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Physicians' use of handheld computers is increasing, but still incomplete. Device usability is a commonly cited adoption barrier. This study explores physicians' usability evaluations and adoption preferences for handheld computers. We conducted a randomized crossover study to compare the Apple iPod Touch and Palm Tungsten C. The study was conducted in a laboratory setting with 23 internal medicine resident physicians from Duke Medical Center. Participants used each device to respond to clinical questions based on hypothetical cases and completed a survey based on the extended Technology Acceptance Model. The iPod Touch had significantly higher ratings than the Tungsten C for perceived ease of use, perceived usefulness, subjective norm, image, and intention to use. Perceived ease of use was an important determinant of participants' intention to use handheld computers. Improving ease of use may encourage handheld computer adoption among physicians.

Headings:

Portable computers

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Comparing the Usability of Apple and Palm Handheld Computing Devices among Physicians: A Randomized Crossover Study

by

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Introduction

For years, physicians have used handheld computers to retrieve information and apply computing power at the point of care [1]. In the last decade there has been an increasing trend in handheld computer use by physicians, with adoption rates ranging from 45 to 85% in recent years [2]. Some studies suggest that handheld computers are underutilized by physicians [3] and have yet to be fully implemented in health care [4]. Several studies have explored the barriers to adoption of these devices by physicians [5-7], with many reports citing usability as a key obstacle [8-10]. This research explores how usability and other factors may contribute to handheld computer adoption by physicians.

Background

A body of research has examined the uses and benefits of handheld computers in medicine. Applications for decision support and information retrieval – including pharmacopeias, medical calculators, and medical references – are the most popular among physicians [7 10-13]. Pharmacopeias have the highest prevalence (69 – 100%†) [14-19]. This trend corresponds with the perception that handheld computers increase patient safety by providing appropriate drug dosing recommendations and decreasing medication errors [14 20 21]. Studies showing reductions in drug interactions in the outpatient setting [22] and reductions in

† of physicians using a handheld computer in clinical practice

length of stay and antibiotic prescribing in the critical care unit [23] corroborate this perceived benefit.

Medical reference materials – including text books, journals, and practice guidelines – are also popular among physicians (38 – 66%) [14-19]. This trend corresponds with another perception that handheld computers provide quick and easy access to relevant medical resources [6 14], thereby improving patient care [5 21]. This perceived benefit is confirmed by studies showing improved evidence-based practice [24] and adherence to treatment and diagnosis guidelines [25] with handheld computers.

Physicians use handheld computers for other tasks beyond pharmacopeia and medical reference research. Medical calculators are widely used (61 – 89%) along with scheduling, contact management, and note-taking tools that come pre-loaded on most devices (42 – 92%) [14-17]. Patient tracking, medical billing and coding, web browsing, email, and electronic prescribing applications are also used, but much less frequently [7 14-17]. Even so, these and other tools may contribute to the perception among some physicians that handheld computers improve efficiency and [14] and enhance productivity [26]. For collecting clinical research data, randomized studies show increased speed and data integrity with handheld computers when compared to paper-based instruments [27 28]. Additionally, research examining novel uses such as voluntary medication event reporting [29] and automated triage for bioterrorist disasters [30] have yielded positive results.

Adoption barriers

Despite the numerous uses and benefits of medical handheld computing, recent studies suggest that adoption by physicians is incomplete [3 4]. Several studies have examined the adoption barriers of these devices. While organizational barriers – including security and privacy concerns related to HIPAA – are prevalent [12 31-33], the majority of obstacles involve the usability of handheld computers. Ease of use is a key issue. Physicians frequently cite poor user interfaces [6 8 24] and difficult data entry [3 8 9 14 24 32] as major impediments to adoption. They also cite limitations in computer memory [3 14 34], battery life [3 6 9], device speed [3 6 14 24], and screen size [3 9 14 24] as significant barriers.

Along with ease of use, usefulness is important for usability. Some physicians question whether handheld computers are useful in medicine. The lack of need or motivation is often cited as a barrier to adoption [3 5 9 34]. This is bolstered by concerns about the accuracy and completeness of clinical tools for handheld devices [6 32 34] – as well as reliability of the devices themselves [6 14]. When we consider additional barriers such as cost [6 12] and low comfort with technology [3 7], we begin to understand why handheld computers may be underutilized.

Study purpose

To explore how usability and other factors may contribute to handheld computer adoption by physicians, we compared a newer platform (Apple™ iPod Touch) to a more established platform (Palm™ Tungsten C) through a randomized crossover trial to determine whether physicians consider one interface to be more usable. We chose the Palm mobile platform as the traditional interface since studies

show it is the dominant platform among physicians (74 – 90%†) compared to Windows Mobile™ (9 – 16%†) [14 16 17 35]. We chose the Apple platform as our emerging interface because of its innovative design and multi-touch functionality as well as the relative lack of research on Apple handheld computers in medicine.

