O'Sullivan, D., Doyle, J., Michalowski, W., Wilk, S., Thomas, R. & Farion, K. (2014). Expanding usability analysis with intrinsic motivation concepts to learn about CDSS adoption: a case study. Health Policy and Technology, 3(2), pp. 113-125. doi: 10.1016/j.hlpt.2014.02.001

Expanding usability analysis with intrinsic motivation concepts to learn about CDSS adoption: a case study

ABSTRACT

Objectives

Despite many clinical decision support systems (CDSSs) being rated as highly usable, CDSSs have not been widely adopted in clinical practice. We posit that there are factors aside from usability that impact adoption of CDSSs; in particular we are interested in the role played by MDs intrinsic motivation to use computer-based support. Our research aim is to investigate the relationship between usability and intrinsic motivation in order to learn about adoption of CDSS in clinical practice.

Methods

Following the evaluation of a CDSS, 19 MDs completed a 2 part questionnaire about their intrinsic motivation to use computer-based support in general and the usability of the evaluated CDSS.

Results

The analysis of MDs motivation to use computer-based support demonstrated that MDs are comfortable using computer-based support and in general find using it quite easy (a motivation rating of 0.66 on a (0, 1) scale was computed). However MDs also reported a perceived lack of competence associated with a lack of prior experience using technology in practice, which results in pressure and tension. The considered CDSS scored highly on all usability dimensions and a usability rating of 0.74 was recorded. The examination of the relationship between motivation and usability suggested that users who were motivated to use computer-based support experienced better usability than those who reported low levels of motivation.

Conclusions

Our small case study suggests that an important factor supplementing the usability of CDSSs is intrinsic motivation to use computer-based support in general. We posit that the lack of such a measure thus far in CDSS evaluation may to some extent explain seeming MD satisfaction with CDSSs on one hand, but their limited adoption on the other. We recommend that clinical managers responsible for deploying CDSS should invest in training MDs to use technology underlying computer-based support applications instead of focusing only on the features of the specific CDSS to be deployed.

1. INTRODUCTION

CDSSs have been defined as "systems that apply knowledge to patient data in order to generate patient-specific advice" [1]. Despite the fact that CDSSs have been shown to improve MDs performance [2], reduce prescription errors [3], and improve adherence with recommended standards of care [4], actual use of CDSSs in practice is still relatively limited [5]. Research on the adoption of technology in general has established that usability is an important factor [6-10], and studies on the adoption of CDSSs have largely focused on usability issues where the ISO 9241-11 standard defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [11]. Evaluation of CDSS usability is often guided by Bates et al's "Ten Commandments" for effective clinical decision support [12], which put forward features such as speed, delivering information in real-time and seamless integration with workflow as critical success factors for usable and acceptable systems. Others have examined usability factors specific to the clinical environment that hinder acceptance of CDSSs and major impediments include discomfort in patient-doctor communication, lack of time to use CDSSs, a lack of evidence in guiding decisions, a lack of user control, disruptiveness, poor fit with workflow and decreased support for face-to-face dialogue when using technology at the point-of-care [5, 13, 14].

Studies on technology adoption outside the clinical domain report that user attitudes are an important success factor. The Theory of Reasoned Action (TRA) posits that behavior is predicted by a person's attitude [15]. Davis [6] adapted the TRA in the development of the Technology Acceptance Model (TAM), which has gained widespread acceptance within the information systems research community and has been applied in the evaluation of CDSSs [16-19]. A key criticism of TAM and its successor TAM2 has been the lack of a factor addressing user motivation. In order to address this shortcoming, Venkatesh et al. [20], formulated a unified model, the Unified Theory of Acceptance and Use of Technology which brings together a motivational model of user acceptance with the TAM. However, the model focuses on extrinsic motivational drivers while ignoring an individual's intrinsic feelings towards information system usage [21]. Extrinsic motivation is external to the individual and includes measures such as rewards and incentives [22] whereas intrinsic motivation refers to an individual's likelihood to engage in activities for the inherent satisfaction the person derives from the activity [23]. According to self-determination theory, intrinsic motivation is the core type of motivation driving participation in many types of activities including those involving computer-based tools [24].

The literature cites many attempts to measure intrinsic motivation. Webster and Martocchio [25] conceptualized intrinsic motivation as "computer playfulness" and a game context was introduced to computer-based training to make the task more intrinsically motivating. Their scale has been used to examine the role of intrinsic motivation in using decision support for real estate, property management, and financial services [6, 26, 27]. The Intrinsic Motivation Inventory (IMI) [28] is a theory that assesses intrinsic motivation in terms of participants' interest and enjoyment, perceived competence, effort, value and usefulness, felt pressure and tension, perceived choice, and relatedness to others while performing a target activity. Studies using the IMI have assessed subjects' intrinsic motivation to perform a wide range to tasks from computing [29] to participation in sports [30].

