Identifying the Value of a Clinical Information System during the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic has significantly augmented the urgency for service providers to identify and develop clinically urgent system alterations into healthcare systems to facilitate antibody testing and treatment interventions. However, it has been difficult to determine how users assess the value of an information system in terms of its functionality and features. Conversely, the system development process to address urgent user requirements, for example, developing new functionality for COVID antibody testing, has been beset by a myriad of difficulties as research to understand the value of specific aspects of clinical information systems has been elusive. This study addresses this knowledge gap by identifying specific aspects of a national clinical information system in Wales, UK. Through a series of semi-structured interviews, a quantitative study of 559 clinical users and a focus group, the study deconstructs system-related value into 14 unique attributes that have been found to vary according to different types of user roles and geographic location.

Attribution theory is identified in this study as a novel and effective way to study this multifaceted concept of system value. The identification of component attributes of the value of a clinical information system provides insights for service users, system developers, and organization managers to prioritize and focus their system development activity by using an importance ranking identified through this study.

Keywords: attribute; clinician; healthcare; information system; location; role; value.

1. Introduction

Digital technologies have enabled healthcare providers to adapt novel ways of providing services efficiently that have been changing the culture of service delivery (Academy of Medical Royal Colleges, 2018; Chao, Jen, Hung, Li and Chi, 2007). However, the growth in the use of digitization for clinical information systems has highlighted both opportunities and challenges to extract value from existing systems in order to deliver improved services (Wenzel and Evans, 2019). There is a need for systems to be developed that not only cope with increasing demands but are developed in such a way that they are also resilient to future unplanned events (Tortorella, Fogliatto, Saurin, Tonetto and McFarlane, 2021; Cobianchi, Dal Mas, Peloso, Pugliese, Massaro, Bagnoli and Angelos, 2020).

In the UK, the National Health Service (NHS) has had to contend with resource shortages due to health inequalities, increases in life expectancy, low workforce capacity and underdeveloped technology (Mohammed *et al.*, 2016; Wanless, 2003). The NHS in Wales has also undergone an extended period of austerity that has added unprecedented pressure on the provision of services (Welsh Government 2015). In response, the Welsh

Government (2015) aspired to capture healthcare information electronically, use data collaboratively for treatment, use technology routinely in all care settings, and ultimately use patient data to improve outcomes.

With the death of a UK care home patient on 5th March 2020, COVID-19 brought sudden change to healthcare systems that required urgent attention (Charles and Ewbank, 2020). Information systems were required to conduct high volume pathology testing of COVID-19 samples and information technology to provide agile, adaptive, multifaceted, layered, and timely technology induced interventions (Ebrahim et al., 2020). The impact of the pandemic has placed further strain upon healthcare resources that were already under pressure from an aging population, an increased prevalence of chronic or complex health conditions, and growing patient expectations (Bardhan, Chen and Karahanna, 2020; Cobianchi, Pugliese, Peloso, Dal Mas and Angelos, 2021; Welsh Government, 2020).

In response to the chronic pressures on healthcare systems, there have been increasing calls for targeted research into clinical technologies to facilitate real change in health organizations (Hughes and Vafeas, 2018). However, service quality instruments have not been adequate to sufficiently measure the multidimensional and interdependent nature of information systems (Guimaraes et al., 2009).

In order to improve the functionality of clinical information systems, that are suffering chronic resource shortages along with the acute effects of a global pandemic, there is a need to better understand how to approach the development of those systems. This study addresses this knowledge gap by examining the meaning of information *system value* from a clinical user perspective. This is achieved through identifying the *attributes of value* of a national clinical information system in Wales, UK. The findings indicate the issues of managing and developing clinical information systems, that include the generation of standard operating procedures for clinical users and the challenges of balancing system asymmetry.

The paper is structured as follows: first, the context of the study is presented in order to depict the nature of the Welsh clinical information system and the organization that is responsible for undertaking its development. Following this, a review of the information systems in healthcare literature is undertaken that highlights the generic challenges associated with clinical information systems and their development. Next, the concepts of value are explored before attribution theory is discussed as an approach toward understanding the multiple constituent elements of value. The development of the research hypotheses is then discussed before the methodological considerations of the study are presented. The findings and implications of the study are then discussed before the paper closes with concluding remarks along statements of limitations and suggestions for future research.

Drawing on the existing body of literature on information systems, value and attribution theory, this study offers several significant contributions. Firstly, the study provides a typology of attributes pertaining to clinical information systems that presents a framework for future studies on the value of information systems. It also found that perceptions of the attributes of clinical systems vary according to types of roles at hospitals as well as geographic locations.

2. The Welsh Clinical Portal

The NHS Wales Informatics Service (NWIS) was initiated by the Welsh Government in 2009 to provide a national IT system that is operable from any Welsh location to create, access and edit any patient record in Wales (Welsh Government, 2015). In April 2021, NWIS became a specialized healthboard, named Digital Health and Care Wales (DHCW), whose responsibilities include the development, operational support, change management and release management of the Welsh Clinical Portal (WCP). The WCP is a national clinical information system designed by healthcare practitioners working with information technology experts to integrate multiple clinical data streams into a single web-based information system. This digital platform provides a single access point to patient information, allowing users to access any patient record in Wales from any secondary care location to: 1) update patient records, 2) view GP records, 3) request pathology tests, view pathology/radiology results, 4) maintain clinical documents, 5) maintain clinical notes, and 6) share discharge letters with primary care. It is used by over 30,000 users in all seven health board locations in Wales and Velindre NHS Trust that provides national cancer treatments to all locations. An overview of these hospital locations is provided in Table 1 and Figure 1.

TABLE 1. HOSPITAL LOCATION COMPARISON (SOURCE: STATSWALES)

Hospital Location	Population	Beds	Expenditure
Abertawe Bro Morgannwg University Health Board	389,372	2,150	£1,119,247
Aneurin Bevan University Health Board	591,225	1,773	£1,201,400
Betsi Cadwaladr University Health Board	698,369	2,221	£1,473,226
Cardiff and Vale University Health Board	496,413	1,747	£936,265
Cwm Taf Health Board	445,190	1,211	£664,524
Hywel Dda University Health Board	385,615	1,208	£846,992
Powys Teaching Health Board	132,447	214	£293,287

Velindre NHS Trust	-	40	£528,132
Grand Total	**3,138,631**	**10,564**	**£7,063,073**

FIGURE 1. HOSPITAL LOCATIONS IN WALES

3. Literature Review

3.1. Information Systems in Healthcare

Information systems in healthcare are more complex than other sectors that rely upon software that is developed by public and private technology industries to meet complex service requirements (Savory and Fortune, 2014). The rapid pace of technological developments such as blockchain (Massaro, 2021; White, 2016), innovation initiatives, and research has transformed the provision of healthcare at an unprecedented pace across the world (Manyika and Roxborough, 2011). Despite these advances, it remains a high-risk undertaking that has to contend with the challenges of increasing user requirements (Daskalopoulou et al., 2019).

The management of these complex systems means that even minor modifications to one feature could impact other seemingly unrelated modules or functionality (Service et al., 2014; Wong and Gokhale, 2005). This has exacerbated the accumulation of minor system improvements that have collectively generated ‘spaghetti code’, which system providers do not have sufficient understanding to amend (Neville-Neil, 2018). System development, testing, and fault-finding are therefore time-consuming, problematic, and often imperfect activities (Cinque et al., 2013; Johnson, 2011; Rinsaka and Dohi, 2005).

In order to understand and address these challenges, research has explored the different dimensions of systems development, including the process of innovation (Khodadad-Saryazdi, 2021; Lin and Hsieh, 2014), the management of multiple stakeholders (Lin and Hsieh, 2014), and the influence of organizational and external factors (Naranjo-Gil, 2009). The involvement of users in developing system enhancements has contributed to the mechanism for improving service quality and increasingly successful implementations (Ives and Olson, 1984). In this context, the clinical users are far from the ‘peripheral inside innovators’ that Secunda et al. (2016, p149) state. However, there have been problems when the requirements of primary users have not been properly communicated by their senior managers who have not personally used the system (Oloo and Orwar, 2016).

Despite repeated references to the value of a clinical information system within the literature (Sousa et al., 2019; Marzorati and Pravettoni, 2017; Rivard et al., 2011; Ciasullo et al., 2017), there are limited empirical studies that examine what the value derived from an information system actually means for service users (Alahyari et al., 2017). This is problematic because of the current lack of understanding of the user-perspective of information system value precludes the development of efficacious systems (Al-Karaghouli et al., 2005).