Technology Acceptance Model

We used a modified version of the Technology Acceptance Model (TAM) to collect physicians' usability evaluations and adoption preferences for the two platforms. The original TAM is well established for relating and measuring perceived usefulness, perceived ease of use, and intention to adopt new technology [36-38]. However, additional measures may be necessary when evaluating technologies in a healthcare setting [39].

We based our data collection instrument on an extended TAM that also measures subjective norm, image, job relevance, and result demonstrability [40]. Subjective norm refers to the perception of the technology in the eyes of people that the user deems as important. Image is the perception that the technology will offer social standing. Job relevance refers to the perception of how applicable the technology is to a user's job. Finally, result demonstrability is the perception of tangible results due to technology use [40].

While some elements of the extended TAM are not fully supported when applied to healthcare professionals [41-43], this model is better than other behavioral models for studying health technology adoption [44]. Studies have tested TAM and its variants in the healthcare setting with positive results [45-48].

Hypotheses

We made the following hypotheses in our comparison of the traditional interface (Palm Tungsten C) with the emerging interface (Apple iPod Touch).

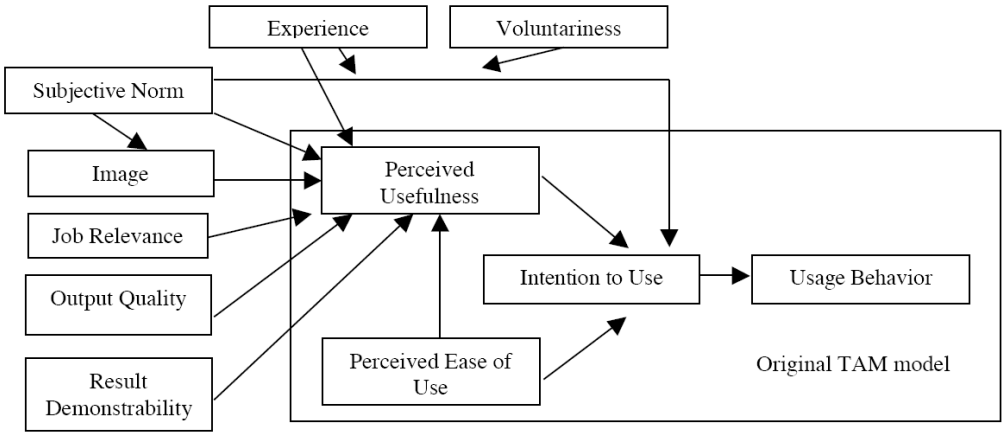
Table 1. **Hypotheses**

Construct	Hypotheses	
Perceived Ease of Use	H_1:	Participants will rate the Apple iPod Touch higher than the Palm Tungsten C for perceived ease of use.
Perceived Usefulness	H_2:	Participants will rate the Apple iPod Touch higher than the Palm Tungsten C for perceived usefulness.
Subjective Norm	H_3:	Participants will rate the Apple iPod Touch the same as the Palm Tungsten C for subjective norm.
Image	H_4:	Participants will rate the Apple iPod Touch higher than the Palm Tungsten C for image.
Job Relevance	H_5:	Participants will rate the Apple iPod Touch the same as the Palm Tungsten C for job relevance.
Result Demonstrability	H_6:	Participants will rate the Apple iPod Touch the same as the Palm Tungsten C for result demonstrability.
Intention to Use	H_7:	Participants will rate the Apple iPod Touch higher than the Palm Tungsten C for intention to use.
	H_8:	Perceived ease of use will be positively associated with intention to use.
	H_9:	Perceived usefulness will be positively associated with intention to use.

H_1 and H_2 stem from the improved interface and navigation features for which the Apple device is widely recognized. H_5, and H_6 arise because we test a nearly identical functionality in both devices that should give the same user results. H_3 assumes participants have not been influenced by their superiors regarding the two devices. On the other hand, H_4 assumes that the novelty of the Apple device may affect user perceptions.

H_8 and H_9 arise from assumptions derived from the extended TAM illustrated in Figure 1 [40]. They are the most significant for this study given our focus on usability perceptions and their effect on technology adoption. We did not examine experience or voluntariness in our study because we tested the devices in a laboratory setting. We also excluded output quality because we controlled participant's interactions with both devices to yield comparable results.

***Figure 1*. Extension of Technology Acceptance Model** [40]



Significance

This study contributes to the understanding of Apple handheld computers in healthcare. As a recently released technology, there is a research gap for these devices. Additionally, the majority of research on physicians' handheld computer use is descriptive – rather than comparative – with little evidence-based guidelines [1 12]. Through randomized crossover trial evidence, we compare usability evaluations and adoption preferences for Palm and Apple devices in order to gain insight into whether the emerging Apple interface might overcome the adoption barriers of traditional devices.

Methods

Design Overview

This study compared the Apple iPod Touch and the Palm Tungsten C in a randomized crossover trial that examined their usability evaluation and adoption preference among resident internists.

Setting and Participants

The study was conducted in the Department of Medicine Library at Duke University Medical Center in March 2009. Only house staff from the internal medicine residency program were recruited including categorical, preliminary, medicine-psychiatry, and medicine-pediatrics residents – there were no other exclusion criteria. We recruited primarily via email and word of mouth. Participants received 25 dollars compensation and a complimentary meal upon completion.