Motivation is commonly considered a necessary construct in encouraging workers to move away from their normal work practices and towards improved technology adoption. For example, Malhorta and Galletta [31] found that users with higher intrinsic motivation for the end goals of a computer system tend to make a greater effort to master the system. The authors concluded that "even the best-designed systems are not used if they are not aligned with users' intrinsic motivations". Interestingly they point out that poor understanding about motivation could lead to an overemphasis on schemes for fostering extrinsic motivation such as incentives (which are commonly used to encourage CDSS adoption) and that such incentives may actually be detrimental as users can perceive them as controlling.

Based on evidence from other domains, we posit that a better understanding of MDs attitudes towards CDSSs, in particular the factors that intrinsically motivate them to use such systems could lead to improved levels of usability and thus adoption. To this end we describe the results of a case study where MDs used a CDSS in the Emergency Department (ED) for a period of 12 months. We use these results to examine the relationship between usability and motivation in order to learn about adoption of CDSS in clinical practice. The remainder of this paper is organized as follows. In the Methods section we include a description of the evaluation of a CDSS for estimating asthma exacerbation severity. In the Results section we present an analysis of responses from questionnaires administered after the evaluation of the CDSS. We conclude with insights gained into MDs motivation to use computer-based support, and provide some recommendations for improved adoption of CDSSs.

2. METHODS

2.1 A CDSS for managing pediatric asthma exacerbations

The Mobile Emergency Triage – Asthma Exacerbation (MET3-AE) system is a CDSS for supporting management of pediatric asthma exacerbations [32]. The system runs on desktop computers and mobile devices including tablets, and interacts with hospital information systems using Health Level 7 (HL7) messages. Diagnostic capabilities of MET3-AE are provided by an embedded decision model that uses a Naïve Bayes classifier to predict asthma exacerbation severity within 2 hours of nursing triage. A screenshot from MET3-AE is shown in Figure 1 below and a full description of MET3-AE can be found in [32].

Figure 1: MET3-AE CDSS

2.2 Case study setting

An evaluation of the MET3-AE CDSS [33], approved by the hospital's ethics review board, was started in February 2009 in the ED of the Children's Hospital of Eastern Ontario (CHEO) in Ottawa, Canada and lasted for about 12 months. The purpose of the evaluation was to assess the accuracy of the embedded MET3-AE's decision model and to compare it to the performance of other diagnostic modalities. A total of 39 MDs which included Senior Medical Residents (SMRs) and staff physicians (ED MDs) used MET3-AE. This represented about 2/5 of all MDs working in the hospital ED (see Table 1 for a description of the participants). Participating

MDs used the MET3-AE CDSS installed on Motion Computing C5 tablet computers [34], which had just been introduced as the supported mobile device in the ED. Prior to the study all participants were given short orientation sessions about the purpose of the study and use of the Motion Computing C5 tablet.

Table 1. Participant characteristics

	ED MD	**SMR**
Gender		
Male	5	4
Female	6	4
Expertise		
>10 years' experience	4	0
<10 years' experience	7	8
Age		
<40 years	5	8
>40 years	6	0

Following completion of the evaluation of MET3-AE's decision model, we administered a two-part questionnaire to participants where responses were captured using a combination of Likert-type scale ratings and binary (yes/no) answers. The first part (see Appendix A) was designed to elicit MDs intrinsic motivation to use computer-based support where we define computer-based support as any software applications and computing devices (including desktop and mobile computers), that help in routine clinical activities. In analyzing intrinsic motivation we capitalized on the general structure of the IMI. The second part of the questionnaire (see Appendix B) was designed to capture data about usability of MET3-AE by measuring concepts from the ISO 9241-11 standard for usability, namely effectiveness, efficiency and satisfaction. These questionnaires were completed by 19/39 MDs. Subsequently the relationship between intrinsic motivation to use computer-based support and usability of MET3-AE was analyzed by comparing the responses from both questionnaires and the analyses of these questionnaires forms the basis of the case study reported in this paper. We need to note that the ability to use statistical techniques for data analysis is limited because of the case study format that focuses on a specific and small group of MDs working in a single clinical setting [35]. This is in contrast to a typical experimental study which would feature random selection and/or random assignment of participants. The data analysis presented in our case study is descriptive with the aim of summarizing the data and providing a succinct description of the patterns and relationships that are revealed. All inferences beyond the case study need to be non-statistical and further investigations will be required to conclusively establish linkages.