3.2. Concepts of Value

Value has been studied by philosophers, economists, and psychologists in a multitude of disciplines or contexts. The principle texts on value were primarily concerned with the morality of man, the intrinsic values of society and the natural environment (Plato, 360 BC/1941; Laërtius, 1925; Lactantius, 313 AD). Although, Socrates also contemplated value in terms of price, friendship, desire, education, reason and possessions (Xenophon, 371 BC/1914). Later works advanced the thinking of moral value and many drew upon the immutable commandments of religion (Windelband, 1901/2006; Descartes, 1641/1996) while others reasoned around the transcendental existence of mankind (Ehrenfels, 1916/1948; Sartre, 1945/2001; Bosanquet, 1899; Leibniz, 1951/1985).

The value of material artifacts and the objects of production gradually surfaced to become the dominant discourse (Howard, 1930; Lotze, 1843/2012). For example, Petty (1690) examined value in monetary terms of rent from land, cost of buildings, the price of goods, the price of commodities in fashion and wages for labor while George Edward Moore (1903) described value as reason, task-benefit and the worth of an object constituted from the sum of its parts. Indicating the importance of the study of value, within this body of work arose perhaps some of the most influential treatises by Adam Smith and Karl Marx, among others, upon which modern society and concepts of value were shaped (Marshall, 1890; Ricardo, 1821; Smith, 1776/1904; Marx, 1867).

The contemporary literature indicates a shift from material concepts of value to a service-dominant logic that is predicated upon experience and the cocreation of value (Ramaswamy and Ozcan, 2017; Lusch and Vargo, 2014; Sandstrom et al., 2008; Prahlad and Ramaswamy, 2000). From this perspective, value means different things to different people and has been explained through its effect on satisfaction, expectations, and behavior (Phillips and Reynolds, 2009; Sørensen and Askegaard, 2007). Consequently, "*the challenges in service innovation are how to capture constantly changing priorities of consumers, design new services that incorporate new technologies, and create new business models that generate new service value*" (Yang and Hsiao, 2009, p328).

The healthcare literature draws primarily upon service-dominant logic and concepts of value that have been explained in terms of differentiated services and treatments offered to patients (Walters and Jones, 2001), patient-centeredness and holism (Howie et al., 2004), improved patient-health, shorter treatment periods and low repeat visits (Bansal, 2004). However, the monetary concept of value has not been displaced entirely (Pitta and Laric, 2004).

The literature indicates a fundamental challenge in the study of value, that is, the multifarious ways in which it can be conceptualized and the multitudinous ways that it may be perceived. In the context of healthcare information systems, specifically the Welsh health service, the user base comprises a vast number of clinical specialties working in regional NHS Trusts with different historical and cultural backgrounds, distributed over a large geographic area to serve the national population of approximately 3.1 million. Consequently, this study draws upon attribution theory as a means of unpacking the concepts of value that are pertinent to the users of WCP.

3.3. Attribution Theory

Attribution theory was first explained by Fritz Heider (1958) as the reasoning by ordinary people of the causes, events or outcomes in everyday language that has been referred to as naive psychology. Attribution theory enables studies to understand the causes of a phenomenon in terms of how specific that cause is to an individual, the relevance of the attribution between individuals, its consistency over time and its contextual relevance (Bowling, 2002). Its usefulness is indicated by its adoption as the lens for the examination of a broad range of issues including human resources management (Colaiacovo, Guerci and Gilardi (2021), public stigma through the Covid-19 crisis (Nguyen, Croucher, Diers-Lawson and Maydell, 2021), and corporate social responsibility (Ginder, Kwon and Byun, 2021; Moehl and Friedman, 2021).

Customers evaluate service performance even when they do not contemplate the actual reasons for their evaluation (Woodruff, 1997). Thus, customers regularly assess a service using causal attributions to provide insights into what they value in that service (Oliver, 1999). Attributions can also explain the causes behind behavior that influence occurrences (Bem, 1972). These play a central role in providing details on certain causes, determinants, and consequences (Folkes, 1988). Attributions have been used by individuals to also determine the causes behind their behavior and the behaviors of others from observed events (Fishbein and Ajzen, 1975).

Even though individuals provide explanations in commonly used language that are not scientifically conceptualized, analysed or tested, they observations are similar to that of scientists as they process information in a logical and analytical fashion (Folkes, 1988).

Value related attributes have been the primary focus of political discussions on healthcare and policy (Greer and Rowland, 2007).

Healthcare attributions need to be considered from a whole-system perspective and in terms of the benefit of providers delivering the right care in the right place (NHS Confederation, 2013). Although the value of healthcare services has been evaluated by clinicians by considering attributes (Devlin and Appleby, 2020), this study goes further to examine specific attributes of the clinical system itself.

4. Hypothesis Development

Cohen et al. (2016) identified aspects of hospital information systems in terms of system quality (system responsiveness and ease of learning), information quality (information detail), service quality (sufficient support) and data quality (complete, accurate records and records never missing). The clinician's experiences of an information system have been categorized as regulatory compliance, clinical necessity, sponsor importance, investigator importance, quality assurance and resource commitment (Butler et al., 2016). System users have indicated that they derive value from the quality of care, efficient clinical practice, professional status or autonomy and medical dominance (Rivard et al., 2001), quality, management, support, usefulness and ease of use (Mursityo et al., 2018), along with process, communication, cost and data (Marzorati and Pravettoni, 2017). Studies have explored what should be done to improve customer value and satisfaction without considering why consumers make such evaluations (Woodruff, 1997). In reality, customers measure a service using causal attributions that provide insight into what they value in that service (Oliver, 1999). With the growth of the service industry, a knowledge of the quality of goods is insufficient to understand service quality because services are different to goods in terms of intangibility, heterogeneity and inseparability (Parasuraman *et al.*, 1988). Contrastingly, value expectations and perceptions vary depending on customer experience, circumstances and situation (Day, 2002). Although there have been a number of frameworks on attributes that affect usability of technology, there has not been any consensus or clarity on the value (dependent variable) of a clinical information system.

H1: Different users identify different attributes of the value of the WCP.

Secondly, research into user perceptions of services has highlighted the critical influence of different user roles in value evaluations (Hardyman et al., 2014). Studies have identified the importance of refocusing efforts to understand the needs and expectations of service users in terms of supporting the patient treatment pathway (Academy of Medical Royal Colleges, 2013). User experiences of hospital systems vary between multiple perspectives including doctors, nurses and administrators (Cline and Luiz 2012; Secundo et al., 2019). It is important to understand the value perceptions of different actors are unique to their behavior that are influenced by differences in individual working practices (Hughes and Vafeas, 2018). Conversely, the subject of value attributes has been studied within an institutional context but its meaning is dependent upon the context of its evaluation (Morosan, 2018).

H2: The attributes of value for WCP vary in importance between different roles.

Thirdly, studies on value indicate that user perceptions vary according to different locations (Heinonen et al., 2013). Although hospital characteristics are known to be related, there are limited empirical studies examining the differences in system value perceptions between local hospital settings (Lin et al., 2019). Moreover, studies indicate that practices and processes that influence the provision of patient care are varied between geographic locations that require further exploration (Hughes and Vafeas, 2018). Furthermore, value also influences demographic groups differently based on their social locations (Schwartz, 1999). Clinical studies also demonstrate that there are differences in the strengths or weaknesses in hospital services between different locations (Nordgren and Åhgren, 2013).

H3: The attributes of value for WCP vary in importance between hospital locations.

5. Methodology

This study adopted a pragmatic approach using a sequential mixed-methods design that comprised a qualitative study to inform questions for a quantitative study. Studies on health sciences have previously used mixed research methods to achieve an accurate and comprehensive interpretation from empirical research (Cohen et al., 2016; Campos et al., 2017). This exploration is conducted in three phases.

5.1. Phase 1 - Interviews

In phase 1, semi-structured interviews were conducted with different clinical roles such as consultants, doctors, nurses, pharmacists and non-clinical staff at different hospital locations as indicated in Table 1. This was in accord with earlier studies that also adopted semi-structured interviews to understand user perceptions of the context of healthcare systems (Rivard et al., 2011; Aarts et al., 2004). This phase drew on the experience of clinicians in terms of their assessment of system value through 14 interviews that lasted approximately between 40 minutes and 1 hour.

The responses from each interview were recorded on a dictaphone and transcribed verbatim into a Word document. A thematic analysis was conducted on the transcripts from the qualitative study using NVivo to identify themes that represent value attributes by using the thematic analysis suggested by Braun and Clarke (2006) to: 1) enable familiarization with the data, 2) generate initial codes, 3) search for themes, 4) review themes regularly, 5) define and name themes, and 6) produce a final list of themes.