Randomization and Intervention

The study coordinator enrolled research participants via email and an online scheduling web application. Participants arrived at the Department of Medicine Library at the scheduled time. Upon consent, participants were randomly assigned to a sequence order for examining the devices: test the Apple iPod Touch first and then the Palm Tungsten C, or vice versa. Participants were randomized by drawing numbers from a bag; there was equal probability of drawing either device.

After receiving either the iPod Touch or the Tungsten C, participants used the Epocrates medical reference software on the device to respond to clinical questions based on a hypothetical case. The questions required participants to carry out a medical calculation, a drug reference task, and a disease reference task using the

software suite. Participants then exchanged their devices for their second handheld platform - those with an iPod Touch received a Tungsten C and vice versa – to respond to a comparable set of clinical questions. Due to strong similarities between the versions of Epocrates for the iPod Touch and the Tungsten C, different case studies were generated for each device (Appendices E and F).

Outcomes

Participants completed a brief survey to collect background details. Following each case study, participants completed a questionnaire evaluating their experiences with the device (Appendix A). The questionnaire was based on the extended version of the Technology Acceptance Model (TAM). The primary measured outcomes were intention to use, perceived usefulness, perceived ease of use, subjective norm, image, job relevance, and result demonstrability. These outcomes were measured with a seven-point Likert scale (1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree).

After using both handheld platforms, participants responded to open-ended questions regarding their opinions on technology adoption and their experiences. All surveys and questionnaires were administered via laptop computers using Qualtrics web software.

Statistical Analysis

We compared measured outcomes between the iPod Touch and Palm Tungsten C using independent two-sample t-tests. We conducted multiple linear regression analysis to investigate the association between the extended TAM

constructs illustrated in Figure 1. All statistical analyses were conducted with JMP statistical software.

Ethical Considerations

The Duke University Health System Institutional Review Board and the University of North Carolina at Chapel Hill Behavioral Institutional Review Board determined that our protocol met the criteria for exemption as described in 45 CFR 46.101(b)(2). A trained research assistant obtained consent from all participants. See Appendices B through D for supporting documentation.

Role of the Funding Source

The study was supported by the Haynes IT Adoption Fund in the Department of Medicine, Duke University. The funding source had no role in the design, conduct, data analysis, or reporting of this study.

Results

Baseline Characteristics

We recruited 23 participants from the 163 Duke Medicine residents eligible for the research, and all completed the study. Participants were predominantly male and were early in their residency training (Postgraduate year mean = 1.78, SD = 0.90). The majority of participants had already incorporated handheld computers into their clinical practice, and almost all had previous experience with handheld computers (Table 2). Additionally, nearly all participants had previously used the Epocrates drug database in its web or handheld formats.

Table 2. **Baseline Characteristics**

Characteristic, *n (%)*	**Study Group** *(n = 23)*
Gender	
Male	17 (74)
Female	6 (26)
Postgraduate Year	
PGY1	11 (48)
PGY2	7 (30)
PGY3	4 (17)
PGY4	1 (4)
Handheld Computer Experience	
Clinical Setting	14 (61)
Any Setting	21 (91)
Previous Epocrates Use	21 (91)
First Device Assignment	
Apple iPod Touch	13 (57)
Palm Tungsten C	10 (43)

Comparison of Handheld Computers

Table 3 compares participant ratings for the extended TAM constructs between the two devices. On average, participants rated the iPod Touch significantly higher than the Tungsten C for measures of perceived usefulness, perceived ease of use, subjective norm, image, and intention to use ($p < 0.05$ for all constructs). There were no significant differences between the two devices for measures of job relevance and result demonstrability. See Appendix A for the average participant ratings for each survey question.

Table 3. **Comparison of Participant Ratings for Handheld Computers**

Construct	iPod Touch *mean† (SD)*	Tungsten C *mean† (SD)*	t	p-value
Perceived Usefulness	5.88 (0.81)	5.42 (0.95)	2.92	0.0079
Perceived Ease of Use	5.72 (1.11)	4.88 (1.15)	2.77	0.0111
Subjective Norm	3.59 (1.39)	2.91 (1.21)	2.69	0.0134
Image	4.26 (1.29)	2.87 (1.55)	5.54	<0.0001
Job Relevance	4.91 (1.22)	4.87 (1.29)	0.16	0.8777
Result Demonstrability	5.43 (0.85)	5.25 (0.94)	1.61	0.1213
Intention to Use	5.89 (1.15)	4.30 (1.37)	4.06	0.0005

†Rating on a seven-point Likert scale (1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree)

Relationships between Constructs

Multiple regression analysis was conducted to confirm the relationships between constructs put forth in the extended TAM (Figure 1).

Table 4 shows the effects of perceived usefulness, perceived ease of use, and subjective norm on the intention to use for each device. Perceived ease of use was a statistically significant determinant of intention to use for the iPod Touch ($p < 0.05$), but not so for the Tungsten C ($p < 0.10$). Perceived usefulness and subjective norm

were not statistically significant determinants of intention to use for both devices. The extended TAM could account for 53% of the variance in usage intentions for the iPod Touch and 32% of the variance in usage intentions for the Tungsten C.