3. RESULTS

3.1 Motivation to use clinical computer-based support

3.1.1 Questions

Whilst designing the questionnaire for measuring intrinsic motivation we considered using explicit theories such as the IMI. However it was felt that by using generic IMI statements our study would lose its focus on computer-based support in the ED. Thus, we designed the questionnaire to reflect the specifics of the case study whilst incorporating motivational concepts outlined by the IMI into individual questions. In particular, our questionnaire incorporated concepts of effort, perceived competence, and pressure and tension. We also considered the IMI concept of interest and enjoyment, however, we decided against the term "enjoyment" in particular as it does not fit with the realities of the ED. We therefore replaced this concept with the related notion of "comfort". We hypothesized that our comfort scale will be a close proxy for "interest and enjoyment". We did not use the remaining IMI subscales. Relatedness refers to relatedness to others while performing a target activity which was not applicable in our context. Using the technology was voluntary therefore perceived choice was also not applicable. The value and usefulness subscale from IMI is used in internalization studies, the idea being that people internalize and accept a set of norms and values that are established by other individuals, groups, or society as a whole. In our study we were interested in evaluating individual experiences of motivation - MDs were asked to examine and diagnose patients on their own with the help of MET3-AE, and thus no team work nor group decision making was involved, - therefore we did not use this subscale. Therefore intrinsic motivation to use computer-based support was measured by incorporating the outlined concepts (effort, perceived competence, comfort, and pressure and tension), into questions that polled participants about their experience and professional activities involving computer-based clinical support (questions 1-3 from Appendix A), and their attitude towards mobile devices (questions 4-6 from Appendix A). Questions 1-5 were answered by all participants; question 6 was answered by 15 out of 19 participants. A mapping of questions to motivation subscales is shown in Table 2.

Table 2. Mapping questions to motivation subscales

Question	**IMI Subscale**
Question 1	Comfort
Question 2	Perceived Competence
Question 3 (a) Question 3 (b)	Pressure and Tension Perceived Competence
Question 4	Pressure and Tension
Question 5	Pressure and Tension
Question 6	Effort

3.1.2 Responses

For question 1, 86% of respondents said they were comfortable using technology with the remaining stating that they were neutral. For question 2, regarding proficiency in relation to their peers, 75% rated themselves as average (effectively a medium rating) and the remaining 25% rated themselves as above average (effectively a rating of high). In question 3, participants were asked about work related computer-based support applications. Specifically in part (a) they were asked how often they used a given application, and in part (b) how they rated their level of expertise. The results (in % of participants) for each computer-based support application are shown in Tables 3 and 4. The most frequently used applications were Email, Picture Archiving and Communications Systems (PACS) and Electronic Health Records (EHR). The least frequently used applications were research databases and statistical software. The majority of participants considered themselves to be of average competence, for example 36%, 53% and 42% considered that they were of average expertise when using the most frequently used applications (Email, PACS and EHR's respectively).

Table 3. Frequency (%) of use of computer-based support applications (Question 3a, Appendix A)

Application / Frequency	Medical websites	Medical repositories (e.g.	Creating/ modifying documents	Creating/ modifying spreadsheets	Sending/ receiving email	Viewing images on PACS	Clinical repositories or EHRs	Research databases/ statistical

		PubMed)						software
Daily	58	21	50	5	95	74	74	0
Few Times a Week	37	21	39	32	5	21	16	10
Few Times a Month	5	37	11	26	0	0	5	15
Few Times a Year	0	21	0	32	0	0	5	32
Never	0	0	0	5	0	5	0	43

Table 4. Levels of expertise (%) for computer-based support applications (Question 3b, Appendix A)

Application /Expertise	Medical websites	Medical repositories (e.g. PubMed)	Creating/ modifying documents	Creating/ modifying spreadsheets	Sending/ receiving email	Viewing images on PACS	Clinical repositories or EHRs	Research databases/ statistical software
Expert	21	10	16	5	32	10	10	5
Above Average	37	26	53	32	32	32	38	10
Average	42	54	31	42	36	53	42	37
Below Average	0	10	0	16	0	5	10	16
No Experience	0	0	0	5	0	0	0	32

The responses to question 4 reveal that only 42% of MDs use a mobile device as part of clinical practice. We were surprised by this rather low number given the relatively young age of the participants. Regarding the actual mobile device used (question 5), 79% had not used the Motion Computing C5 tablet before the study. Participants were asked in question 6 to rate the ease of use of features of the C5 tablet. 54% percent regarded the digital pen as easy to use; 60% found the data entry features easy to use, but these percentages fell to 42% and 38% for accessing ED management software or EHRs, and use at the point-of-care (Table 5).

