig. (2-tailed)	0.001	0.141	0.786	0.018	0.043	0.000	0.004	0.000	0.000	0.008	.	
BI	Correlation Coefficient	-0.252	0.118	0.060	0.212	-.370**	.600**	0.105	0.172	.298*	.394**	.509**	1.000
	Sig. (2-tailed)	0.059	0.384	0.659	0.114	0.005	0.000	0.436	0.200	0.025	0.002	0.000	.

Appendix G: RDE Spearman's Correlations (+ Moderators)

		Age	Gender	Exp.	Specialty	Vol.	PE	EE	SI	FC	SF	TA	BI
Age	Correlation Coefficient	1.000											
	Sig. (2-tailed)	.											
Gender	Correlation Coefficient	0.221	1.000										
	Sig. (2-tailed)	0.335	.										
Exp.	Correlation Coefficient	0.343	0.427	1.000									
	Sig. (2-tailed)	0.127	0.053	.									
Specialty	Correlation Coefficient	-.439*	-.594**	-0.335	1.000								
	Sig. (2-tailed)	0.047	0.004	0.137	.								
Vol.	Correlation Coefficient	0.082	-0.229	-0.386	-0.021	1.000							
	Sig. (2-tailed)	0.725	0.318	0.084	0.929	.							
PE	Correlation Coefficient	-0.082	0.280	.453*	-0.168	-.612**	1.000						
	Sig. (2-tailed)	0.723	0.219	0.039	0.467	0.003	.						
EE	Correlation Coefficient	0.247	.482*	.698**	-0.286	-.573**	.754**	1.000					
	Sig. (2-tailed)	0.281	0.027	0.000	0.209	0.007	0.000	.					
SI	Correlation Coefficient	-0.048	0.098	0.266	-0.143	-.466*	.620**	.534*	1.000				
	Sig. (2-tailed)	0.836	0.672	0.244	0.537	0.033	0.003	0.013	.				
FC	Correlation Coefficient	0.262	.483*	.761**	-0.360	-.524*	.651**	.849**	.641**	1.000			
	Sig. (2-tailed)	0.252	0.027	0.000	0.109	0.015	0.001	0.000	0.002	.			
SF	Correlation Coefficient	0.310	.527*	.497*	-0.247	-0.423	.447*	.784**	.517*	.705**	1.000		
	Sig. (2-tailed)	0.172	0.014	0.022	0.280	0.056	0.042	0.000	0.016	0.000	.		
TA	Correlation Coefficient	-0.057	-0.018	0.109	-0.126	-0.043	0.259	.468*	0.266	0.207	0.371	1.000	
	Sig. (2-tailed)	0.806	0.939	0.637	0.587	0.854	0.258	0.032	0.243	0.367	0.098	.	
BI	Correlation Coefficient	-0.017	0.292	.445*	-0.285	-.444*	.741**	.813**	.678**	.606**	.692**	.665**	1.000
	Sig. (2-tailed)	0.942	0.200	0.043	0.211	0.044	0.000	0.000	0.001	0.004	0.001	0.001	.

Appendix H: DQT Spearman's Correlations (+ Moderators)

