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ScienceDirect

Procedia Computer Science 63 (2015) 332 – 339

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**Procedia**  
Computer Science

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The 5th International Conference on Current and Future Trends of Information and  
Communication Technologies in Healthcare (ICTH 2015)

## Implementation of a Game-Based Information System and e- Therapeutic Platform in a Pediatric Emergency Department Waiting Room: Preliminary Evidence of Benefit

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### Abstract

**Background:** Pain, dehydration and anxiety are often not well managed in the paediatric emergency department (PED) waiting room (WR), particularly when wait times are long. Children who experience better WR care may require fewer diagnostic tests and other interventions downstream in the PED. WR time can present a unique opportunity to engage families in their own management. We developed *iCare Adventure*, a game based information system and e-therapeutic platform, and implemented it in a tertiary care PED WR. We report the results of our initial benefits evaluation. **Research question:** Is exposure to *iCare Adventure* associated with improvements in PED WR care? **Methodology:** An unblinded controlled clinical trial was performed, with intervention being exposure to *iCare Adventure*, and control being standard waiting room care. Primary outcome measures: patient-reported pain, patient and parent-reported satisfaction and amount of oral rehydration therapy (ORT) consumed in the WR. Secondary outcomes: physician dwell time and interventions ordered after leaving the WR. **Results:** Compared to controls, older intervention subjects showed significant improvements in pain control, and both patient and parent satisfaction. Among younger patients, a significant reduction in the ordering of blood work was observed. No differences in ORT or other post-waiting room interventions were seen. **Conclusions:** *iCare Adventure* is associated with improvements in pain control and parental/patient satisfaction in the PED WR, and a reduction in blood work ordered subsequently. Future research will focus on understanding the age-related discrepancy in findings, and in further validating these findings.

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Peer-review under responsibility of the Program Chairs

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**Keywords:** Game-Based Information Systems, e-Therapeutics, Pediatric Emergency Care, Health Informatics, Collaborative models,

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## 1. Introduction

Pediatric emergency department (PED) waiting rooms (WR) are challenging places, for both clients and staff. Triage nurses face a highly pressured, decision-dense workspace, full of conflicting agendas. Children and their parents present in a state of uncertainty and fear; many wait for prolonged periods to be treated and reassured. Helping one patient requires that another patient waits. Long waits with sick, frightened children are exacerbated by boredom; the risk of infection, however, generally precludes the institutional provision of shared WR toys. Explanations that might blunt the anticipatory dread or demystify the care process depend upon the availability of WR staff, most particularly the triage nurse. During periods of high patient flow, this human resource is often maximized, and information flow suffers.

We know quite a bit about this structural dysfunction and its impact on patient care. Optimal pain management, for example, starts at the triage desk, but requires repeated assessment to ensure treatment adequacy.<sup>1</sup> Perhaps consequently, pain control in the WR is often inadequate.<sup>2</sup> Similarly, oral rehydration therapy (ORT) for dehydration is better than intravenous rehydration, but requires significant time to complete.<sup>3</sup> ORT is easily started in the WR, yet adherence in PEDs is poor.<sup>4</sup> Easily followed WR protocols improve ORT.<sup>4,29</sup> Anxiety is common in both children and parents<sup>5,6,7</sup>, and can persist, at times becoming a greater issue than the pain itself.<sup>8</sup> Most of this distress is unwarranted, and treatable with information.<sup>7</sup> High patient volumes serve to both lengthen the wait and compromise care.<sup>9,10,11,12</sup>

Patient and parent satisfaction is associated with the quality of communication, the adequacy of pain medication and the quality of the WR.<sup>16,17,18,19</sup> In crowded conditions with long waits, patient and parent satisfaction suffers and disruptive WR behaviour is more common.<sup>13,14</sup> In our institution, a relatively small pediatric emergency department (PED) with roughly 30,000 annual visits, more than 10,000 patient visits per year involve waits of more than one hour to be seen by a physician; at least 2,600 wait more than 3 hours each year.<sup>15</sup>

Pain control can be enhanced, anxiety minimized and satisfaction improved in WRs using a variety of media and interventions, including child life intervention, therapeutic clowning, music, art, video and cartoon material.<sup>20,21,22,23,24,25,26,27,28</sup>

With appropriate information flow, WR time might represent a unique opportunity to engage parents and children in their own management. Human resources are scarce, but nearly all children in PED WRs are accompanied by a parent, who with proper guidance might be empowered to help in the management of their own child. Further, children whose pain, anxiety or rehydration are better managed prior to evaluation by physician may require fewer investigations, less physician evaluation time, and fewer interventions on leaving the WR.