Table 5. Ease of use (%) of mobile device features (Question 6, Appendix A)

Device/Ease of Use	Easy	Neutral	Difficult
Digital Pen	54	40	6
Data Entry	60	34	6
Access to Sunrise ED Manager	42	42	16
Use at the point-of-care	38	54	8

3.2 A Motivational Analysis

The data presented in the previous subsection was evaluated using the motivation concepts borrowed from the IMI tool – effort, comfort, perceived competence, and pressure and tension in order to construct a scale measuring MDs motivation to use computer-based support.

3.2.1 Effort Subscale

Effort is a negative predictor of intrinsic motivation – if MDs are to be motivated to move away from their traditional way of working, the effort required to learn and use computer-based support must be low. The answers to question 6 of Appendix A indicated that the majority of respondents thought that the C5 tablet was easy to use with 50% or more stating the digital pen, data entry and use at the point-of-care features were very easy or easy to use. To quantify these results we constructed a scale to take values between 0 and 1 (scaled such that higher values indicate higher motivation), and we describe its construction in two stages. Firstly, as effort is a negative predictor of motivation we scaled the responses with values 1, 2 and 3, with 3 allotted to "easy" and 1 assigned to "difficult". Each respondent was allocated an effort score consisting of the average of the four individual features of the C5 tablet, and the average of this score across all participants was 2.4 out of a possible maximum of 3. To produce a more immediately interpretable scale, the above effort score was converted using a linear transformation to a (0,1) scale, that is, by subtracting one from each observation and dividing the result by 2, yielding a final effort score of 0.7 on the (0, 1) scale. Since high scores represent low effort (desirable for adoption of the tool), this score can be interpreted as indicative of a relatively low effort for participating MDs. The Cronbach's alpha value for this scale was very high at 0.94.

3.2.2 Comfort Subscale

Responses to question 1 from Appendix A indicated that MDs were positively predisposed towards using computer-based support – 86% stated they were comfortable with it. The questionnaire contained only one question related to comfort, so it can be regarded as a single item scale. Given that comfort is a positive predictor of intrinsic motivation, a response of "comfortable" was assigned a score of 3, neutral a score of 2, and "not comfortable" a score of 1.This yielded an high average score of 2.84 out of a possible maximum of 3 which was transformed to 0.92 on the (0, 1) scale.

3.2.3 Perceived Competence Subscale

In general, MDs only considered themselves to be of average competence - 63% rated themselves as of average (or medium) proficiency in relation to their peers and the majority of MDs rated themselves as average when asked about their expertise using computer-based support applications. This was despite the fact that all MDs used at least one computer-based support application each day with over half (58%) using up to 3 applications daily (detailed data not shown). The results also suggest that MDs feel most competent at general tasks such as sending and receiving email (most likely used frequently outside the clinical environment) than performing specialized tasks such as using research databases.

The above assessment can be summarized in a quantitative fashion by scaling the responses to questions 2 and 3(b) and generating an average score for each respondent. As perceived competence is a positive predictor of intrinsic motivation, the levels of expertise for the eight computer applications in question 3(b) were scaled from 1 through 5 with 5 relating to the top category (expert). We scaled question 2 on a scale of 1, 3 and 5, with 5 allotted to the highest category. Thus each respondent was allocated a perceived competence score consisting of the average of the items and the result for the combined scale was 3.32 out of a possible maximum of 5. In the second stage, the sale was converted to the interval (0, 1) by subtracting 1 and dividing each respondent's mean response by 4. The average of this scale score across all participants was 0.58, slightly over the mid-point of the competence scale. A suitably high Cronbach's alpha value of 0.81 was recorded for the 8-item scale. This quantified assessment confirms the conclusion drawn from the earlier qualitative analysis: the respondents as a whole do not rate their competence particularly highly and a lack of perceived confidence can be seen as a potential barrier to MDs use of technology and CDSSs.

3.2.4 Pressure and Tension Subscale

Responses to question 4 of Appendix A revealed that just 42% of MDs currently use a mobile device at work whilst question 5 showed that only 21% had previous experience with the C5 tablet. Many participants commented that this lack of prior use added to levels of pressure and tension when using computer-based support. This suggests that frequency of use of computing devices, as well as frequency and range of computing activities are candidates for a pressure and tension scale. Thus, a scale for pressure and tension based on questions 3(a) (frequency of use), 4 (use of a portable device), and 5 (prior use of the C5 Motion Computing tablet) was constructed. Given that pressure and tension is a negative predictor of motivation, a reversed scale was constructed with question 3(a) scored from 1 through 5 in the first stage of construction, with the highest score allotted to "daily" use and questions 4 and 5 scored 1 or 5, with "yes" (indicating previous use), being scored highest in both cases. Individual scores were calculated as the average of each of the ten items. As the pressure and tension scale is reversed, a high score would indicate a low level of anxiety. The result for the combined scale was 2.8 out of a possible maximum of 5. As before, the second stage transforms these individual measures to the interval (0, 1), by first subtracting 1 and dividing the result by 4. On this scale, the average score over all participants was 0.45. Such a low mean score suggests that there are an appreciable number of participants who experience anxiety at the prospect of using computing devices in clinical practice. An acceptable Cronbach's alpha value of 0.79 was recorded for the 10-item perceived competence scale.