		Age	Gender	Exp.	Specialty	Vol.	PE	EE	SI	FC	SF	TA	AT	BI
Age	Correlation Coefficient	1.000												
	Sig. (2-tailed)	.												
Gender	Correlation Coefficient	-.479*	1.000											
	Sig. (2-tailed)	0.024	.											
Exp.	Correlation Coefficient	.536*	-0.256	1.000										
	Sig. (2-tailed)	0.026	0.322	.										
Specialty	Correlation Coefficient	0.237	-0.116	-0.110	1.000									
	Sig. (2-tailed)	0.289	0.607	0.675	.									
Vol.	Correlation Coefficient	-0.003	0.042	-0.065	0.218	1.000								
	Sig. (2-tailed)	0.990	0.853	0.804	0.330	.								
PE	Correlation Coefficient	-0.153	-0.195	0.005	-.514*	-0.383	1.000							
	Sig. (2-tailed)	0.497	0.384	0.986	0.014	0.078	.							
EE	Correlation Coefficient	-0.013	-0.342	-0.294	-0.350	-0.241	.755**	1.000						
	Sig. (2-tailed)	0.955	0.119	0.252	0.110	0.280	0.000	.						
SI	Correlation Coefficient	0.228	-.474*	0.087	-0.338	-0.349	.567**	.601**	1.000					
	Sig. (2-tailed)	0.308	0.026	0.740	0.124	0.111	0.006	0.003	.					
FC	Correlation Coefficient	-0.120	-0.263	-0.233	-.496*	-0.279	.732**	.806**	.534*	1.000				
	Sig. (2-tailed)	0.595	0.237	0.369	0.019	0.209	0.000	0.000	0.010	.				
SF	Correlation Coefficient	-0.393	-0.036	-0.221	-0.271	-0.337	0.417	0.415	0.337	.562**	1.000			
	Sig. (2-tailed)	0.070	0.872	0.393	0.223	0.126	0.054	0.055	0.125	0.006	.			
TA	Correlation Coefficient	0.025	-0.066	0.239	-0.053	-0.042	0.370	.536*	0.303	0.301	0.193	1.000		
	Sig. (2-tailed)	0.913	0.772	0.356	0.815	0.852	0.090	0.010	0.171	0.173	0.389	.		
AT	Correlation Coefficient	-0.102	-0.217	-0.094	-0.144	-0.336	.711**	.656**	0.400	.765**	.554**	0.271	1.000	
	Sig. (2-tailed)	0.653	0.333	0.720	0.522	0.126	0.000	0.001	0.065	0.000	0.007	0.223	.	
BI	Correlation Coefficient	-0.144	-0.051	0.141	-0.378	-.508*	.665**	.457*	.435*	.547**	0.298	0.388	.628**	1.000
	Sig. (2-tailed)	0.523	0.822	0.588	0.083	0.016	0.001	0.032	0.043	0.008	0.179	0.075	0.002	.

REFERENCES

1. Ammenwerth, E., et al., *Evaluation of health information systems—problems and challenges.* International journal of medical informatics, 2003. **71**(2): p. 125-135.
2. Tang, D. and L. Chen. *A review of the evolution of research on information Technology Acceptance Model*. in *Business Management and Electronic Information (BMEI), 2011 International Conference on*. 2011.
3. *e-Learning for Healthcare*. 15 Dec 2014 15 Dec 2014]; Available from: http://www.e-lfh.org.uk/programmes/health-informatics/.
4. Callen, J.L., J. Braithwaite, and J.I. Westbrook, *Contextual Implementation Model: A Framework for Assisting Clinical Information System Implementations.* Journal of the American Medical Informatics Association, 2008. **15**(2): p. 255-262.
5. Lorenzi, N.M., et al., *Crossing the implementation chasm: a proposal for bold action.* J Am Med Inform Assoc, 2008. **15**(3): p. 290-6.
6. Han, Y.Y., et al., *Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system.* Pediatrics, 2005. **116**(6): p. 1506-1512.
7. Lorenzi, N.M. and R.T. Riley, *Organizational aspects of health informatics: Managing technological change*. 1995, New York: Springer-Verlag.
8. Zayim, N., S. Bozkurt, and M.K. Samur. *Organizational issues in health informatics applications: Findings from a systematic review*. in *Biomedical Engineering and Informatics (BMEI), 2011 4th International Conference on*. 2011.
9. Poon, E.G., et al., *Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals.* Health Aff (Millwood), 2004. **23**(4): p. 184-90.
10. Hostgaard, A.M. and C. Nohr, *Dealing with organizational change when implementing EHR systems.* Stud Health Technol Inform, 2004. **107**(Pt 1): p. 631-4.
11. Holden, R.J. and B.-T. Karsh, *The Technology Acceptance Model: Its past and its future in health care.* Journal of Biomedical Informatics, 2010. **43**(1): p. 159-172.
12. Davis, F.D., *User acceptance of information technology: system characteristics, user perceptions and behavioral impacts.* International Journal of Man-Machine Studies, 1993. **38**(3): p. 475-487.
13. Anderson, J.G., *Clearing the way for physicians' use of clinical information systems.* Commun. ACM, 1997. **40**(8): p. 83-90.
14. Poon, E.G., et al., *Assessing the level of healthcare information technology adoption in the United States: a snapshot*. 2006, BioMed Central Ltd.
15. Saleem, J.J., et al., *Current challenges and opportunities for better integration of human factors research with development of clinical information systems.* Yearb Med Inform, 2009: p. 48-58.
16. Sullivan, F. and J.C. Wyatt, *ABC of Health Informatics*. ABC. 2009: Blackwell Publishing Ltd.