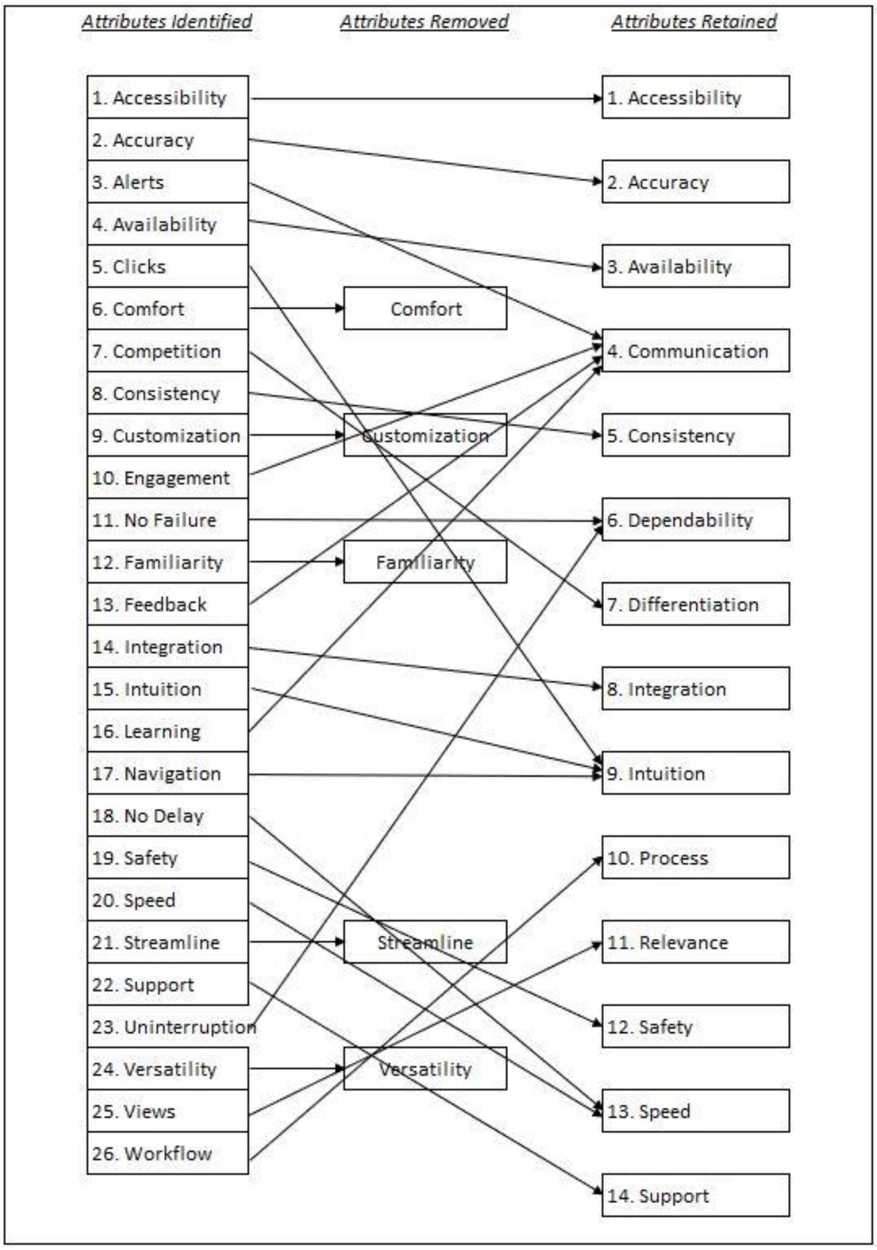
The interview transcripts were analyzed line-by-line that resulted in the identification of 26 individual themes namely: 1) accessibility, 2) accuracy, 3) alerts, 4) availability, 5) clicks, 6) comfort, 7) competition, 8) consistency, 9) customization, 10) engagement, 11) no failure, 12) familiarity, 13) feedback, 14) integration, 15) intuition, 16) learning, 17) navigation, 18) no delay, 19) safety, 20) speed, 21) streamline, 22) support, 23) uninterruption, 24) versatility, 25) views, and, 26) workflow.

5.2. Phase 2 – Focus Group

In phase 2, a focus group discussion was conducted with IT experts from DHCW in Cardiff, UK, consisting of technical support staff, system developers, testers, and system managers to validate the attributes with the use of relevant inferences from the interview transcripts. Focus groups have been used effectively to engage experts in healthcare research to more effectively understand system use (Côté-Arsenault and Morrison-Beedy, 2005; Carr et al., 2003).

The discussions at the focus group enabled the reduction of the initial 26 themes to 14 attributes (relying on interview transcript references) that were: 1) accessibility (‘easy to log into the system when automatically logged out during an interruption or inactivity resulting in a system timeout'), 2) accuracy ('an absence of data errors when editing or updating the system'), 3) availability ('the system is operational and readily useable at any time'), 4) communication ('patient information is easily shared between users and departments to support the patient treatment pathway'), 5) consistency ('the appearance of screens, buttons and data-format is the same'), 6) dependability ('no task interruption from system crashes or when updating the patient record'), 7) differentiation ('the system has all the necessary functionality in one place without the need for users to log into other systems'), 8) integration ('external information is configured and displayed within a single login'), 9) intuition ('the system preempts the user's next action with minimal clicks, scrolling or navigation'), 10) process ('the system is compatible with internal workflow processes and local practices'), 11) relevance ('the information displayed is succinct and easy to understand'), 12) safety ('the patient record is secure and the integrity of the data is maintained'), 13) speed ('the clinical system is responsive and quick with no delays on data retrieval'), and 14) support ('staff provide advice and resolve system incidents within the expected service timescales'). The validation of the value attributes that involves the merger and removal of attributes as appropriate from feedback from the focus group are illustrated in figure 2.

FIGURE 2. FOCUS GROUP VALIDATION OF ATTRIBUTES



5.3. Phase 3 – Survey

In phase 3, a quantitative study was conducted with users at different locations to ensure rigor through a validation of the findings from the qualitative study with the larger clinical user community. Healthcare studies have previously extended findings from qualitative studies into quantitative studies to obtain a generalization from the broader population (Konduri et al. 2017; Alipour et al., 2019).

This study invited users to participate in the survey voluntarily by providing a link on the WCP homepage to participate in the survey through SurveyMonkey. The measurements were operationalized from prior studies for each of the 14 attributes that were contextualized for a healthcare setting. For each question, a six-point Likert scale (strongly disagree, disagree, slightly disagree, slightly agree, agree and strongly agree) was used to rate each sub-factor as used in previous healthcare studies (Cohen et al., 2016; Alipour et al., 2019).

A pilot survey was conducted with 50 users at hospitals to determine the suitability of the questions and the length of time required to complete the survey. A large proportion of the respondents from the pilot study emphasized that the survey was too long and indicated that clinicians in an emergency hospital would not have enough time to complete a survey that consisted of 69 questions. Therefore, the survey was revised by reducing the questions for each attribute from three questions to two questions. This revision on the number of questions for each attribute reduced the total number of survey questions from 69 questions to 31 questions as illustrated in Appendix B. This study invited users to participate in the survey on a voluntary basis by providing a link in the Welsh Clinical Portal homepage that took them to the survey on the survey monkey website.

A purposive sample was used in selecting experienced users who were able to provide perspectives directly related to information systems research (Fernandes et al., 2017; Hughes and Vafeas, 2018). Reliability tests were used to test the data from qualitative studies for reliability in terms of any deviations from normality (Golafshani, 2003). The data was analyzed using standard multiple regression analysis to determine the effect of the relationship of each attribute on value.

In phase 3, the users, as described below, were invited to voluntarily participate in a quantitative study that resulted in 559 completed responses after 61 responses were not used due to incomplete data. The majority of the survey respondents were female (67%). The largest respondents were nurses (29%) followed by consultants (27%). Next, non-clinicians made up 25%, followed by doctors (14%). Pharmacists made up 4% of the total respondents. Of the hospital locations that participated in the survey, the largest was Cwm Taf Health Board (29%) followed by Betsi Cadwaladr Health Board (26%). Abertawe Bro Morgannwg University Health Board was the next highest (23%) followed by Hywel Dda Health Board (14%). Aneurin Bevan Health Board was represented by 5%, followed by Velindre NHS Trust that made up 2% of the responses. Powys Teaching Health Board made up just 1% of the total respondents. Cardiff and Vale University Health Board took a decision not to participate in this phase on account of an internal organizational decision. A demographic profile of the respondents from the quantitative study is provided in Table 2.