3.2.5 A Motivation Scale

The results for the 4 subscales (effort, comfort, perceived competence, and pressure and tension) are shown in Figure 2 below. These were combined and an average score of 0.66 on the (0, 1) scale was computed for intrinsic motivation to use computer-based support.

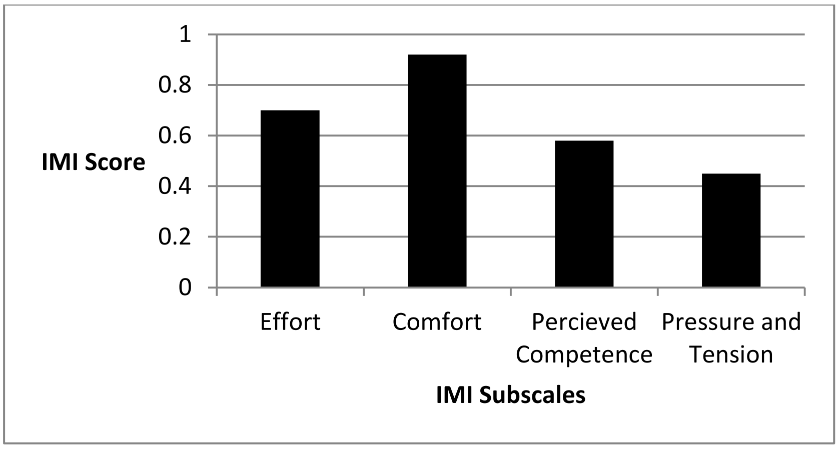

Figure 2: IMI subscales and scores

3.3 Usability of MET3-AE CDSS

3.3.1 Questions

While our research primarily investigates MD's motivation to use computer-based support, as part of the case study we took the opportunity to examine the usability of a CDSS (appendix B), and to investigate if there is a link between motivation and usability. Participants were asked to answer five questions (1-5 from Appendix B) and between 5 and 15 participants responded to individual questions therefore results reported are calculated using the response rate per question. Although the response rate for this part of the questionnaire was lower than for the previous, it is generally accepted that 5 users is sufficient for usability testing [36].

3.3.2 Responses

For question 1, 60% of MDs found electronic data collection using MET3-AE to be quicker than pen and paper, 20% found it to be slower than pen and paper, while the remaining respondent reported no noticeable differences in speed between the two methods. For question 2, 80% of MDs found the system easy to navigate whist 20% rated navigation as neutral. For question 3, all respondents found the data entry features intuitive. In response to question 4, 80% of MDs felt that all the functionality they required, or anticipated requiring, was available in MET3-AE. In terms of overall experience (question 5), 40% found MET3-AE easy to use, 40% found it average, and 20% reported it difficult to use..

3.3.3 A Usability Scale

The results of the usability evaluation of MET3-AE were positive indicating that in terms of the ISO 9241-11 standard definition usability, MDs found the system effective, efficient and satisfactory. A usability scale was created by scoring the four 3-category questions on a scale from 1 to 3, with 3 allocated to the most positive option, and by scoring the one binary question as 3 for a "no" answer and 1 for a "yes" answer. The average of these assessments over all respondents yielded a usability rating of 2.48 out of a maximum of 3. Finally, this was converted using a linear transformation to a (0, 1) scale, that is, by subtracting one from each observation and dividing the result by 2. The average of the transformed usability scores becomes 0.74 on the (0, 1) scale. Given such positive findings we would expect no major obstacles to the adoption of MET3-AE among participating MDs. However previous experience and similar usability studies from the literature indicate this might not to be the case [2-4, 13, 37, 38]. Furthermore, as the overall score we obtained for motivation (0.66) was lower than that for usability (0.74), we posit that usability is not the only factor at play in the adoption of CDSS and that MDs intrinsic motivation to use computer-based support also plays an important role.