17. Venkatesh, V., et al., *User Acceptance of Information Technology: Toward a Unified View*. MIS Quarterly, 2003. **27**(3): p. 425-478.
18. Venkatesh, V., T.A. Sykes, and Z. Xiaojun. *'Just What the Doctor Ordered': A Revised UTAUT for EMR System Adoption and Use by Doctors*. in *System Sciences (HICSS), 2011 44th Hawaii International Conference on*. 2011.
19. Davis, F.D., *Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology*. MIS Quarterly, 1989. **13**(3): p. 319-340.
20. Davis, F.D., R.P. Bagozzi, and P.R. Warshaw, *User Acceptance of Computer Technology: A Comparison of Two Theoretical Models.* Management Science, 1989. **35**(8): p. 982-1003.
21. Baxter, G., et al., *Socio-Technical Systems Engineering Handbook*. p. 103.
22. Sommerville, I., *Introducing sociotechnical systems*. 2013.
23. Klein, L., *What do we actually mean by 'sociotechnical'? On values, boundaries and the problems of language.* Applied Ergonomics, 2014. **45**(2, Part A): p. 137-142.
24. Trist, E. and K. Bamforth, *Some social and psychological consequences of the Longwall method.* Human relations, 1951. **4**(3): p. 3-38.
25. Weisbord, M.R., *Productive Workplaces: Dignity, Meaning and Community in the 21st Century* 2012, New York: Jossey-Bass.
26. Eason, K., *Afterword: The past, present and future of sociotechnical systems theory.* Applied Ergonomics, 2014. **45**(2, Part A): p. 213-220.
27. Cherns, A., *The Principles of Sociotechnical Design.* Human Relations, 1976. **29**(8): p. 783-792.
28. Cherns, A., *Principles of Sociotechnical Design Revisted.* Human Relations, 1987. **40**(3): p. 153-161.
29. Clegg, C.W., *Sociotechnical principles for system design.* Applied Ergonomics, 2000. **31**(5): p. 463-477.
30. Davis, L.E., *The coming crisis for production management: technology and organization.* International Journal of Production Research, 1971. **9**(1): p. 65.
31. Taylor, J.C., *Job Design Criteria Twenty Years Later*. 2nd ed. ed. 1977, Santa Monica, CA: Goodyear Press.
32. Waterson, P., et al., *Defining the methodological challenges and opportunities for an effective science of sociotechnical systems and safety.* Ergonomics, 2015. **58**(4): p. 565-599.
33. Katz, D. and R. Kahn, *The Social Psychology of Organisations*. 1966, New York: Wiley.
34. Davis, M.C., et al., *Advancing socio-technical systems thinking: A call for bravery.* Applied Ergonomics, 2014. **45**(2, Part A): p. 171-180.
35. Waterson, P., T. Stewart, and L. Damodaran, *Advances in sociotechnical systems understanding and design: A Festschrift in honour of K.D. Eason.* Applied Ergonomics, 2014. **45**(2, Part A): p. 133-136.
36. Sommerville, I., *sociotechnical systems*. 2010.
37. Sommerville, I., *System success and failure*. 2013.