TABLE 2. DEMOGRAPHIC PROFILE OF SURVEY RESPONDENTS

Characteristics	Number	Percentage
Gender		
Female	375	67%
Male	184	33%
Age		
< 30	52	9%
30 - 40	122	22%
41 - 50	195	35%
51 - 60	167	30%
> 60	23	4%
Role		
Consultant	153	27%
Doctor	80	14%
Nurse	164	29%
Other	138	25%
Pharmacist	24	4%
Location		
Aneurin Bevan Health Board	26	5%
Abertawe Bro Morgannwg University Health Board	131	23%
Betsi Cadwaladr University Health Board	145	26%
Cwm Taf Health Board	160	29%
Hywel Dda Health Board	76	14%
Multiple	3	1%
Powys Teaching Health Board	6	1%
Velindre NHS Trust	12	2%

5.4. Reliability Tests

The quantitative data was tested using IBM SPSS for reliability and consistency using Cronbach alpha (α) and scores lower than the cut-off value of 0.700 were excluded from the model. Next, the results of the survey were tested for multicollinearity to test for a tolerance of more than 0.2 and a variance inflation factor (VIF) of less than 10. The data shows that the average VIF was less than 1, the lowest tolerance value was 0.331 and the highest VIF was 3.190 to indicate there was no multicollinearity bias for any of the predictor variables in the regression model. The data were tested for heteroscedasticity to ensure that the predictor variable was constant and the residuals at each level of the predictor had a similar variance. A histogram was created using the residuals associated with the dependent variable to check the variances of the independent variables (Appendix C). Appendix D shows that the data points were close to the line of least squares with some deviation. There was some abnormality in terms of the scatter plot data points that spread out at the start and grew closer to indicate some heteroscedasticity in the regression model (Appendix E).

Next, a Durbin Watson test was used to test for serially correlated errors or autocorrelation to show that the model was not the optimum least-squares unbiased estimator. The conservative rule-of-thumb for Durbin Watson tests is between 1.5 and 2.5. The value for this model was 2.057 in table 3 indicating there was no autocorrelation.

TABLE 3. DURBIN WATSON TEST

Model Summary*				
R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.772[a]	0.596	0.585	0.651	2.057
a. Predictors: (Constant), Accessibility, Accuracy, Availability, Communication, Consistency, Dependability, Differentiation, Integration, Intuition, Process, Relevance, Safety, Speed, Support				
*Dependent Variable: Value				

The model was tested for outliers in terms of extremely high or low values. Box-whisker plots were applied to the data to identify values that fall above the upper quartile (75th percentile) score and below the lower quartile (25th percentile) score. The extreme values were transformed through winsorization[1] before the regression analysis was performed. The data were subjected to the Kolmogorov-Smirnova tests to check for normality in the distribution scores. As non-significant results consisting of a value of more than .05 indicates normality, the data showed that the significance was 0.000 for all value attributes to indicate the distribution was significantly different from a normal distribution. Thus, it had a non-normal value that was common for large samples where significant results of small deviations from normality did not definitively indicate a deviation from it.

6. Analysis

This section statistically examines the relationships between each attribute to value to enable the categorization of those attributes that have a significant relationship to value compared to those attributes that do not have the same relationship. In addition, the attributes with a large beta value were also examined to understand the strength of their unique contribution to value. Therefore, the use of the significance and beta values enabled the reorder of each attribute according to their overall importance, by role and different hospital location.

6.1. Attributes by Importance

A multiple regression analysis was conducted to determine the causal effect of each attribute on value. The model showed that the p-value was significant as indicated in table 4. The model showed that the coefficient was significant to indicate that hypothesis H1 is

[1] Winsorization minimizes the influence of outliers to a dataset by replacing their original value by the next nearest value of an observation that is not an outlier itself (Charles P. Winsor in 1941).

supported. Further analysis was conducted to assess the strength of individual attributes on value and the significance of each attribute as illustrated in table 5. The standardized coefficient beta values were used to identify the variables that made the strongest unique contribution to explain the dependent variable. The outcome from the analysis enabled this study to re-order the attributes by importance firstly using their significance value and then their beta values. The attributes that were significant were: 1) accessibility (p = 0.002), 2) accuracy (p = 0.000), 3) consistency (p = 0.003), 4) process (p = 0.000), and 5) safety (p = 0.000).

TABLE 4. MULTIPLE REGRESSION MODEL

Coefficients[a]						
ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	301.763	14	21.555	48.378	.000[b]
	Residual	231.237	519	0.446		
	Total	533.000	533			

a. Dependent Variable: Value

b. Predictors: (Constant): Accessibility, Accuracy, Availability, Communication, Consistency, Dependability, Differentiation, Integration, Intuition, Process, Relevance, Safety, Speed, Support

Alternatively, the attributes that were not significant were: 1) availability (p = 0.113), 2) communication (p = 0.108), 3) dependability (p = 0.113), 4) differentiation (p = 0.924), 5) integration (p = 0.054), 6) intuition (p = 0.052), 7) relevance (p = 0.052), 8) speed (p = 0.498) and 9) support (p = 0.954). Next, using the standardized coefficient beta values, the significant attributes were ordered by importance as: 1) process (p = 0.000; beta = .243), 2) safety (p = 0.000; beta = .144), 3) accuracy (p = 0.000; beta = .131), 4) accessibility (p = 0.002; beta = .127), and 5) consistency (p = 0.003; beta = .131).

TABLE 5. VALUE ATTRIBUTE SIGNIFICANCE LEVELS

Coefficient*					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-3.474	0.416		-8.342	0.000
Accessibility	0.127	0.041	0.127	3.092	0.002
Accuracy	0.193	0.054	0.131	3.598	0.000
Availability	0.072	0.045	0.072	1.586	0.113
Communication	-0.057	0.035	-0.057	-1.608	0.108
Consistency	0.099	0.034	0.131	2.939	0.003
Dependability	0.063	0.040	0.074	1.585	0.113
Differentiation	-0.004	0.040	-0.004	-0.096	0.924
Integration	0.055	0.028	0.061	1.929	0.054
Intuition	0.072	0.037	0.088	1.945	0.052
Process	0.242	0.049	0.243	4.952	0.000
Relevance	0.114	0.059	0.064	1.948	0.052
Safety	0.150	0.035	0.144	4.320	0.000
Speed	-0.030	0.045	-0.030	-0.678	0.498
Support	0.002	0.037	0.002	0.058	0.954
*Dependent Variable: Value					

The remaining attributes that were not significant were ordered by importance firstly by significance followed by standardized coefficient beta values as: 6) relevance (p = 0.052; beta = .064), 7) intuition (p = 0.052; beta = .088), 8) integration (p = 0.054; beta = .061), 9) communication (p = 0.108; beta = .057), 10) availability (p = 0.113; beta = .074), 11) dependability (p = 0.113; beta = .074), 12) speed (p = 0.498; beta = .030), 13) differentiation (p = 0.924; beta = .004), and 14) support (p = 0.954; beta = .002). The attributes were reordered according to overall importance as illustrated in table 6.

TABLE 6. ATTRIBUTES RE-ORDERED BY IMPORTANCE

Ordered Alphabetically		Re-ordered by Importance (Sig. and Beta)			
No	Attribute	No	Attribute	Beta	Sig.
1	Accessibility	10	Process	0.243	0.000
2	Accuracy	12	Safety	0.144	0.000
3	Availability	2	Accuracy	0.131	0.000
4	Communication	1	Accessibility	0.127	0.002
5	Consistency	5	Consistency	0.131	0.003
6	Dependability	11	Relevance	0.064	0.052
7	Differentiation	9	Intuition	0.088	0.052
8	Integration	8	Integration	0.061	0.054
9	Intuition	4	Communication	-0.057	0.108
10	Process	3	Availability	0.072	0.113
11	Relevance	6	Dependability	0.074	0.113
12	Safety	13	Speed	-0.030	0.498
13	Speed	7	Differentiation	-0.004	0.924
14	Support	14	Support	0.002	0.954

6.2. Attributes by Clinical Role

Additional analysis indicates the significant effect of attributes on value based on individual user roles. Multiple regression analysis was conducted on each attribute to determine their importance for users such as consultants, doctors, nurses, pharmacists and non-clinicians. The analysis in table 7 shows that different roles perceived the importance of each attribute differently.