3.4 The Relationship between Intrinsic Motivation and Usability

In order to understand the possible relationship between intrinsic motivation and a respondent's assessment of usability we compared responses across both questionnaires. In particular we compared responses obtained for question 5 from Appendix B where participants were asked to summarize their overall experience of usability, with responses obtained for each question from Appendix A. Question 5 had the highest response rate of all questions from questionnaire B with fifteen out of nineteen possible users responding. Each of these 15 MDs had supplied answers to all questions from the questionnaire in Appendix A, therefore a direct comparison of their answers for motivation and usability was possible.

To quantitatively compare responses we categorized the answers supplied for each question into binary responses. For example, question 5, Appendix B was categorized into “easy” versus “average/difficult” and question 1 from Appendix A was categorized into “comfortable” versus “neutral/not comfortable”. We constructed 2x2 tables linking usability (question 5, Appendix B) with intrinsic motivation (all questions from Appendix A). We then calculated the odds ratio which provides information on the strength of the relationship between two variables, to quantify the association between usability and each measure of intrinsic motivation. An odds ratio greater than 1 indicates a positive association, an odds ratio less than 1 indicates a negative association with 0 as the clearly specified value for total negative association, and an odds ratio precisely equal to 1 implies no association. These results are discussed in the next section. Due to the small sample size some odds ratios are either infinity (division by zero), or indeterminate (zero divided by zero) and cannot be evaluated. The odds ratios should be interpreted solely as data summaries because of the case study design of the experiment. Statistical inference based on such data is not valid.

3.4.1 Effort and usability

The reported levels of effort (question 6, Appendix A), for the 6 MDs who reported good usability (question 5, Appendix B) are low – all consider the digital pen and data entry easy to use, 4 reported accessing dedicated ED software and using the device at the bedside was easy and 2 reported it as neutral. The 9 MDs who reported poorer usability (question 5, Appendix B) reported higher levels of effort across all features of the C5 tablet with a majority of respondents indicating the features were either neutral or difficult to use. The odds ratios for these associations are shown in Table 6. All are large, and support inferred associations with the above summary.

Table 6. Odds ratio comparison for effort (question 6, Appendix A) and usability (question 5, Appendix B)

	Effort		
	Easy	Neutral / Difficult to use	Odds Ratio

Usability

Digital pen

Easy to use	6	0	Infinity
Neutral/Difficult to use	2	7	

Data entry

Easy to use	6	0	Infinity
Neutral/Difficult to use	3	6	

Access to dedicated ED and EHR software

Easy to use	4	1	24
Neutral/Difficult to use	1	6	

Use at the point-of-care

Easy to use	4	2	12
Neutral/Difficult to use	1	6	

3.4.2 Comfort and usability

For respondents (6 MDs) who reported that MET3-AE was easy to use (question 5, Appendix B), all reported high levels of comfort with technology (question 1, Appendix A). MDs who reported that MET3-AE was of average usability or difficult to use (9 respondents) reported relatively lower levels of comfort. The odds ratio for this association is shown in Table 7, but because of the zero count (small number of respondents in the "neutral/not comfortable column), the odds ratio takes on a value of infinity. This might suggest that with a bigger sample the odds ratio would be large, i.e., an indication of a positive association between usability and comfort.

Table 7. Odds ratio comparison for comfort (question 1, Appendix A) and usability (question 5, Appendix B)

		Comfort	
	Comfortable	Neutral /	Odds Ratio

		Not comfortable	
Usability			
Easy to use	6	0	Infinity
Average/Difficult to use	2	7	

3.4.3 Perceived competence and usability

For the 6 MDs who reported good usability (question 5 Appendix B), half of them reported above average proficiency in relation to their peers with none reporting below average proficiency (question 2, Appendix A). For the 9 MDs who reported average or difficult usability, only 3 assessed themselves as having 'above average' proficiency when compared to their peers, with the remaining 6 MDs stating they were of 'average' proficiency. An odds ratio of 2 for the association between perceived competence and usability is shown in Table 8 demonstrating that computer proficiency compared to peers is an influencing factor in motivation to use computer-based support.

Table 8. Odds ratio comparison for perceived competence (question 2, Appendix A) and usability (question 5, Appendix B)

	Perceived Competence		
	Above Average	Average / Below Average	Odds Ratio
Usability			
Easy to use	3	3	2
Average/Difficult to use	3	6	

Question 3b, Appendix A asked MDs to rate their level of expertise with various computer-based support applications. For quantitative comparison, the responses were categorized into binary responses of "expert"/ "above average" and "average"/ "below average"/ "no experience" (see Table 3) and cross tabulated with answers for usability (Question 5, Appendix B) as shown in Table 9. The results show a mix of positive and negative associations between perceived competence using individual computing applications and usability. The strongest positive associations involve applications that MDs may also use outside of the clinical environment and are likely more familiar with (e.g. browsing websites, modifying documents and using email).