38. Sommerville, I., *Socio-technical systems failure*. 2012.
39. Eason, K. and P. Waterson, *Fitness for purpose when there are many different purposes: Who are electronic patient records for?* Health Informatics Journal, 2014. **20**(3): p. 189-198.
40. Berg, M., *Patient care information systems and health care work: a sociotechnical approach.* International Journal of Medical Informatics. **55**(2): p. 87-101.
41. Aarts, J. and P. Gorman, *IT in health care: sociotechnical approaches "To Err is System".* International journal of medical informatics, 2007. **76**: p. S1-S3.
42. Berg, M., J. Aarts, and J. van der Lei, *ICT in health care: sociotechnical approaches.* Methods of information in medicine, 2003(42): p. 297-301.
43. Giuse, D.A. and K.A. Kuhn, *Health information systems challenges: the Heidelberg conference and the future.* International journal of medical informatics, 2003. **69**(2): p. 105-114.
44. Brandt, C.A., et al., *Reengineering a database for clinical trials management: lessons for system architects.* Controlled clinical trials, 2000. **21**(5): p. 440-461.
45. Eason, K., *Local sociotechnical system development in the NHS National Programme for Information Technology.* Journal of Information Technology, 2007. **22**(3): p. 257-264.
46. Fairey, M., *The need to be needed.* The British Journal of Healthcare Computing & Information Management, 2005. **22**(5): p. 3-4.
47. Eason, K. and P. Waterson, *The implications of e-health system delivery strategies for integrated healthcare: Lessons from England.* International journal of medical informatics, 2013. **82**(5): p. e96-e106.
48. Beynon-Davies, P., *Human error and information systems failure: the case of the London ambulance service computer-aided despatch system project.* Interacting with Computers, 1999. **11**(6): p. 699-720.
49. Heeks, R., *Information systems and developing countries: Failure, success, and local improvisations.* The information society, 2002. **18**(2): p. 101-112.
50. Littlejohns, P., J.C. Wyatt, and L. Garvican, *Evaluating computerised health information systems: hard lessons still to be learnt*. Vol. 326. 2003. 860-863.
51. Kaplan, B. and N. Shaw, *Future directions in evaluation research: people, organizational, and social issues.* Methods of Information in Medicine-Methodik der Information in der Medizin, 2004. **43**(3): p. 215-231.
52. Whetton, S., *Health informatics: a socio-technical perspective.* 2005.
53. Poon, P. and C. Wagner, *Critical success factors revisited: success and failure cases of information systems for senior executives.* Decision Support Systems, 2001. **30**(4): p. 393-418.
54. Ward, R., et al., *The attitudes of health care staff to information technology: a comprehensive review of the research literature.* Health Information & Libraries Journal, 2008. **25**(2): p. 81-97.
55. Berg, M., *Implementing information systems in health care organizations: myths and challenges.* International Journal of Medical Informatics, 2001. **64**(2-3): p. 143-156.

56. Lorenzi, N.M., et al., *Antecedents of the people and organizational aspects of medical informatics review of the literature.* Journal of the American Medical Informatics Association, 1997. **4**(2): p. 79-93.
57. Button, G., *Technology in working order: Studies of work, interaction, and technology*. 1993: Routledge.
58. Schneider, K. and I. Wagner, *Constructing the 'Dossier Représentatif'.* Computer Supported Cooperative Work (CSCW), 1992. **1**(4): p. 229-253.
59. Bowers, J., *Making it work: a field study of a "CSCW network".* The Information Society, 1995. **11**(3): p. 189-207.
60. Woolgar, S., *Science, the very idea.* 1988.
61. Kaplan, B., *Evaluating informatics applications—some alternative approaches: theory, social interactionism, and call for methodological pluralism*. International journal of medical informatics, 2001. **64**(1): p. 39-56.
62. Markus, M.L. and C. Tanis, *The enterprise systems experience-from adoption to success.* Framing the domains of IT research: Glimpsing the future through the past, 2000. **173**: p. 207-173.
63. Johnson, C.W. *Case Studies in the Failure of Healthcare Informati on Systems* 2010; Available from: http://www.dcs.gla.ac.uk/~johnson/papers/AHRQ/case_study.pdf.
64. Brennan, S., *The NHS IT Project: The Biggest Computer Programme in the World-Ever!* 2005: Radcliffe Publishing.
65. Peltu, M., K. Eason, and C. Clegg, *How a Sociotechnical approach can help NPfIT deliver better NHS patient care.* British Computer Society. Accessed February, 2008. **7**: p. 2011.
66. Waterson, P., *Health information technology and sociotechnical systems: A progress report on recent developments within the UK National Health Service (NHS).* Applied ergonomics, 2014. **45**(2): p. 150-161.
67. *Healthcare Information and Management Systems Society (HIMSS)*. 2015; Available from: http://www.himss.org/library/ehr/?navItemNumber=13261.
68. Milan, J., *ENGLAND'S NATIONAL PROGRAMME-The NPfIT in London: A case study-The Royal Marsden NHS Foundation Trust find a mismatch between its needs and the policies of the NPfIT. Dr Jo Milan explains.* British Journal of Healthcare Computing and Information Management, 2005. **22**(2): p. 26-29.
69. Heinrich, L.J. and F. Lehner, *Informationsmanagement: Planung, Überwachung und Steuerung der Informationsinfrastruktur*. 2005: Oldenbourg Verlag.
70. Palvia, S.C., R.S. Sharma, and D.W. Conrath, *A socio-technical framework for quality assessment of computer information systems.* Industrial Management & Data Systems, 2001. **101**(5): p. 237-251.
71. Butler, M. and A.D. Bender, *Intensive care unit bedside documentation systems. Realizing cost savings and quality improvements.* Computers in Nursing, 1998. **17**(1): p. 32-8; quiz 39-40.