Accuracy was ranked highest by the largest user group, nurses (p = 0.000; beta = 1) and ranked second in importance by consultants (p = 0.000; beta = .76). Process was ranked second by doctors (p = 0.000; beta = .82) and other users (p = 0.036; beta = .87). Other attributes ranked as most important were relevance by consultants (p = 0.000; beta = .82), support by doctors (p = 0.000; beta = .87), differentiation by others (p = 0.025; beta = .97) and safety by pharmacists (p = 0.013; beta = 1). Similarly, attributes ranked as next most important were integration by nurses and accessibility by pharmacists (p = 0.020; beta = .98). As the attributes were not the same for different user roles, hypothesis H2 is supported.

TABLE 7. ATTRIBUTES ORDERED IN IMPORTANCE BY ROLE

Attributes Ordered in Importance by Role					
No	Consultant	Doctor	Nurse	Other	Pharmacist
1	Relevance	Support	Accuracy	Differentiation	Safety
2	Accuracy	Process	Integration	Process	Accessibility
3	Support	Differentiation	Accessibility	Relevance	Consistency
4	Process	Speed	Safety	Accuracy	Accuracy
5	Accessibility	Dependability	Process	Dependability	Availability
6	Availability	Accessibility	Availability	Intuition	Dependability
7	Intuition	Consistency	Speed	Availability	Relevance
8	Dependability	Relevance	Dependability	Support	Communication
9	Consistency	Intuition	Intuition	Consistency	Differentiation
10	Integration	Accuracy	Relevance	Speed	Integration
11	Speed	Safety	Support	Safety	Intuition
12	Differentiation	Availability	Differentiation	Integration	Process
13	Safety	Communication	Communication	Communication	Speed
14	Communication	Integration	Consistency	Accessibility	Support

6.3. Attributes by Location

Similar to the analysis provided for clinical roles, the attributes were ordered by importance according to user perceptions at each hospital location as indicated in table 8. Accuracy was ranked as most important in Aneurin Bevan (p = 0.000; beta = 1), Cwm Taf (p = 0.001; beta = .93), and Hywel Dda (p = 0.007; beta = .89) and process was identified as most important in Abertawe Bro Morgannwg (p = 0.000; beta = .82), and Powys (p = 0.036; beta = .87). The largest location, Betsi Cadwaladr, identified safety as the most important value attribute (p = 0.013; beta = 1) and ranked second in importance (p = 0.000; beta = .83) at the Hywel Dda location. The smallest location, Velindre NHS Trust that provides cancer treatments, identified differentiation (p = 0.038; beta = .83) of highest importance. Although support was ranked last overall, it was ranked second in importance (p = 0.000; beta = .87) in Betsi Cadwaladr location. Aneurin Bevan that has legacy systems ranked integration as second highest (p = 0.000; beta = 1) in importance. Other attributes ranked second highest in importance were accessibility (p = 0.001; beta = .92) by Cwm Taf, availability by Powys (p = 0.002), and communication (p = 0.045; beta = .82) by Velindre NHS Trust.

TABLE 8. ATTRIBUTES ORDERED IN IMPORTANCE BY LOCATION

No	Abertawe Bro Morgannwg	Aneurin Bevan	Betsi Cadwaladr	Cwm Taf	Hywel Dda	Powys	Velindre
1	Process	Accuracy	Safety	Accuracy	Accuracy	Process	Differentiation
2	Dependability	Integration	Support	Accessibility	Safety	Availability	Communication
3	Relevance	Accessibility	Relevance	Availability	Process	Intuition	Relevance
4	Differentiation	Safety	Accuracy	Dependability	Intuition	Safety	Accessibility
5	Support	Process	Process	Relevance	Relevance	Consistency	Accuracy
6	Intuition	Consistency	Dependability	Intuition	Consistency	Relevance	Availability
7	Consistency	Communication	Consistency	Process	Integration	Support	Consistency
8	Integration	Differentiation	Speed	Support	Availability	Dependability	Dependability
9	Accuracy	Availability	Differentiation	Consistency	Differentiation	Accessibility	Integration
10	Accessibility	Dependability	Accessibility	Integration	Support	Accuracy	Intuition
11	Safety	Intuition	Intuition	Speed	Dependability	Communication	Process
12	Communication	Relevance	Availability	Safety	Speed	Differentiation	Safety
13	Availability	Speed	Communication	Differentiation	Accessibility	Integration	Speed
14	Communication	Support	Integration	Communication	Communication	Speed	Support

A complete list of attributes by significance and beta values by role and location is available in Appendix A.

7. Discussion

Although there has been prior research on the relationship between services and value, explorations on the meaning of value relating to specific aspects or features of a clinical information system have been sparse. Therefore, where research has used dimensions, and attributes in service literature, a indication of what users actually value or how they perceive value from a clinical information has not been adequately explored. Previous studies have theorized that perceived value as the assessment of the utility of a product in contrast to perceived service quality from the user's judgement about the superiority or excellence of a service (Zeithaml, 1988). Where service quality literature has previously relied on dimensions (Parasuraman et al., 1988), this exploration draws on service science and information technology studies to identify multiple causal interactions between an explicit list of system related attributes and value. This exploration extends observations of previous studies into technical and functional categories: 1) technical (accuracy, availability, consistency, dependability, differentiation, dependability, integration, intuition, relevance, safety, and speed) and 2) functional (communication, process, and support). In addition, this study identified five attributes (process, safety, accuracy, accessibility, and consistency) that have a significant effect on value.

The identification of these 14 attributes present a typology of the facets of system value that users have identified for an information system. Users usually start evaluating a system at the point of login. Studies assert that users make evaluations of the usefulness of a system in terms of the ease of system and data accessibility (Christensen and Bailey, 2000). Despite the rules for authentication to ensure that the optimal checks are in place at multi-levels to protect patient information should ensure that access to systems are quick and simplified that enables users to seamlessly continue tasks when clinicians are interrupted from their work stations. This finding aligns with studies that indicate value assessments for services are predicated upon experience (Vargo and Lusch, 2011). Studies by Hilary and Hsu (2011) highlight the importance of accuracy that affects the reputation of individuals and the organization from accurate data and treatment notes within the patient record. Clinicians have indicated that unavailability of a clinical system can result in an accumulation of their workload, treatment delays and an increase in patient waiting times. Healthcare studies aligns with this view that emphasize the directs benefits of system availability on cost reductions, operational efficiencies and improved healthcare (Cline and Luiz, 2013).

This study highlights the importance users place on being able to view their individual workloads each day in the form of patient lists and electronic alerts in the form of flags for more serious patients against their patient record. Users mentioned that systems should be designed with consistency of appearance on screens and electronic forms. The ability to drill down from the patient list to a patient's information and then navigate back to patient lists through another route within a system enhances user experience. The rules for test requesting with the systems in secondary care and primary care should be consistent in terms of obeying the same rules when placing a pathology test request. In other words, design consistency enhances the capability of systems to derive more value from resources (Dubbs, 2002).

While clinical users would like to customize parts of systems to suite their personal preferences, there was consensus that there were constraints on the extent of customizable features within national clinical systems due to it extended use across the country. System users engage in activities that enable service customization according to their working practices by understanding customer behaviour that enables users to alter system settings to suit their individual needs (Troye and Supphellen, 2012). Users expect to complete tasks once and without the disruption of losing unsaved work on a system. Studies by Ifinedo (2011) highlight the importance of the dependability of systems by implementing service strategies to anticipate and respond to system-disruptions thereby enhancing system resilience.

Clinical users recognized the importance of differentiation within the system that enabled clinical results for any patient in Wales to be viewable within any Welsh hospital a few minutes after the electronic test request has been placed. Results that would have had to be obtained by phoning the laboratory are now readily available in clinical systems within a few minutes. The importance of differentiation within systems enables the providers to adjust system features to user needs which studies indicate have a direct affect on value perceptions (Cort et al., 2007). Similarly, the potential of systems to enable inter-operability through integration between disparate systems brings enhanced benefit to inter-departmental working (Batada and Rahman, 2012). An intuitive system design reduces the effort for users to complete tasks (Mikkelsen et al., 2007). Studies on healthcare indicate that users associate the relevance of the data being presented on the screen directly to the actual reliability of the system (Marton, 2003).

Clinicians have expressed frustration when systems are slow whether it is to load a patient record or the time to save information on a record. Studies indicate that the absence of software enhancements has resulted in speed issues from memory leaks, unreleased locks, non-terminated threads, shared-memory and storage fragmentation (Zhao and Wu, 2013).