Table 9. Odds ratio comparison for perceived competence (question 3b, Appendix A) and usability (question 5, Appendix B)

	Perceived Competence		
	Expert / Above Average	Average / Below Average / No Experience	Odds Ratio
Usability			
Browsing medical websites			
Easy to use	4	2	5
Average/Difficult to use	2	5	
Conducting searches of medical repositories			
Easy to use	2	4	0.625
Average/Difficult to use	4	5	
Creating or modifying documents			
Easy to use	5	1	6.25
Average/Difficult to use	4	5	
Creating or modifying spreadsheets			
Easy to use	2	4	1
Average/Difficult to use	3	6	
Sending or receiving email			
Easy to use	4	2	1.6
Average/Difficult to use	5	4	
Viewing images on PACS			

Easy to use	3	3	2
Average/Difficult to use	3	6	

Using clinical repositories

Easy to use	2	4	0.625
Average/Difficult to use	4	5	

Using research databases/ statistical software

Easy to use	0	6	Infinity
Average/Difficult to use	3	6	

3.4.4 Pressure and tension and usability

Question 3a, Appendix A asked MDs how frequently they use clinical support applications. For MDs reporting good usability (question 5, Appendix B), 50% of the answers regarding how frequently they use clinical support applications were in the "daily" category (Table 2). MDs that assessed usability as average or difficult used computer-based support applications slightly less frequently - 45% of the answers provided by this group were "daily". Responses were categorized into binary responses of "daily" and "a few times a week"/ "a few times a month"/ "a few times a year"/ "never" and cross-tabulated with answers for usability (Question 5, Appendix B) as shown in Table 10.

Table 10. Odds ratio comparison for pressure and tension (question 3a, Appendix A) and usability (question 5, Appendix B)

	Pressure and Tension		
	Daily	Weekly / Monthly / Yearly / Never	Odds Ratio
Usability			
Browsing medical websites			
Easy to use	5	1	

Average/Difficult to use	5	4	4

Conducting searches of medical repositories

Easy to use	3	3	3.5
Average/Difficult to use	2	7	

Creating or modifying documents

Easy to use	3	3	1
Average/Difficult to use	4	4	

Creating or modifying spreadsheets

Easy to use	1	5	Infinity
Average/Difficult to use	0	9	

Sending or receiving email

Easy to use	5	1	Infinity
Average/Difficult to use	9	0	

Viewing images on PACS

Easy to use	5	1	2.5
Average/Difficult to use	6	3	

Using clinical repositories

Easy to use	5	1	1.42
Average/Difficult to use	7	2	

Using research databases/ statistical software

Easy to use	0	6	Indeterminate
Average/Difficult to use	0	9	

Question 4, Appendix A polled MDs about their use of mobile devices in practice. Of the 6 MDs who reported good usability (question 5, Appendix B), 4 currently use a mobile device at work. Conversely for the 9 MDs who reported poor usability (question 5, Appendix B), only 3 of these participants use a mobile device in practice. Table 11 shows a strong positive association between motivation in the form of prior use of a mobile device and perceived usability.

Table 11. Odds ratio comparison for pressure and tension (question 4, Appendix A) and usability (question 5, Appendix B)

	Pressure and Tension		
	Yes	No	Odds Ratio
Usability			
Easy to use	4	2	4
Average/Difficult to use	3	6	

Question 5, Appendix A asked MDs if they had used the specific mobile device before the study. It's seems the choice of mobile device has little impact – for the 6 participants reporting good usability (question 5, Appendix B), none had used the C5 tablet before the study, whereas 3 out of the 9 participants reporting poor usability had previously used the device. The odds ratio calculated in Table 12 quantitatively demonstrates that the specific mobile device has a negative association.

Table 12. Odds ratio comparison for pressure and tension (question 5, Appendix A) and usability (question 5, Appendix B)

	Pressure and Tension		
	Yes	No	Odds Ratio
Usability			
Easy to use	0	6	0
Average/Difficult to use	3	6	

4. CONCLUSIONS

We have presented results from a case study that analyzed responses from a questionnaire designed to elicit information about the intrinsic motivation of MDs to use computer-based support. We associated these responses with answers provided by MDs regarding the usability of a CDSS in order to explore possible links between MDs motivation to use computer-based support and usability of CDSSs. Our analysis showed that MDs are generally comfortable using computer-based support and find it easy to use, however they do not consider themselves particularly competent with computing devices and experienced high levels of pressure and tension when using computer-based support. Given a high rating for MET3-AE on a constructed usability scale, it could be expected that the CDSS would be readily adopted in practice. However, MET3-AE was not used by MDs following the study. We associated our results for intrinsic motivation and usability of MET3-AE and our analysis suggests that intrinsic motivation is strongly related to the usability of CDSSs. In general, MDs who reported higher levels of motivation to use computer-based support also reported better usability of the evaluated CDSS. This observation was valid across all motivational constructs– participants who experienced good usability reported higher levels of comfort, lower levels of effort and pressure and tension as well as greater perceived of competence.