We have developed *iCare Adventure*, a game-based information system and e-therapeutic platform specifically designed for the PED WR setting. This system distracts and normalizes with game play, treats anxiety with customized information, and provides supported e-therapeutics in the WR, at this point for pain management and ORT. This system has been implemented in a tertiary care PED WR while undergoing a clinical trial to establish whether its use is associated with improved care.

## 2. System Design and Development

*iCare Adventure* is a Private Multiplayer Online Social Game (PMOSG), consisting of a number of iPads<sup>®</sup> (Apple Corp, USA) connected within a closed network, i.e. access is restricted to selected players, and internet or institutional network access is impossible. Players have the opportunity to customize their own avatar with regard to hair, clothing, skin color and gender. Players interact with each other in a highly controlled and positive fashion, and may exchange (highly regulated) questions and answers, including requests to play games-within-game together online, as well as the animated exchange of hearts as expressions of caring and good will. The game uses a travel metaphor to allow a transient escape from current stressors, and provides the opportunity to explore a number of different geographic locations. Video pop-ups offer more information about any of the locations visited. Game play is non-competitive, explorative and distractive. Cooperative and parallel play, and positive connections between patients and families are encouraged. The game is controlled via iPad, and is supported by a common large wall

screen showing the locations of each player. A computer controlled robot attached to the system adds distraction and is another information source.

As well, *iCare Adventure* provides therapeutic videos customized to the child. Patients and parents view videos generated by Child Life Specialists and our own emergency personnel, narrated by our institutional medical clown. These are selected by the triage nurse in response to perceived patient need. The videos reframe and demystify injury and illness, inform about medical procedures and processes, and introduce important coping skills. Customization to patient is critical. The child who is clearly anxious will be shown a video about how to worry effectively, while a child with a laceration might be shown a video explaining, at an age specific level, the physiology of blood and clotting, as well as one that teaches breathing technique when holding still. Any child, as the game is explored, has access to all videos, however those which automatically pop-up are selected based on their medical presentation. The concept is to extend Child Life and triage nurse capabilities by allowing access to a wide variety of topics and concerns.

Finally, *iCare Adventure* permits individual messaging to both parents and patients via the iPads, allowing us to guide parents through pain and ORT management. All children are assessed for pain early in the game cycle; those who report significant pain receive intermittent requests to update this information. We have adapted the Faces Pain Scale – Revised (FPS-R)<sup>33</sup> to electronic format and have incorporated this into the game; validation of this electronic version is underway. The system programatically identifies treatment failure and feeds this information back via a glanceable display to the triage nurse, who may then adjust care. For children requiring ORT, the ORT pathway is initiated by the triage nurse. These children are then given further information via video clip about ORT and are subsequently reminded about consumption every 10 minutes.

Our team consists of a unique collaboration between a local technology industry partner (Everage Inc) and academic health care, with an arrangement that provides Everage Inc with the intellectual property (IP) rights, uses a tertiary care institution as an industry test bed, and provides the institution involved with an unlimited license and technical support to use the technology once developed. *iCare Adventure* was developed over a 3 year period with extensive input from emergency physicians, Child Life staff, nurses, clinical informatics, pain management researchers, and health administrators. Innovation in acute care faces substantial obstacles<sup>32</sup>; our development model has married industry informed development processes, including Lean and Agile methodologies, to local clinical champions and the rigorous evidence-based benefit analysis required by academic medicine. Further, we have accomplished this with many hours of in-kind work by all involved, but with very low amounts of direct funding. The institutional component is less than \$30,000 to date, funded in part by a Translating Research Into Care (TRIC) grant from the IWK Foundation (\$18,000) and in part by existing academic funds remaining from other projects. The total cost from our institutional operating budget is measured in hundreds of dollars.