The importance of adequate support structures is a prerequisite for the positive measurement of user satisfaction in the context of enterprise resource planning (Batada and Rahman, 2012).

There is evidence from this study that processes and working practices differ between hospitals, the study provides evidence that clinicians inevitably have to adjust their working practices to work with certain system modules for national systems that are constrained by limitations of customizing a national clinical system. This aligns with studies on system implementation and user adoption where its success is determined by the translation of local working practices, workflows and pathways into the system in operation (Aarts et al. 2004).

The safety aspect of systems has been a salient concern within healthcare (Cohen et al., 2016) as there are strict requirements to adhere to guidelines from information governance principles and the need to verify the provenance of data in clinical systems. Simple events such as a reduction in system performance carry the projected risk of affecting clinical content that can impact the safety of patients. This study indicates that the standards of safety for healthcare should be enhanced iteratively to the levels of the safety standards of, for example, the high-quality expectations required by the airline industry. When medical paper notes were in use previously, clinicians relied on the drug formulary for transcribing medications that immediately presented a risk as soon as users deviated away from referring to it. However, the national formulary has now been integrated into WCP’s test requesting screen where users simply select pre-populated pharmaceutical values from the formulary that has improved the accuracy of prescribing and medicine transcribing. Studies assert that the reduction of errors in patient information based on its legibility, completeness, meaningfulness, and integrity has been a key factor in the adoption of healthcare systems (Oroviogoicoechea et al., 2008).

In addition to identifying the value related attributes of an information system, the influences of specific attributes on various clinical user roles are evident. For example, Cline and Luiz (2012) indicate that there are variants between the evaluation of a healthcare system by different clinical professions such as doctors and nurses in terms of their usage experience. Furthermore, this study highlights that clinicians such as doctors and consultants who primarily provide a diagnosis relying on the data integrity or provenance has a direct knock-on-effect to providing the correct treatment.

While there were variances in the perceptions of different user roles, this study also indicates that there are variants in attribute preferences between different hospital locations. The ability of systems and data accuracy was ranked as most important for three health boards followed by the facility within the modules for local process workflows to support the patient's treatment pathway. The qualitative analysis confirms that electronic records significantly reduced occurrences of illegibility, incorrect medication doses, and errors in treatment notes. For instance, users at Velindre NHS Trust, that only treat cancer patients, highlighted differentiation as the most important attribute from their need to customize features and modules to treat terminal patients as cancer related modules facilitated the monitoring and treatment of chronic conditions.

While this paper highlights the theoretical contributions through the typology of value attributes that directly pertain to systems value, it also highlights practical implications of the study. The implication of each attribute to the user experience in a healthcare setting has been highlighted in addition to the effect of each attribution on the timely delivery of treatments for patient and waiting times. This study asserts that system development activity that prioritises the value attributes identified from this study will directly enhance the overall quality of systems and healthcare. In other words, the contributions of this paper are multifaceted that extends knowledge of system attributes and service delivery in a hospital setting.

8. Conclusions

This study evaluates the impact of the introduction of an innovative clinical information system adding to a limited literature in a health care context (Rippa and Secundo, 2019; Wang et al., 2020). Clinical information systems are an important facet of modern global healthcare as populations increase in number and age. However, while the development of information systems in general are problematic, clinical information systems are replete with a myriad of context-specific problems to address the complexities of diverse clinical specialist users that are culturally and geographically dispersed. In order to advance our understanding of this complex area this study presents an examination of the clinical user-perceptions of the attributes of value of a national clinical information system. This study makes three important contributions to knowledge.

First, it proffers theoretical contribution though presenting a typology of the attributes of clinical information system value. By deconstructing value into its constituent attributes this study affords a means of obtaining a detailed understanding of the features and characteristics of clinical information systems that are valued by their users. This advances our theoretical understanding of the value of clinical information systems, which has been often cited without robust empirical evidence.

Second, this study identifies the relative importance of the attributes of value for different clinical and non-clinical types of user roles. Whereas it may be reasonably assumed that clinical user types and their jobs are consistent across institutional and geographic boundaries, it is incorrect to assume that user perceptions of system value are similar between them. System designers and developers need to recognize, and cater for, the different system aspects for different user disciplines.

Third, it reveals that the perceptions of clinical information system value differ according to location. This is a novel finding for those that are responsible for the development of information systems that are geographically dispersed. Managers of distributed clinical information systems, and policymakers who develop nation-wide systems must therefore be mindful of the differences in requirement perceptions that may persist between different locations.

Collectively, these findings provide a practical framework for system designers and developers to adopt when utilizing user-based approaches. Reducing value to its constituent attributes can be a productive approach to understanding the design and development of information systems in the public sector, social care and commercial sectors. Increasing the level of granularity of our understanding of system value through its constituent attributes can assist in overcoming the communication problems that can exist between managers, users and developers. This innovative system offers increased efficiency and system effectiveness to enhance health care performance in a challenging environment.

Managerial Implications

Clinical Managers should develop standard operating procedures and work instructions for front-end systems. Not only is this ‘good practice’ and promotes consistent training and usage, but it will also support the development of standardized clinical information systems and reduce the burden on technical support activities.

Systems Development Managers have to moderate service requests for user-specific functionality against the constraints of standardization for national clinical systems. Limited technical resources preclude the completion of every system enhancement request and therefore clinical developments must be prioritized over cosmetic changes.

Systems Development Managers that operate at different locations or have divided responsibilities there is a need to maintain high levels of communication and transparency of development activities to ensure that the common goal of standardization is achieved and that resources are most effectively deployed. However, where clinical systems span large areas or cover multiple healthcare locations, the need for standardization needs to balanced with the potential benefits of developing asymmetrical clinical information systems that are tailored toward local needs: the degree of asymmetry

Limitations

There are limitations to this study as the context of this research was confined to the development and application of a national clinical information system in Wales, UK. The observations of this study should be confirmed or refined through examining clinical information systems in other geograhical contexts. While the study is particularly valuable through its examination of rapid systems development in response to the Covid-19 pandemic, and a robust and meaningful sample had been examined (559 responses), these conditions may have compromised the acquisition of a larger data set.

Future Research

Future research should endeavor to understand how perceptions of system value and its attributes are shaped by the evolving nature of information systems and the changing demand landscape. Valuable further insight could be gained through the study of the attributes of clinical information system during times of steady-state development. Research should explore the influence of organization culture, national culture, roles, and other demographics upon these user perceptions. In particular, the study of national clinical information systems that are characterized by their distribution across geographies and regions of governance would be valuable in indicating the relative influence of these factors. The study of clinical information systems may be further developed through the examination of those attributes that are consistent across cultures, medical disciplines and time, and those attributes that are highly variable. Identifying the consistency of attributes of value may aid in the development of formalized clinical information system development methodologies.