Table 4. **Regression Analysis of Extended TAM Constructs**

Construct Explained	Apple iPod Touch		Palm Tungsten C	
	R^2	*β*	R^2	*β*
Intention to Use	0.53		0.32	
Perceived Usefulness		0.21		0.44
Perceived Ease of Use		0.59*		0.45†
Subjective Norm		0.16		0.44†
Perceived Usefulness	0.66		0.42	
Subjective Norm		(0.02)		(0.42)*
Image		(0.15)		0.06
Job Relevance		0.20*		(0.05)
Result Demonstrability		0.21		0.39
Perceived Ease of Use		0.44**		0.24
Image	0.46		0.22	
Subjective Norm		0.63***		0.64*

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.1$. Adjusted R^2s are shown. β: standardized regression coefficients

Table 4 also shows the effects of subjective norm, image, job relevance, result demonstrability, and perceived ease of use on perceived usefulness. For the iPod Touch, perceived ease of use was a significant determinant of perceived usefulness ($p < 0.01$) as was job relevance ($p < 0.05$). The extended TAM could account for 66% of the variance in perceived usefulness for the iPod Touch. For the Tungsten C, only subjective norm was a significant determinant of perceived usefulness ($p < 0.05$). The extended TAM could account for 42% of the variance in perceived usefulness for the Tungsten C.

Lastly, subjective norm was a statistically significant determinant of image for both the iPod Touch ($p < 0.001$) and the Tungsten C ($p < 0.05$). The extended

TAM could account for 46% and 22% of the variance in image for the iPod Touch and Tungsten C respectively (Table 4).

Qualitative Results

Participants' qualitative responses were analyzed for common themes in handheld computer adoption and experiences (Table 5). Consistent with other studies, pharmacopeias were the most commonly used resource by participants already using handheld computers for clinical practice. Furthermore, perceptions of quick and easy access to information were seen as the primary benefits of clinical handheld computing.

Many participants (n = 14, 61%) indicated that perceived ease of use is the most important variable in the extended TAM for device adoption decision making, followed by perceived usefulness (n = 7, 30%), and job relevance (n = 2, 9%). Several participants (n = 11, 48%) suggested that cost – a factor excluded in the model – is an important determinant of intention to use.

When asked about their iPod Touch experience, participants had positive remarks about the device's ease of use, speed, portability, interface, and image. Twenty-one of the 23 residents (91%) indicated they would choose an iPod Touch over a Tungsten C because of those characteristics. However, some participants complained of difficulty typing with the iPod's touch screen keyboard. However, these criticisms may be an issue of familiarity: an Apple handheld computer user reported difficulties using the Tungsten C, while a Palm user found the iPod Touch to be more difficult.

Another common theme was the perception that the iPod Touch would be easier to use in non-clinical applications, such as playing music and web browsing. While many felt this trait might could increase the adoption of the iPod Touch in healthcare settings, one participant saw a negative consequence – that non-clinical applications might distract physicians from their clinical responsibilities.

Table 5. **Summary of Qualitative Responses**

Topic	Top Responses (in decreasing order)	
Past experience with handheld computers for clinical use	Pharmacopeia Text references Medical calculators	
Perceived benefits of handheld computers for clinical use	Provides quick access to information Save time	
Perceived barriers to handheld computers for clinical use	Preference for other tools and resources Difficult to use Unreliable Lack of need Lack of exposure to devices Poor battery life Devices are heavy	
Experience with Palm Tungsten C	*Pros* Effective for information retrieval Easy data entry with keypad	*Cons* Dated design Difficult to use Has too many buttons
Experience with Apple iPod Touch	*Pros* Easy to use Offers non-clinical functionality Good user interface Fast system speed Portable	*Cons* Text entry was difficult Non-clinical functions could be distracting
Important factors missing from the extended Technology Acceptance Model	Cost Non-clinical utility of device Look and feel of device in hand Amount of time before technology becomes outdated	

When asked about their Tungsten C experiences, participants had criticisms about the device's ease of use. Even so, one resident said he preferred the Tungsten C over the Windows Mobile device he received at the beginning of his residency

training. Also of note, one participant found the Tungsten C to be more difficult to use than other Palm platform devices. Two participants (9%) indicated a preference for the Tungsten C over an iPod Touch because they were already familiar with Palm devices and preferred the full keyboard for data entry.

Some participants were skeptical about the value of any handheld computer in a clinical setting. One participant believed that handheld computing in medicine is a good idea, but the devices are too difficult to use to be practical. Residents who were not using handheld devices in clinical practice cited a preference for resources in either print or desktop computer formats. Others felt handheld computers were not "absolutely necessary" in most contexts, and there were complaints that the devices were not fully integrated into hospital record systems. Some participants went further, regarding the reliance on handheld computers as a reflection of poor medical knowledge. Perceptions of the utility of handheld computers in medicine did not change significantly from before the intervention (mean rating = 5.70 on a seven-point Likert scale) to after (mean rating = 5.90, t = 1.42, $p = 0.17$).