72. Heathfield, H.A., et al., *Evaluating large scale health information systems: from practice towards theory.* Proceedings of the AMIA Annual Fall Symposium, 1997: p. 116-120.
73. van Gennip, E.M.S.J. and J.L. Talmon, eds. *Assessment and evaluation of information technologies in medicine*. Studies in health technology and informatics Vol. 17. 1995, Amsterdam; Oxford.
74. Dewan, N.A. and N.M. Lorenzi, *Behavioral health information systems. Evaluating readiness and user acceptance.* MD Comput, 2000. **17**(4): p. 50-2.
75. Moehr, J.R., *Evaluation: salvation or nemesis of medical informatics?* Computers in Biology and Medicine, 2002. **32**(3): p. 113-125.
76. Appelbaum, S.H., *Socio-technical systems theory: an intervention strategy for organizational development.* Management Decision, 1997. **35**(6): p. 452-463.
77. Pasmore, W.A., *Designing effective organizations: The sociotechnical systems perspective*. Vol. 6. 1988: John Wiley & Sons Inc.
78. Grenville, N.D., *A Sociotechnical Approach to Evaluating the Effects of Managerial Time Allotment on Department Performance*, in *Industrial and Systems Engineering*. The Virginia Polytechnic Institute and State University. p. 176.
79. Trist, E., *The evolution of socio-technical systems.* Occasional paper, 1981. **2**: p. 1981.
80. Walker, G., et al., *Command and control: the sociotechnical perspective*. 2009: Ashgate Farnham,, UK.
81. Davis, L.E., *Evolving alternative organization designs: their sociotechnical bases.* Human Relations, 1977. **30**(3): p. 261-273.
82. Clegg, C., *The National Programme for IT (NPfIT)–Lessons from elsewhere.* Information Technology, 2008. **6**: p. 9.
83. Di Maio, P., *Towards a Metamodel to Support the Joint Optimization of Socio Technical Systems.* Systems, 2014. **2**(3): p. 273-296.
84. Van de Ven, A.H., *Central problems in the management of innovation.* Management science, 1986. **32**(5): p. 590-607.
85. Pasmore, W., et al., *Sociotechnical systems: A North American reflection on empirical studies of the seventies.* Human relations, 1982. **35**(12): p. 1179-1204.
86. Hackman, J.R. and G.R. Oldham, *Motivation through the design of work: Test of a theory.* Organizational behavior and human performance, 1976. **16**(2): p. 250-279.
87. De Sitter, L.U., J.F. Den Hertog, and B. Dankbaarl, *From complex organizations with simple jobs to simple organizations with complex jobs.* Human relations, 1997. **50**(5): p. 497-534.
88. De Carvalho, P.V., *Ergonomic field studies in a nuclear power plant control room.* Progress in Nuclear Energy, 2006. **48**(1): p. 51-69.
89. Chems, A., *Principles of Socio-technical Design Revisited.* Human Relations, 1987. **40**(3): p. 153-162.
90. Mavor, A.S. and R.W. Pew, *Human-System Integration in the System Development Process:: A New Look*. 2007: National Academies Press.