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APPENDIX A. MULTIPLE REGRESSION: BY ROLE AND LOCATION

Abertawe Bro Morgannwg Health Board														
Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Relevance	.76	0.000	Dependability	.77	0.009	Process	.82	0.000	Dependability	.76	0.000	Safety	-	0.000
Consistency	.68	0.000	Differentiation	.74	0.013	Safety	.69	0.000	Process	.75	0.000	Accessibility	-	-
Intuition	.55	0.000	Process	.73	0.017	Availability	.67	0.000	Accuracy	.68	0.000	Accuracy	-	-
Dependability	.45	0.001	Accessibility	.66	0.026	Speed	.66	0.000	Intuition	.63	0.000	Availability	-	-
Process	.45	0.001	Speed	.62	0.054	Dependability	.63	0.000	Relevance	.61	0.000	Communication	-	-
Accuracy	.44	0.001	Availability	.48	0.153	Intuition	.58	0.002	Availability	.60	0.000	Dependability	-	-
Availability	.44	0.002	Consistency	.45	0.157	Accessibility	.56	0.003	Differentiation	.53	0.001	Differentiation	-	-
Support	.36	0.011	Relevance	.33	0.341	Relevance	.52	0.006	Support	.50	0.001	Integration	-	-
Integration	.33	0.019	Communication	.28	0.399	Support	.49	0.011	Consistency	.47	0.002	Process	-	-
Speed	.29	0.046	Safety	.28	0.399	Integration	.44	0.024	Integration	.47	0.003	Relevance	-	-
Safety	.27	0.049	Intuition	.27	0.414	Differentiation	.37	0.063	Safety	.37	0.017	Speed	-	-
Accessibility	.25	0.082	Support	.22	0.541	Consistency	.19	0.335	Communication	.30	0.049	Support	-	-
Differentiation	.32	0.260	Accuracy	.09	0.796	Communication	.19	0.341	Speed	.30	0.060	Consistency	-	-
Communication	.03	0.784	Integration	.01	0.974	Accuracy	.63	-	Accessibility	.21	0.172	Intuition	-	-
Aneurin Bevan Health Board														
Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Support	.76	0.045	Process	.87	0.022	Integration	1.00	0.000	Differentiation	.97	0.025	Consistency	.96	0.002
Speed	.71	0.070	Consistency	.28	0.038	Accuracy	1.00	0.000	Consistency	.81	0.184	Availability	.99	0.008
Availability	.59	0.161	Accuracy	.61	0.192	Accessibility	.99	0.002	Integration	.81	0.184	Accessibility	.98	0.020
Integration	.54	0.211	Support	.54	0.259	Safety	.98	0.017	Support	.81	0.185	Dependability	.97	0.023
Safety	.47	0.235	Intuition	.49	0.320	Communication	-	0.017	Process	.74	0.251	Support	.87	0.121
Relevance	.34	0.450	Integration	.41	0.418	Intuition	.89	0.104	Accuracy	.66	0.338	Intuition	.87	0.122
Consistency	.02	0.588	Communication	-	0.673	Consistency	.99	0.184	Accessibility	.57	0.423	Differentiation	.65	0.349
Dependability	.22	0.632	Safety	.22	0.674	Speed	.91	0.259	Availability	.57	0.423	Relevance	.57	0.423
Process	.13	0.770	Dependability	.15	0.776	Dependability	.86	0.333	Dependability	.57	0.423	Safety	.57	0.423
Accessibility	.08	0.852	Relevance	.15	0.776	Support	.85	0.353	Safety	.57	0.423	Speed	.56	0.440
Accuracy	.06	0.887	Differentiation	.06	0.906	Process	-	-	Speed	.57	0.423	Accuracy	.52	0.478
Differentiation	.34	0.943	Speed	.04	0.932	Availability	-	-	Intuition	.52	0.478	Process	.46	0.537
Intuition	.02	0.963	Accessibility	.04	0.935	Relevance	-	-	Relevance	.33	0.667	Integration	.33	0.667
Communication	-	-	Availability	.03	0.946	Differentiation	-	-	Communication	-	0.742	Communication	-	0.767
Betsi Cadwaladr Health Board														
Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Relevance	.82	0.000	Support	.87	0.000	Availability	.64	0.000	Dependability	.62	0.000	Safety	1.00	0.013
Accuracy	.76	0.000	Process	.81	0.000	Accessibility	.60	0.000	Speed	.57	0.000	Differentiation	.99	0.067
Process	.74	0.000	Differentiation	.74	0.000	Process	.58	0.000	Consistency	.53	0.001	Intuition	.97	0.134
Dependability	.68	0.000	Speed	.69	0.001	Relevance	.57	0.000	Availability	.52	0.001	Communication	.87	0.320
Consistency	.58	0.001	Accessibility	.63	0.004	Speed	.56	0.000	Process	.49	0.002	Availability	.87	0.320
Speed	.56	0.001	Dependability	.63	0.005	Accuracy	.52	0.000	Accuracy	.46	0.004	Support	.51	0.654
Support	.53	0.001	Relevance	.61	0.006	Intuition	.52	0.000	Relevance	.44	0.005	Accessibility	.51	0.654
Differentiation	.43	0.013	Consistency	.61	0.007	Differentiation	.46	0.000	Differentiation	.43	0.007	Process	.19	0.874
Accessibility	.43	0.014	Intuition	.58	0.010	Dependability	.43	0.001	Safety	.42	0.009	Accuracy	.02	0.987
Intuition	.42	0.017	Availability	.45	0.060	Integration	.42	0.001	Support	.42	0.009	Dependability	.02	0.987
Availability	.41	0.017	Accuracy	.33	0.177	Consistency	.32	0.016	Intuition	.39	0.015	Relevance	-	-
Safety	.40	0.021	Integration	.25	0.305	Communication	.29	0.031	Accessibility	.37	0.024	Integration	-	-
Integration	.34	0.057	Safety	.10	0.693	Support	.29	0.031	Integration	.33	0.043	Consistency	-	-
Communication	.22	0.223	Communication	.08	0.751	Safety	.49	-	Communication	.15	0.360	Speed	.02	-
Cwm Taf Health Board														
Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Relevance	.77	0.000	Process	.65	0.000	Accuracy	.67	0.000	Accuracy	.54	0.002	Accuracy	.93	0.001
Accessibility	.74	0.000	Accuracy	.63	0.001	Relevance	.65	0.000	Relevance	.50	0.004	Accessibility	.92	0.001
Availability	.74	0.000	Dependability	.62	0.001	Accessibility	.63	0.000	Safety	.46	0.007	Availability	.92	0.001
Intuition	.74	0.000	Accessibility	.60	0.001	Consistency	.55	0.000	Communication	.42	0.015	Dependability	.86	0.006
Process	.73	0.000	Safety	.57	0.002	Dependability	.53	0.000	Support	.39	0.026	Relevance	.70	0.049
Dependability	.70	0.000	Consistency	.48	0.011	Intuition	.51	0.000	Dependability	.38	0.031	Integration	.67	0.064
Support	.65	0.000	Intuition	.48	0.013	Safety	.51	0.000	Process	.37	0.039	Speed	.65	0.078
Accuracy	.62	0.000	Speed	.43	0.030	Process	.50	0.000	Integration	.36	0.045	Process	.57	0.134
Consistency	.62	0.000	Differentiation	.39	0.051	Support	.48	0.001	Intuition	.32	0.072	Support	.55	0.155
Integration	.60	0.000	Support	.39	0.054	Availability	.46	0.001	Availability	.27	0.129	Intuition	.47	0.232
Speed	.53	0.000	Availability	.35	0.087	Speed	.45	0.001	Speed	.25	0.171	Communication	.44	0.265
Safety	.40	0.008	Relevance	.34	0.095	Differentiation	.39	0.006	Consistency	.23	0.192	Consistency	.40	0.324
Differentiation	.34	0.027	Integration	.19	0.351	Integration	.22	0.131	Differentiation	.19	0.290	Safety	.17	0.671
Communication	.22	0.156	Communication	.12	0.903	Communication	.06	0.642	Accessibility	.18	0.324	Differentiation	.29	0.945

Hywel Dda Health Board

Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Relevance	.71	0.006	Safety	.83	0.000	Accessibility	.64	0.001	Safety	.67	0.012	Accuracy	.89	0.007
Consistency	.62	0.010	Process	.78	0.000	Intuition	.64	0.001	Relevance	.63	0.021	Speed	.74	0.056
Intuition	.60	0.013	Intuition	.72	0.001	Process	.54	0.011	Process	.58	0.036	Dependability	.71	0.069
Integration	.61	0.027	Availability	.70	0.002	Speed	.49	0.021	Differentiation	.55	0.048	Relevance	.71	0.071
Availability	.60	0.028	Consistency	.68	0.002	Relevance	.49	0.024	Speed	.55	0.049	Safety	.65	0.109
Accessibility	.48	0.057	Differentiation	.68	0.002	Accuracy	.42	0.052	Dependability	.36	0.225	Communication	.59	0.160
Process	.49	0.086	Relevance	.66	0.004	Communication	.39	0.064	Intuition	.34	0.251	Differentiation	.55	0.196
Accuracy	.43	0.134	Support	.65	0.005	Consistency	.37	0.077	Availability	.28	0.354	Consistency	.55	0.200
Support	.33	0.260	Dependability	.63	0.006	Integration	.35	0.112	Accuracy	.27	0.359	Intuition	.54	0.211
Dependability	.31	0.288	Speed	.59	0.011	Dependability	.28	0.212	Accessibility	.24	0.417	Availability	.37	0.403
Communication	.25	0.341	Accuracy	.47	0.055	Support	.27	0.223	Support	.20	0.502	Support	.35	0.434
Safety	.21	0.429	Accessibility	.42	0.088	Safety	.15	0.491	Communication	.16	0.583	Integration	.33	0.467
Speed	.23	0.450	Communication	.19	0.448	Availability	.10	0.647	Integration	.14	0.647	Process	.32	0.482
Differentiation	.41	-	Integration	.07	0.781	Differentiation	.08	0.729	Consistency	.08	0.772	Accessibility	.22	0.623