Discussion

Comparison of Apple iPod Touch and Palm Tungsten C

This study confirmed several of our hypotheses (Table 1). Participants rated the iPod Touch more favorably for perceived ease of use and perceived usefulness (H_1, H_2), possibly because of its novel interface and navigation features. This preference was further validated by participants' positive remarks about the iPod Touch's superior interface and potential usefulness in clinical as well as non-clinical settings. Additionally, we suggested that the novelty of the iPod Touch would positively affect users' perceptions of its image (H_4). This was supported by our comparative analysis and substantiated by participants' qualitative descriptions of the "cool" and "attractive" iPod Touch.

We proposed that participants' ratings of job relevance and result demonstrability would not differ between the two platforms since we tested nearly identical functionalities that would yield similar results on both devices (H_5, H_6). Our findings support this premise, and participants commented that both devices were similar in effectiveness for using the Epocrates application.

We were mistaken in our assertion that users' ratings of subjective norm would be similar for the two platforms (H_3). We assumed that participants would not be significantly influenced by superiors or colleagues for the choice of handheld computing platforms, but our comparative analysis did not support this notion. Participants felt that people important to them would prefer the iPod Touch over the Tungsten C.

For intention to use, we suggested participants would rate the iPod Touch more favorably than the Tungsten C (H_7). This hypothesis was strongly supported by our comparative analysis, while 91% of participants (21 of the 23 residents) indicated an intention to use the iPod Touch before a Tungsten C in their qualitative remarks.

Relationships between Constructs

Our regression analysis confirmed only one of the relationships put forth by the extended TAM: perceived ease of use is positively associated with intention to use (H_8). This association was statistically significant for the iPod Touch only. Participants also reported in their qualitative responses that perceived ease of use was the most important construct for determining intention to use. In addition, we hypothesized that perceived usefulness would be positively associated with intention to use (H_9), but these results were not significant.

We saw a statistically significant negative association between subjective norm and perceived usefulness for the Tungsten C. This unexpected finding is counterintuitive: it suggests that when highly regarded physicians prefer the Tungsten C, the participants will perceive the device as less useful. Perhaps participants might have had poor experiences with handheld devices similar to the Palm Tungsten C despite positive recommendations from their superiors and colleagues. Some participants reported receiving handheld computers at the beginning of medical school or residency, and most of them reported negative experiences with those devices. Therefore, these participants might not trust

recommendations from superiors and colleagues, especially for traditional interfaces.

Implications for Practice

According to our findings, perceived ease of use is the most important factor determining physicians' intentions to use handheld computers. Participants recognized the devices' potential usefulness and job relevance in clinical practice, but they were deterred by difficult to use interfaces. This may explain participants' preference for the iPod Touch over the Tungsten C. Several participants were impressed by the iPod's large touch screen and intuitive navigation scheme, while noting that the Palm design was difficult to use. At the same time, results indicated that both devices were similarly relevant to clinical work. Health organizations wishing to encourage handheld computer adoption by physicians should identify the platform that maximizes ease of use and functionality.

Factors not measured by the extended TAM may offer insight into physicians' technology acceptance preferences. One factor is cost since nearly half of all respondents cited this as a major hindrance to handheld adoption. Additionally, participants discussed the importance of non-job related functionality. If devices could be clinically useful as well as offer functions such as web browsing and multimedia entertainment, this may encourage adoption by physicians. Participants repeatedly cited this point in their discussion of the iPod Touch. Finally, the compatibility with existing hospital systems and workflow may be an important determinant of intention to use. For example, one participant noted the importance of integrating handheld computers with hospital record systems. If physicians are

frequently accessing patient files on desktop computers, they are less motivated to carry a separate computing device. Another participant reinforced this idea, noting that all preferred resources are already available in print and desktop computer formats, so the handheld computer must offer easier access in order to encourage adoption.

Limitations

The study sample size was small, which limited the power of the statistical analyses. Participants with prior handheld computing experience were not excluded and this may have led to bias. As an experimental study in a controlled laboratory setting, participants evaluated the devices for a short period of time, which might not simulate daily clinical use. This could limit the generalizability of the results. Moreover, participants only used the Epocrates application, and did not test other functionalities, such as web surfing or word processing. Therefore, findings may be attributed to the Epocrates interface rather than the hardware itself. We intended to include an online browsing activity for this study, but our hospital environment did not support wireless network access for Palm devices due to security reasons.

Future Research

To foster handheld computer adoption in medicine, we recommend further comparative studies on the usability evaluations and adoption preferences of physicians. A next step is conducting larger trials over extended periods of time in clinical settings and to include print and desktop references as a control. Furthermore, there should be testing of additional platforms in the marketplace, such as Windows Mobile™ and Blackberry™. Such research would guide physicians

in their selection of a handheld platform as well as provide handheld computer manufacturers and software programmers with evidence for improved clinical design and applications.