### 3. Research and Methods

#### 3.1. Setting

*iCare Adventure* was implemented in the IWK Emergency Department in Halifax, Nova Scotia, Canada in the fall of 2014. The IWK is the tertiary health care centre for pediatrics and women's health for maritime Canada; its PED is the definitive pediatric trauma and resuscitation centre, and sees children from birth to 15 years of age inclusive for all diagnoses, and to 18 years of age inclusive for mental health. Approximately 30,000 visits per year are seen in the department, of which roughly 26,000 are direct to the pediatric emergency physicians. Flow is typical of most Canadian PEDs, with afternoons and evenings providing the highest patient numbers.

The PED care team was kept abreast of the developmental work related to our system via staff meetings and requests for comments; a significant degree of input toward this development came from our clinical colleagues in this fashion. Prior to commencing data collection, we underwent a three month workflow integration and change management process to ensure that important patient-care related workflow was not disrupted by our project, and to educate staff about their respective roles.

### 3.2. Research Questions

Our primary research questions are – Does exposure to *iCare Adventure* result in:

- better parent and patient satisfaction with WR care?
- better pain management in the WR?
- better adherence to ORT while in the WR?

Our secondary questions are – Does exposure to *iCare Adventure* result in:

- fewer interventions (admissions, intravenous placements, blood work or radiographs ordered) on leaving the WR?
- less physician time on leaving the WR?

### 3.3. Methodology

This was an un-blinded controlled clinical trial, in which intervention was exposure to the game-based information system, and control was standard care. Data collection ran from January to April 2015. Days were blocked as “Intervention” or “Control” on an alternate daily basis. True randomization was seen as theoretically problematic. The nature of patient flow in PEDs in winter is heavily influenced by viral epidemics which may peak and ebb within only a few days; alternate days allocation offered the greater likelihood that such epidemics would be equally shared between control and intervention groups. An intent-to-treat philosophy was followed; no attempt was made to control for technology brought from home, nor to ensure that children actually used our technology.

Study population included children aged 4 years and older presenting for care. Those with mental health issues were excluded as they have a completely different trajectory and wait time in our institution than other patient streams. Those who might have difficulty communicating in English, or whose involvement, in the opinion of care or registration personnel, might conflict with good care were also excluded. Convenience sampling was used, and occurred at the time of registration when the family was informed about the study.

Primary outcome measures consisted of parent and patient reported satisfaction, patient-reported pain scales and parent-reported consumption of ORT, all captured with paper surveys on leaving the waiting room. We used the FPS-R<sup>33</sup>, a validated pain scale for the self reporting of pain in children, for our paper surveys. Our secondary outcome measures included the time spent under the care of a physician once placed in an acute care bed (“dwell” time), whether an intravenous (IV) was placed, if blood work or radiographic imaging ordered after leaving the WR, and whether the child was admitted. These were captured by chart audit after discharge. We also obtained daily total census figures from our decision support unit for the data collection period.

Parents were informed of the study via paper handout at the time of registration. Consent was assumed by completion of paper surveys. No child was refused access to the system, regardless of participation in the study. Power calculations indicated that a 10% difference in satisfaction scores could be detected with a p value of <0.05 in a population of 1000 participants. We therefore set this as our subject recruitment goal. Research Ethics Board approval was obtained.

Data was coded by research personnel into a spreadsheet flatfile, then was cleaned and transferred to an Access<sup>®</sup> database (Microsoft Corp, <https://products.office.com/en-us/>). Statistical analysis used Excel<sup>®</sup> (Microsoft Corp, <https://products.office.com/en-us/>).

### 3.4. Study Mechanics and Flow

Triage nurses were asked to identify appropriate videos for each eligible child. This information was passed to the registration clerks, who, on intervention days, appropriately activated the iPads and dispensed them. All parents received a research information sheet at this point. A unique study identifying number was written on both the

patient's clinical record and the parent / patient surveys to permit data linkage with the subsequent chart audit. On leaving the WR, the nurse placing the child into an acute care bed gave the one page parent / patient surveys to the families. Incentives (a draw for two iPads) were used to encourage health care worker compliance with this information pathway. No incentives were offered to families. Children were allowed to continue to use the iPads for entertainment while in acute care. iPads were returned to a central cleaning station, usually by the parents, but occasionally by staff. Here, they were cleaned with alcohol wipes prior to being re-inserted in the charging station. The study was run initially 24 hours per day, but a combination of low patient flow rates, lower staff numbers, and the absence of technical support effectively closed down data collection between midnight and 08:00.