Powys Health Board

Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Process	-	-	Process	-	0.000	Availability	-	-	Process	.87	0.036	Support	-	-
Support	-	-	Safety	-	0.000	Safety	-	-	Dependability	.90	0.225	Dependability	-	-
Dependability	-	-	Intuition	-	0.001	Relevance	-	-	Intuition	.91	0.251	Process	-	-
Accessibility	-	-	Availability	-	0.002	Accuracy	-	-	Accessibility	.23	0.417	Accessibility	-	-
Accuracy	-	-	Consistency	-	0.002	Speed	-	-	Support	.10	0.502	Accuracy	-	-
Availability	-	-	Relevance	-	0.004	Accessibility	-	-	Communication	.91	0.583	Availability	-	-
Communication	-	-	Support	-	0.005	Communication	-	-	Integration	.44	0.647	Communication	-	-
Consistency	-	-	Dependability	-	0.006	Consistency	-	-	Consistency	.91	0.772	Consistency	-	-
Differentiation	-	-	Accuracy	-	0.055	Dependability	-	-	Accuracy	-	-	Differentiation	-	-
Integration	-	-	Accessibility	-	0.088	Differentiation	-	-	Availability	-	-	Integration	-	-
Intuition	-	-	Integration	-	0.781	Integration	-	-	Relevance	-	-	Intuition	-	-
Relevance	-	-	Communication	-	-	Intuition	-	-	Safety	-	-	Relevance	-	-
Safety	-	-	Differentiation	-	-	Process	-	-	Speed	-	-	Safety	-	-
Speed	-	-	Speed	-	-	Support	-	-	Differentiation	-	-	Speed	-	-

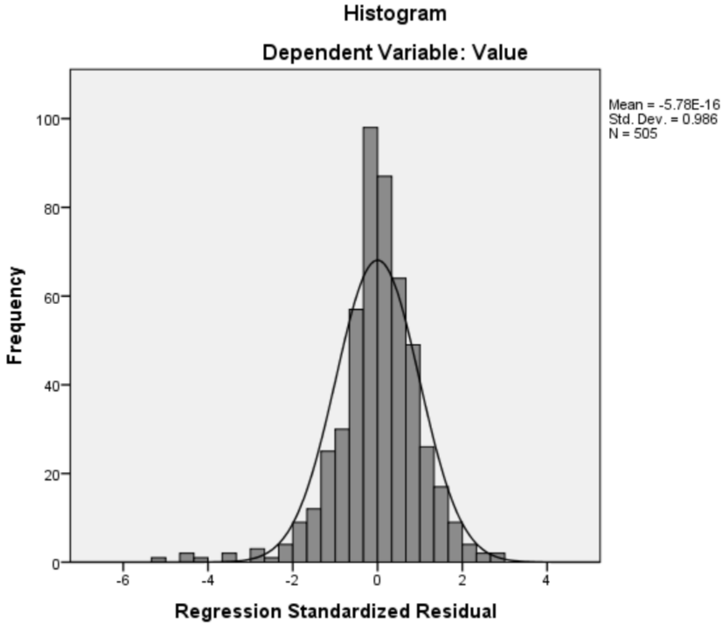
Velindre Health Board

Consultant			Doctor			Nurse			Other			Pharmacist		
Attribute	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*	*Attribute*	*Beta*	*Sig.*
Intuition	.87	0.127	Accessibility	-	-	Accessibility	-	-	Differentiation	.83	0.038	Accessibility		-
Speed	.97	0.131	Accuracy	-	-	Accuracy	-	-	Relevance	.82	0.042	Accuracy		-
Integration	.88	0.316	Availability	-	-	Availability	-	-	Communication	.82	0.045	Availability		-
Relevance	.85	0.351	Communication	-	-	Communication	-	-	Consistency	.80	0.051	Communication		-
Accessibility	.50	0.497	Consistency	-	-	Consistency	-	-	Integration	.80	0.054	Consistency		-
Safety	.25	0.743	Dependability	-	-	Dependability	-	-	Accuracy	.76	0.074	Dependability		-
Availability	.38	0.748	Differentiation	-	-	Differentiation	-	-	Safety	.68	0.131	Differentiation		-
Consistency	.11	0.887	Integration	-	-	Integration	-	-	Intuition	.60	0.206	Integration		-
Accuracy	.02	0.982	Intuition	-	-	Intuition	-	-	Speed	.22	0.665	Intuition		-
Communication	-	-	Process	-	-	Process	-	-	Availability	.18	0.727	Process		-
Dependability	-	-	Relevance	-	-	Relevance	-	-	Accessibility	.08	0.871	Relevance		-
Differentiation	-	-	Safety	-	-	Safety	-	-	Dependability	-	-	Safety		-
Process	-	-	Speed	-	-	Speed	-	-	Process	-	-	Speed		-
Support		-	Support	-	-	Support	-	-	Support	-	-	Support		-

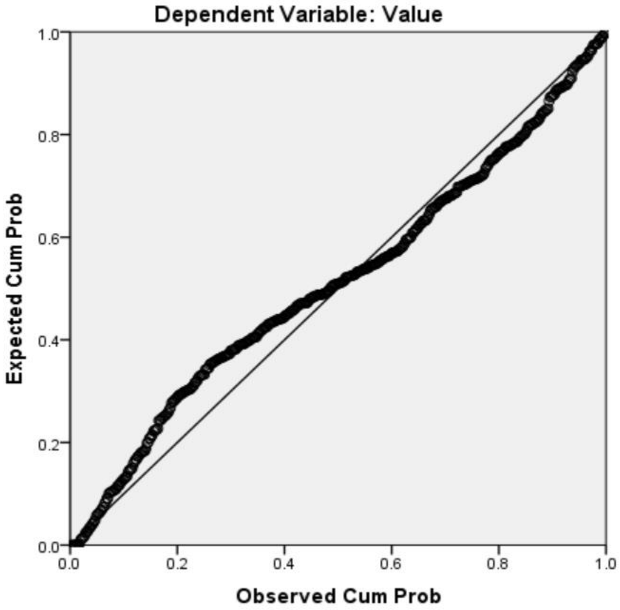
APPENDIX B. OPERATIONALIZATION OF SURVEY QUESTIONS

Attribute	*No*	*Question*	*Reference*
Accessibility	1	I have no difficulty logging into WCP	Lwonga and Komba, 2015
	2	I can log in very easily	Shaqrah and Husain, 2014
Accuracy	3	The electronic patient record helps to reduce errors	Cline and Luiz, 2013
	4	I am satisfied with the accuracy of WCP	Somers et al., 2003
Availability	5	WCP is available most of the time	Kirkley and Rewick, 2003
	6	The patient record is available when I need it	Vishwanath et al., 2010
Communication	7	WCP displays notifications indicating tasks to be undertaken	Alloghani et al., 2015
	8	WCP reminds me to follow up on patients	Alloghani et al., 2015
Consistency	9	The information in WCP is well formatted	Lin, 2010
	10	The information in WCP is displayed consistently	Messner, 2007
Dependability	11	I could lose information while working in WCP	John, 2015
	12	WCP is reliable	Ifinedo, 2011
Differentiation	13	WCP does not require me to access other systems to find the content I need	Heo, 2013
	14	The patient record contains sufficient information for my requirements	Somers et al., 2003
Intuition	15	The navigation within WCP is intuitive	Heo, 2013
	16	I spend a large proportion of my time actively clicking the mouse	Mikkelsen et al., 2007
Integration	17	WCP is compatible with other systems	Akbar, 2013
	18	WCP contains information that was previously only available in other syste	Batada and Rahman, 2012
Process	19	WCP provides information for use in all treatment situations	Messner, 2007
	20	WCP works well with internal workflow processes	Lin, 2010
Relevance	21	The information in WCP is directly applicable to my decisions or actions	Lee et al., 2010
	22	The content in WCP is relevant to my needs	Heo, 2013
Safety	23	The information in WCP is more secure than on paper	Cline and Luiz, 2013
	24	I'm not worried about the security of data in WCP	Alloghani et al., 2015
Speed	25	WCP is fast in terms of response times	Kirkley and Rewick, 2003
	26	WCP provides content at an acceptable speed	Heo, 2013
Support	27	Support staff always solve my problems	Stone et al., 2007
	28	Support staff are able to help with technical problems	Abdulwahab and Zulkhairi, 2011
Value	29	WCP adds value to the patient care that I provide	Doll and Torkzadeh, 1998
(dependant	30	I feel there is value in using WCP	Premkumar and Ramamurthy, 1995
variable)	31	I feel WCP is of value as it helps me in my tasks	Batada and Rahman, 2012

Appendix C. Test for Heteroscedasticity



Appendix D. Test for Normality



Appendix E. Scatterplot Test for Heteroscedasticity