91. Stanton, N.A., et al., *Handbook of human factors and ergonomics methods*. 2004: CRC Press.
92. Holden, R.J. and B.-T. Karsh, *A theoretical model of health information technology usage behaviour with implications for patient safety.* Behaviour & Information Technology, 2009. **28**(1): p. 21 - 38.
93. Mezni, H., *Adoption of Telehealth by Healthcare Professionals: An Overview of Theoretical Models and Their Application.* MCIS 2008 Proceedings, 2008: p. 38.
94. Wu, I.-L. and J.-L. Chen, *An extension of trust and TAM model with TPB in the initial adoption of on-line tax: an empirical study.* International Journal of Human-Computer Studies, 2005. **62**(6): p. 784-808.
95. Triandis, H.C., *Interpersonal behavior*. 1977: Brooks/Cole Publishing Company Monterey, CA.
96. Challenger, R., C.W. Clegg, and C. Shepherd, *Function allocation in complex systems: reframing an old problem.* Ergonomics, 2013. **56**(7): p. 1051-1069.
97. Turner, M., et al., *Does the technology acceptance model predict actual use? A systematic literature review.* Information and Software Technology, 2010. **52**(5): p. 463-479.
98. Sheppard, B.H., J. Hartwick, and P.R. Warshaw, *The Theory of Reasoned Action: A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research.* Journal of Consumer Research, 1988. **15**(3): p. 325.
99. Fishbein, M. and I. Ajzen, *Belief, attitude, intention and behavior: An introduction to theory and research*. 1975.
100. Venkatesh, V. and F.D. Davis, *A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies.* Management Science, 2000. **46**(2): p. 186-204.
101. Vallerand, R.J., *Toward a hierarchical model of intrinsic and extrinsic motivation.* 1997.
102. Davis, F.D., R.P. Bagozzi, and P.R. Warshaw, *Extrinsic and intrinsic motivation to use computers in the workplace1*. Journal of applied social psychology, 1992. **22**(14): p. 1111-1132.
103. Ajzen, I., *The theory of planned behavior.* Organizational behavior and human decision processes, 1991. **50**(2): p. 179-211.
104. Taylor, S. and P.A. Todd, *Understanding Information Technology Usage: A Test of Competing Models.* Information Systems Research, 1995. **6**(2): p. 144-176.
105. Mathieson, K., *Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior.* Information Systems Research, 1991. **2**(3): p. 173-191.
106. Harrison, D.A., P.P. Mykytyn Jr, and C.K. Riemenschneider, *Executive decisions about adoption of information technology in small business: theory and empirical tests.* Information Systems Research, 1997. **8**(2): p. 171-195.
107. Taylor, S. and P. Todd, *Assessing IT Usage: The Role of Prior Experience.* MIS Quarterly, 1995. **19**(4): p. 561-570.

108. Thompson, R.L., C.A. Higgins, and J.M. Howell, *Personal Computing: Toward a Conceptual Model of Utilization.* MIS Quarterly, 1991. **15**(1): p. 125-143.
109. Rogers, E.M. and F.F. Shoemaker, *Communication of Innovations; A Cross-Cultural Approach.* 1971.
110. Roger, E.M., *Diffusion of innovations.* New York: Free Press, 1995. **41**: p. 1002-1037.
111. Moore, G.C. and I. Benbasat, *Development of an instrument to measure the perceptions of adopting an information technology innovation.* Information systems research, 1991. **2**(3): p. 192-222.
112. Tornatzky, L.G. and K.J. Klein, *Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings.* IEEE Transactions on engineering management, 1982. **29**(1): p. 28-45.
113. Moore, G.C. and I. Benbasat, *Integrating diffusion of innovations and theory of reasoned action models to predict utilization of information technology by end-users*, in *Diffusion and adoption of information technology*. 1996, Springer. p. 132-146.
114. Bandura, A., *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall series in social learning theory. 1986.
115. Compeau, D.R. and C.A. Higgins, *Computer self-efficacy: Development of a measure and initial test.* MIS quarterly, 1995: p. 189-211.
116. Davis, F.D., *A technology acceptance model for empirically testing new end-user information systems : theory and results*. 1985, Massachusetts Institute of Technology.
117. Lee, Y., K.A. Kozar, and K.R.T. Larsen, *The Technology Acceptance Model: Past, Present, and Future.* Communications of the Association for Information Systems, 2003. **12**.
118. Venkatesh, V. and H. Bala, *Technology Acceptance Model 3 and a Research Agenda on Interventions.* Decision Sciences, 2008. **39**(2): p. 273-315.
119. Klein, R., *Internet-Based Patient-Physician Electronic Communication Applications: Patient Acceptance and Trust.* e-Service Journal 2007. **5**(2): p. 27-51.
120. Johns, G., *The Essential Impact of Context on Organizational Behavior.* The Academy of Management Review, 2006. **31**(2): p. 386-408.
121. Alvesson, M. and D.A.N. KÄRreman, *CONSTRUCTING MYSTERY: EMPIRICAL MATTERS IN THEORY DEVELOPMENT.* Academy of Management Review, 2007. **32**(4): p. 1265-1281.
122. Yarbrough, A.K. and T.B. Smith, *Technology Acceptance among Physicians.* Medical Care Research and Review, 2007. **64**(6): p. 650-672.
123. Mohamadali, N.A.K. and J.M. Garibaldi. *A Novel Evaluation Model of user Acceptance of Software Technology in Healthcare Sector*. in *Healthinf*. 2010.
124. Huang, K.-Y., N. Choi, and I.N. Chengalur-Smith. *Cultural Dimensions as Moderators of the UTAUT Model: a Research Proposal in a Healthcare Context*. in *AMCIS*. 2010.
125. Wen, H.-C., et al., *Scientific production of electronic health record research, 1991–2005.* Computer Methods and Programs in Biomedicine, 2007. **86**(2): p. 191-196.