Based on our analysis we posit that usability analysis alone which is the usual method for measuring CDSS acceptance and adoption, would not uncover limiting factors associated with intrinsic motivation and therefore does not provide sufficient insight. In light of our observations we recommend that evaluation practices for CDSSs be supplemented with an intrinsic motivation dimension that assesses how much MD's are motivated to use CDSSs. These factors can be elicited by applying theories such as the IMI, or by extending usability models (e.g. the TAM), to include factors such as perceived competence and pressure and tension.

In addition, from a technology policy perspective our observations call for increased training for MDs in order to instill confidence in using computer-based support. We recommend that clinical managers responsible for deploying CDSS should invest in encouraging and training MDs to use the technology underlying computer-based support applications instead of focusing just on the features of the specific CDSS to be deployed. Such familiarization should increase levels of perceived competence and alleviate pressure and tension when using computer-based support in general. This will in turn improve MDs' motivation to use specific CDSS.

We recognize limitations of our research. The case study was conducted at a single clinical center involving a relatively small number of non-randomly selected participants. Demographics were skewed towards younger MDs (68% were under 40 years old). The study involved only MDs, and we recognize that other clinicians, e.g. nurses, also use computer-based support. The study involved one computing device and could not be controlled for the impact of the particular device on overall results. We also recognize that our study was too small to address socio-environmental aspects related to users' motivations to use CDSS, for example there is currently a lack of clear evidence about the impact of CDSSs on patient outcomes. It is important that such issues be addressed by larger studies in the field. However, despite these limitations, we believe that we were able to provide valuable insights into continuing discussion about the factors influencing adoption of CDSSs in practice.

ACKNOWLEDGEMENTS

The authors would like to thank the MDs who participated in the study.

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APPENDIX A: Motivation to use clinical computer-based support

Question 1: How would you rate your comfort level of using technology and computer-based support in practice, in general?

(i) Comfortable

(ii)Neutral (neither comfortable nor not comfortable)

(iii)Not Comfortable

Question 2: How would you rate your computer proficiency in relation to your peers?

(i) Above Average

(ii) Average

(iii)Below Average

Question 3: For each of the following computer-based support applications, please tell us (a): how often you have used it for work-related purposes in the past year,

(i) Daily

(ii) Few times a week

(iii) Few times a month

(iv) Few times a year

(v) Never;

followed by (b): how you would rate your level of expertise.

(i) Expert

(ii) Above Average

(iii) Average

(iv) Below Average

(v) No Experience.

a) Browsing medical websites (e-medicine, Up-to-date)

b) Conducting searches of medical repositories (PubMed, etc.)

c) Creating or modifying documents (word processing)

d) Creating or modifying spreadsheets

e) Sending or receiving Email

f) Viewing images on PACS

g) Using clinical repositories (Sunrise ED Manager) or EHR's

h) Using research databases or statistical software

Question 4: Do you currently use a personal portable device (e.g. smart phone or PDA) for clinical care in your usual practice environment?

(i) Yes

(ii) No

Question 5: Had you used the Motion Computing C5 tablet before the evaluation of MET3-AE?

(i) Yes

(ii) No

Question 6: For the following features of the Motion Computing C5 tablet, how would you rate the effort required to use each feature.

(i) Easy, (ii) Neutral (neither easy nor difficult), (iii) Difficult

a) Digital pen

b) Data entry

c) Access to Sunrise ED Manager

d) Use at the point-of-care

APPENDIX B: Usability of MET3-AE

Question 1: How would you rate your speed collecting and recording data, relative to collecting similar information with pen and paper?

(i) Electronic data capture was quicker than pen and paper

(ii) Electronic data capture was similar to pen and paper

(iii) Electronic data capture was slower than pen and paper

Question 2: How would you rate the ease of navigate between different sections within the MET3-AE?

(i) Easy to navigate

(ii) Neutral (neither easy nor difficult)

(iii) Difficult to navigate

Question 3: Were data entry features, such as pop-up number pads for entering numerical data, intuitive to use?

(i) Intuitive to use

(ii) Neutral (neither intuitive nor not intuitive to use)

(iii) Not intuitive to use

Question 4: Did you feel there was any required functionality missing from MET3-AE?

Yes (please provide information)

No

Question 5: Please rate your overall experience:

(i) Easy to use

(ii) Average

(iii) Difficult to use