We also recommend focusing on objective measures when determining the value of handheld computers in medicine. While many studies have suggested potential and perceived benefits of handheld computers, very few report measured outcomes to validate these benefits. Researchers could conduct large scale trials to determine financial, safety, efficiency, and behavioral outcomes. Further evidence of their benefit will hopefully encourage physicians to adopt handheld computers.

Conclusion

We evaluated the usability of an emerging handheld platform (the Apple iPod Touch) and a traditional platform (Palm Tungsten C) to determine if and why physicians have a preference for one of these devices. We intended to shed light on usability as an adoption factor for handheld computers in clinical settings.

Our results indicated that participants perceived the iPod Touch to be easier to use and more useful than Tungsten C, despite similar job relevance ratings for the two devices. Participants were more likely to use the iPod Touch in their clinical practice, largely due to a perceived ease of use. Indeed, ease of use was the chief determining factor in physicians' intentions to use a handheld computer. This study encourages further comparative research in clinical settings as well as objective measures of the benefits of handheld computers in medicine.

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Appendices

Appendix A. **Participant Ratings for Extended TAM Constructs**		
Construct, *mean (SD)*	**Apple iPod Touch**	**Palm Tungsten C**
Intention to Use		
1. Assuming that significant barriers to use of [device] are overcome, I intend to adopt [device].	5.70 (1.29)	4.04 (1.40)
2. If significant barriers did not exist, I predict I would use a [device].	6.09 (1.08)	4.57 (1.47)
Perceived Usefulness		
1. [Device] could increase my productivity.	5.87 (0.87)	5.30 (0.88)
2. [Device] could improve the quality of the care I deliver.	5.70 (0.93)	5.30 (0.93)
3. [Device] could enhance my effectiveness.	5.78 (0.90)	5.43 (1.12)
4. [Device] could be useful in my job.	6.17 (0.78)	5.65 (1.15)
Perceived Ease of Use		
1. My interaction with [device] will be clear and understandable.	5.78 (1.09)	5.04 (1.07)
2. [Device] will be easy to use.	5.74 (1.18)	5.00 (1.13)
3. Interacting with [device] will not require a lot of mental effort.	5.83 (1.27)	4.74 (1.54)
4. It is easy to get [device] to do what I want it to do.	5.52 (1.41)	4.74 (1.39)
Subjective Norm		
1. Physicians who influence my behavior think I should use [device].	3.57 (1.44)	2.83 (1.23)
2. Physicians who are important to me think I should use [device].	3.61 (1.37)	3.00 (1.24)
Image		
1. Having [device] will be a status symbol.	5.04 (1.30)	3.00 (1.71)
2. Physicians who use [device] have more prestige than those who do not.	3.70 (1.66)	2.87 (1.66)
3. Physicians who use [device] have a high profile.	4.04 (1.55)	2.74 (1.54)
Job Relevance		
1. Usage of [device] is relevant to the delivery of patient care.	5.09 (1.31)	5.09 (1.38)
2. Usage of [device] is important to the delivery of patient care.	4.74 (1.21)	4.65 (1.30)
Result Demonstrability		
1. [Device] could reduce the cost of my care delivery.	5.04 (1.11)	4.96 (1.07)
2. I believe I could communicate to others the consequences of using [device].	5.43 (0.99)	5.17 (1.11)
3. The results of using [device] will be apparent to me.	5.39 (0.94)	5.35 (1.03)
4. It would be easy to explain why using a [device] may be beneficial.	5.87 (0.87)	5.52 (0.90)

Appendix B. Duke University Health System IRB Notice

DECLARATION OF EXEMPTION FROM IRB REVIEW

The DUHS IRB has determined that the following protocol meets the criteria for a declaration of exemption as described in 45 CFR 46.101(b)(2).

Protocol ID: Pro00013447
Protocol Title: Comparing the Usability of Apple Versus Palm Handheld Computing Devices Among Physicians: A Randomized Crossover Study Using the Technology Acceptance Model
Principal Investigator: Martha Adams

This Declaration of Exemption from IRB Review is in effect from 1/27/2009 and will remain in effect until 1/27/2012 ("Termination Date"). However, please be advised that any changes to the proposed research will require a re-application for exemption. If this protocol will be active by the Termination Date, please submit an application for renewal of the Declaration of Exemption to the DUHS IRB at least thirty (30) days prior to the Termination Date.

John Harrelson	1/27/2009
IRB Reviewer	Review Date

DUMC 2712 • Hock Plaza 2424 Erwin Rd Suite 405 • Durham, NC 27705
tel (919) 668-5111 • fax (919) 668-5125

Appendix C. University of North Carolina at Chapel Hill IRB Notice

To: Anthony Joseph
School of Information and Library Science
CB: 3360

From: Behavioral IRB

Date: 2/09/2009

RE: Notice of IRB Exemption
Exemption Category:
Study #: 09-0235

Study Title: Comparing the Usability of Apple Versus Palm Handheld Computing Devices among Physicians: A Randomized Crossover Study Using the Technology Acceptance Model

This submission has been reviewed by the above IRB and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b).