126. Hennington, A., et al., *Information systems and healthcare XXXII: Understanding the multidimensionality of information systems use: A study of nurses' use of a mandated electronic medical record system.* Communications of the Association for Information Systems, 2009. **25**(1): p. 25.
127. Harle, C.A. and M.A. Dewar. *Factors in Physician Expectations of a Forthcoming Electronic Health Record Implementation*. in *System Science (HICSS), 2012 45th Hawaii International Conference on*. 2012. IEEE.
128. Kok, O., N. Basoglu, and T. Daim. *Exploring the success factors of Electronic Health Record systems adoption*. in *Technology Management in the Energy Smart World (PICMET), 2011 Proceedings of PICMET'11:*. 2011. IEEE.
129. Whitten, P., B. Holtz, and L. Nguyen, *Keys to a successful and sustainable telemedicine program.* International Journal of Technology Assessment in Health Care, 2010. **26**(02): p. 211-216.
130. Nwabueze, S.N., et al. *The Effects of Culture of Adoption of Telemedicine in Medically Underserved Communities*. in *System Sciences, 2009. HICSS '09. 42nd Hawaii International Conference on*. 2009.
131. Hofstede, G., *Culture's consequences. Beverly Hills*. 1980, Ca: Sage.
132. Kijsanayotin, B., S. Pannarunothai, and S.M. Speedie, *Factors influencing health information technology adoption in Thailand's community health centers: Applying the UTAUT model.* International Journal of Medical Informatics, 2009. **78**(6): p. 404-416.
133. Wills, M.J., O. El-Gayar, and D. Bennett, *Examining healthcare professionals' acceptance of electronic medical records using UTAUT.* Issues in Information Systems, 2008. **9**(2): p. 396-401.
134. Hamidfar, M., M. Limayem, and S.H. Zegordi. *Using the UTAUT Model to Explore Iranian Physicians and Nurses' Intention to Adopt Electronic Patient Records*. in *CSREA EEE*. 2008.
135. Hennington, A. and B.D. Janz, *Information systems and healthcare XVI: physician adoption of electronic medical records: applying the UTAUT model in a healthcare context.* Communications of the Association for Information Systems, 2007. **19**(1): p. 5.
136. Schaper, L.K. and G.P. Pervan. *An investigation of factors affecting technology acceptance and use decisions by Australian allied health therapists*. in *System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference on*. 2007. IEEE.
137. Schaper, L.K. and G.P. Pervan, *ICT and OTs: A model of information and communication technology acceptance and utilisation by occupational therapists.* International Journal of Medical Informatics, 2007. **76**(Supplement 1): p. S212-S221.
138. Chau, P.Y.K. and P.J. Hu, *Examining a Model of Information Technology Acceptance by Individual Professionals: An Exploratory Study.* Journal of Management Information Systems, 2002. **18**(4): p. 191-229.

139. LaLomia, M.J. and J.B. Sidowski, *Measurements of computer satisfaction, literacy, and aptitudes: A review.* International Journal of Human-Computer Interaction, 1990. **2**(3): p. 231-253.
140. LaLomia, M.J. and J.B. Sidowski, *Measurements of computer attitudes: A review.* International Journal of Human-Computer Interaction, 1991. **3**(2): p. 171-197.
141. Algharibi, A.J. and T.N. Arvanitis, *Adapting the unified theory of acceptance and use of technology (UTAUT) as a tool for validating user needs on the implementation of e-trial software systems*, in *Proceedings of the 25th BCS Conference on Human-Computer Interaction*. 2011, British Computer Society: Newcastle-upon-Tyne, United Kingdom. p. 526-530.
142. Bandura, A., *Human agency in social cognitive theory.* American Psychologist. **44**(9): p. 1175-1184.
143. LaLomia, M.J. and J.B. Sidowski, *Measurements of computer anxiety: A review.* International Journal of Human-Computer Interaction, 1993. **5**(3): p. 239-266.
144. William, G.C. and W.-P. Sonja, *Does the Extended Technology Acceptance Model Apply to Physicians*, in *Proceedings of the 36th Annual Hawaii International Conference on System Sciences (HICSS'03) - Track 6 - Volume 6*. 2003, IEEE Computer Society.
145. Field, A., *Discovering Statistics Using SPSS*. Third Edition ed. 2009, London: SAGE.
146. Kaiser, H., *An Index of Factorial Simplicity*. 1974. p. 31-36.
147. Hutcheson, G.D. and N. Sofroniou, *The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models*. 1999, London: Sage.
148. Falk, R.F. and N.B. Miller, *A primer for soft modeling*. 1992: University of Akron Press.
149. Poon, E.G., et al., *Communication factors in the follow-up of abnormal mammograms.* J Gen Intern Med, 2004. **19**(4): p. 316-23.
150. Leon, A.C., L.L. Davis, and H.C. Kraemer, *The Role and Interpretation of Pilot Studies in Clinical Research.* Journal of psychiatric research, 2011. **45**(5): p. 626-629.
151. Delaney, B.C., et al., *Envisioning a learning health care system: the electronic Primary Care Research Network, a case study.* The Annals of Family Medicine, 2012. **10**(1): p. 54-59.
152. Sullivan, F., et al., *Primary care research networks in the United Kingdom*. Vol. 334. 2007. 1093-1094.
153. Delaney, B., *Primary care research in the postmodern world.* Fam Pract, 2004. **21**(2): p. 123-4.
154. *European General Practice Research Network and its Mission for Strong Research in Primary Health Care.* European Journal of General Practice, 2007. **13**(1): p. 46-47.
155. Ohmann, C. and W. Kuchinke, *Future developments of medical informatics from the viewpoint of networked clinical research. Interoperability and integration.* Methods Inf Med, 2009. **48**(1): p. 45-54.

156. Peterson, K.A., P. Fontaine, and S. Speedie, *The Electronic Primary Care Research Network (ePCRN): a new era in practice-based research.* J Am Board Fam Med, 2006. **19**(1): p. 93-7.
157. Sim, I., et al., *The Electronic Primary Care Research Network: A Grid-Based Computing Infrastructure for Community-Based Clinical Trials in Primary Care.* Journal of General Internal Medicine 2007. **22**(59).
158. ePCRN. *The electronic Primary Care Research Network (ePCRN): Introducing a new era in practice based research*. 2006; Available from: http://www.epcrn.bham.ac.uk/Home/tabid/138/Default.aspx.
159. Tannen, R.L., M.G. Weiner, and D. Xie, *Use of primary care electronic medical record database in drug efficacy research on cardiovascular outcomes: comparison of database and randomised controlled trial findings*. Vol. 338. 2009.
160. Arvanitis, T., et al., *THE CHILDREN'S CANCER AND LEUKAEMIA GROUP (CCLG) FUNCTIONAL IMAGING E-REPOSITORY FOR CLINICAL TRIALS OF CHILDHOOD BRAIN TUMOURS.* 2010.
161. Arvanitis, T.N., et al., *Aiding the Diagnosis and Characterisation of Childhood Cancer: Software Design and Deployment of the Children's Cancer and Leukaemia Group (CCLG) Functional Imaging e-Repository for Clinical Trials of Childhood Brain Tumours*, in *Cancer Research UK*. 2011: UK.
162. *Transform: Translational Research and Patient Safety in Europe*. 4 Dec 2014 [cited 2014; Available from: http://www.transformproject.eu/.
163. McGinnis, J.M., *Evidence-based medicine - engineering the Learning Healthcare System.* Stud Health Technol Inform, 2010. **153**: p. 145-57.
164. Algharibi, A.J., et al., *Adapting the Unified Theory of Acceptance and Use of Technology (UTAUT) for Assessing Future Technology Adoption of an e-Trial Eligibility Criteria Capture and Query Generation Software Tool*, in *10th International Conference on Information Communication Technologies in Health (ICICHT SAMOS 2012).* 2012.
165. Simmons, C. and P. Lehmann, *Tools for Strengths-Based Assessment and Evaluation* 2013, LLC: Springer Publishing Company.
166. *SurveyMonkey*. 27 March 2015]; Available from: https://www.surveymonkey.com/.