Study Description:

Purpose: To measure the degree by which physicians find handheld computing devices usable. This study will compare the usability evaluations and adoption preferences between 2 handheld computers.

Participants: 50 Duke house staff in the internal medicine program.

Procedures: A background questionnaire will be administered. Medical computing and information retrieval tasks will be completed using a handheld Apple computer device and a handheld Palm computer device. A usability questionnaire will also be administered.

Study Specific Details:

Duke University has determined that this research is **exempt** from further review. The University of North Carolina at Chapel Hill's IRB also has determined that this research is exempt.

This letter supersedes any previous letters.

Investigator's Responsibilities:

If your study protocol changes in such a way that exempt status would no longer apply, you should contact the above IRB before making the changes. The IRB will maintain records for this study for 3 years, at which time you will be contacted about the status of the study.

Researchers are reminded that additional approvals may be needed from relevant "gatekeepers" to access subjects (e.g., principals, facility directors, healthcare system).

CC: Jeffery Loo, School of Information and Library Science
Martha Adams, Duke University
Marcia Tauber (School of Information and Library Science), Non-IRB Review Contact

IRB Informational Message—please do not use email REPLY to this address

Appendix D. Participant Consent Form

DUKE UNIVERSITY HEALTH SYSTEM

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Comparing the Usability of Apple Versus Palm
Handheld Computing Devices Among Physicians

You are being asked to take part in this research study because you are Duke internal medicine house staff. Research studies include only people who choose to participate. Please read this consent form carefully and take your time making a decision. As your study doctor or study staff discusses this consent form with you, please ask him/her to explain any words or information that you do not clearly understand. The nature of the study, risks, inconveniences, discomforts, and other important information about the study are listed below.

Anthony Joseph, MSIII, along with Dr. Martha Adams, will conduct the study. It is funded by the Haynes IT Adoption Fund in the Department of Medicine, Duke University.

The purpose of this study is to measure the degree by which physicians find handheld computing devices usable and intend to adopt these technologies. Additionally, this study will compare the usability evaluations and adoption preferences between Apple and Palm handheld computers.

HOW MANY PEOPLE WILL TAKE PLACE IN THIS STUDY?
Approximately 30 people will take part in this study

WHAT IS INVOLVED IN THIS STUDY?
If you agree to be in this study, you will be asked to sign this consent form.

You will then respond to a background questionnaire on your mobile medical computing behavior.

Next, you will use 2 devices to complete medical computing and information retrieval tasks. The devices are the iPod Touch by Apple and the Tungsten C by Palm. The tasks include a drug reference task, a medical calculation, and a medical reference task, all in response to hypothetical case study questions. In this randomized crossover trial, each participant uses both devices, one after the other. You will be randomly assigned (like the flip of a coin) to operate either:

- Arm 1: Apple device first, and Palm device second
- Arm 2: Palm device first, and Apple device second

After executing medical computing tasks on the first device, you will complete a usability questionnaire based on the Technology Acceptance Model. You will then execute a comparable set of tasks and complete the same questionnaire for the second device. Open-ended questions regarding preferences and perceptions are also included.

HOW LONG WILL I BE IN THIS STUDY?
The study should last approximately 1 hour. You can choose to stop participating at any time.

WHAT ARE THE RISKS OF THE STUDY?
There are no physical risks associated with this study. There is, however, the potential risk of loss of confidentiality. Every effort will be made to keep your information confidential, however, this can not be guaranteed. Some of the questions we will ask you as part of this study may make you feel uncomfortable. You may take a break at any time during the study. You may stop your participation in this study at any time.

ARE THERE BENEFITS TO TAKING PART IN THIS STUDY?
If you agree to take part in this study, the only direct benefit to you will be in terms of experience gained with handheld computers.

DUKE UNIVERSITY HEALTH SYSTEM

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Comparing the Usability of Apple Versus Palm
Handheld Computing Devices Among Physicians

WILL MY INFORMATION BE KEPT CONFIDENTIAL?

While the information and data resulting from this study may be presented at scientific meetings or published in a scientific journal, your identity will not be revealed. Each person will be given a participant ID to use on all paper and electronic survey forms. There will be no record linking participant names with participant IDs. All survey forms will be otherwise anonymous. You will be asked to never provide identifying details, such as name, contact details, and other identifying information.

All electronic questionnaire data and qualitative responses will be anonymous and will be securely stored on the UNC Qualtrics server. Access to this server is password protected, with only the study coordinator knowing the password. All paper forms will also be anonymous and safely stored in a locked office suite with only the study coordinator having access. Data analyses will be conducted on completely anonymized responses.

We will only collect names and contact details for the drawing of 2 iPod Touch devices. These names and contact details will not be linked to the data in any way. Names will be collected on paper, and will be safely stored in a locked office suite. Upon completion of this study, all names will be destroyed.

WHAT ARE THE COSTS?

There will be no additional costs to you as a result of being in this study.

WHAT ABOUT COMPENSATION?

You will be compensated with $25 and a complimentary meal upon completion of your participation in the study. You may also choose to enter a drawing to win an Apple™ iPod Touch device used in the study.

WHOM DO I CALL IF I HAVE QUESTIONS OR PROBLEMS?

For questions about the study or a research-related injury, contact Dr. Martha Adams at (919) 681-2452 during regular business hours and at (919) 970-5311 (pager) after hours and on weekends and holidays.

For questions about your rights as a research participant, contact the Duke University Health System Institutional Review Board (IRB) Office at (919) 668-5111.

STATEMENT OF CONSENT

"The purpose of this study, procedures to be followed, risks and benefits have been explained to me. I have been allowed to ask questions, and my questions have been answered to my satisfaction. I have been told that I may contact the Duke University Health System Institutional Review Board (IRB) Office at (919) 668-5111 if I have questions about my rights as a research subject, to discuss problems, concerns, or suggestions related to the research, or to obtain information or offer input about the research. I have read this consent form and agree to be in this study, with the understanding that I may withdraw at any time. I have been told that I will be given a signed copy of this consent form."

_____ _____
Signature of Subject Date

_____ _____
Signature of Person Obtaining Consent Date

Appendix E. Clinical Case for iPod Touch

Clinical Case A

Please write your participant ID number: _____

i. Dr. Larry Greenblatt precepts with you in DOC clinic. Your first patient, Ms. Smith, is wheezing. The nurse tells you the pulse oximeter reading is 92%. You ask for a peak flow measurement and a nebulized albuterol treatment followed by another peak flow measurement to document improvement. The nurse tells you that the initial peak flow is only 240.

Using the MedMath application in Epocrates, calculate the predicted peak flow for this patient. Her age is 25 years and her height is 66 inches.

*Peak Flow:*_____

ii. After the albuterol treatment, Ms. Smith is remarkably improved, peak flow 400, and you are able to discuss a treatment regimen with her. Before you check out with Dr. Greenblatt you want to be sure about your choice of medications. You have some questions about Advair Diskus versus Singulair so you do some background searching first.

Using the drug reference in Epocrates, locate Singulair and answer the following questions:

What is the generic name for this drug? _____

*What is the adult strength dosage for this drug?*_____

*What is the price for one month of treatment at the above dosage?*_____

Part of your remaining conversation with the patient is education about the use of peak flow meters for measurement of PEF at home to follow the day-to-day fluctuation in disease activity. You explain how these measurements offer a guide for drug dosages and further medical consultation. You also give the patient parameters for her "green, yellow, and red zones."

iii. Dr. Anne Phelps, an attending in the resident clinic at Pickett Rd, listens to your presentation about a morbidly obese man who had a good response to Prilosec 20 mg daily for mild GERD. At his last visit he stopped taking Prilosec. Today, 3 months later, he tells you about recurrent GERD symptoms. You decide to do some background research on the types of esophageal syndromes that occur in adults.

Using the disease reference in Epocrates, look up "GERD." In the "Basics" section, list 4 esophageal syndromes that are associated with esophageal injury according to the Montreal definition.

1._____ 2._____

3._____ 4._____

Appendix F. Clinical Case for Tungsten C

Clinical Case B

Please write your participant ID number: _____

i. Dr. Larry Greenblatt precepts with you in DOC clinic. Your first patient, Mr. Jones, is wheezing. The nurse tells you the pulse oximeter reading is 94%. You ask for a peak flow measurement and a nebulized albuterol treatment followed by another peak flow measurement to document improvement. The nurse tells you that the initial peak flow is only 250.

Using the MedMath application in Epocrates, calculate the predicted peak flow for this patient. His age is 28 years and his height is 72 inches.

*Peak Flow:*_____

ii. After the albuterol treatment, Mr. Jones is remarkably improved, peak flow 500, and you are able to discuss a treatment regimen with him. Before you sign out with Dr. Greenblatt you want to be sure about your choice of medications. You have some questions about Advair Diskus versus Singulair so you do some background searching first.

Using the drug reference in Epocrates, locate Advair Diskus and answer the following questions:

What is the generic name for this drug? _____

*What is the highest strength dosage available for this drug?*_____

*What is the price of the above dosage (2 disp packs, 14 ea)?*_____

Part of your remaining conversation with the patient is education about the use of peak flow meters for measurement of PEF at home to follow the day-to-day fluctuation in disease activity. You explain how these measurements offer a guide for drug dosages and further medical consultation. You also give the patient parameters for her "green, yellow, and red zones."

iii. Dr. Anne Phelps, an attending in the resident clinic at Pickett Rd, listens to your presentation of a new patient. The patient is a 45 year old male seeking a prescription for Dilantin. His history reveals new onset seizures 20 years ago. The hospital completed a neurologic evaluation then, but the patient does not know the findings of the evaluation. You decide to do some background research on the diagnosis of new onset seizures in adults.

Using the disease reference in Epocrates, look up "seizure disorders." In the "Diagnosis" section, list 4 items that are considered in the differential of a middle aged patient (25-60) with new onset seizures.

1._____ 2._____

3._____ 4._____