#### 4. Results and Analysis

Data collection proceeded for 91 days (45 control and 46 intervention days) resulting in 441 control and 533 intervention subjects recruited. Control patients tended to arrive on days that had significantly higher patient census. Accordingly, multiple regression was used to assess the need to control for relationship between total daily census and outcome measures. Stratification by daily census was then used as needed, with chi square and student's T-test used as the key statistics. Analyses were performed for each cohort (control vs intervention) as a whole, by age group (pre-adolescent: <10 years old, adolescent: 10 years and older). For those analyses where daily census was found to be a predictor, subgroup analyses in low / normal and high census (>1 standard deviation above the mean) categories were also performed.

##### 4.1 Primary outcome measures

Multiple regression demonstrated that total daily census was a negative independent predictor for older children (10 or more years of age) for both patient and parent satisfaction ( $p < 0.01$ ,  $p < 0.001$  respectively), but not for pain control or ORT. Intervention status was identified, in older children, as an independent predictor of both parent and patient satisfaction, and of self reported pain. This was not so for the younger cohort, and not for ORT in any cohort.

Overall, parents of older children were more likely to rate waiting room care as average, poor or very poor in the control versus intervention groups (16.1% vs 4.2%,  $p < 0.005$ ), a trend that was seen on both low / normal census days (13.7% vs 3.1%,  $p < 0.001$ ) and high census days (24.4% vs 9.7%,  $p = 0.10$ ).

Similarly, in older children, patient satisfaction ratings  $> 3/6$  (i.e. worse) were more common in control versus intervention groups (29.4% vs 17.1%,  $p < 0.01$ ), a trend that again persisted on both low / normal (25.2% vs 15.9%,  $p = 0.05$ ) and high census days (44% vs 23.3%,  $p = 0.07$ ).

In older children, significant pain ( $> 2/10$  on the FPS-R) was reported more frequently in control versus intervention groups (69.3% vs 59.6%,  $p = 0.05$ ). See Table 1.

Table 1. Primary Outcomes for patients 10 years and older

	Intervention	Control	Significance
Poor Parent Satisfaction	4.2%	16.1%	$p < 0.005$
Low/normal census days	3.1%	13.7%	$p < 0.001$
High census days	9.7%	24.4%	$p = 0.10$
Poor Patient Satisfaction	17.1%	29.4%	$p < 0.01$
Low/normal census days	15.9%	25.2%	$p = 0.05$
High census days	23.3%	44%	$p = 0.07$
Self Reported Pain	59.6%	69.3%	$p = 0.05$

#### 4.2 Secondary outcome measures

Intervention status was shown to be an independent predictor only for the ordering of blood work in younger children ( $p < 0.05$ ). Control subjects in the younger age group were more likely than intervention subjects to have blood work ordered after leaving the WR, (13.5% vs 7.7%,  $p < 0.05$ ).

Multiple regression analysis did not show that total daily census was an independent predictor of any of the secondary outcome measures. No other significant differences in secondary measures were found between intervention and control groups.

### 5. Discussion

We have demonstrated that the introduction of a game-based information and e-therapeutic system into a PED WR is feasible, improves client satisfaction and pain control, and reduces the risk of subsequent blood work. We have received many positive comments from our patient population, and the message that we were providing iPad based game play in our WR spread rapidly through our community.<sup>34</sup> Clearly, this was a successful launch. Game-based information and e-therapeutics have subsequently become standard care in our PED.

Our development cycle is iterative. Any implementation is regarded in part as an information gathering process for the next version of the tool. This is particularly true for the first real-world implementation; many lessons have been learned, and we have a number of un-answered questions.

The reasons for the age related discrepancies in observed benefits to care are not clear. Although our patient satisfaction tool is derived from a validated instrument, and the FPS-R is a respected and widely used pain scale, validated in both younger and older children<sup>33</sup>, it is possible that younger children simply cannot provide accurate measurements of pain and satisfaction in this setting. Alternatively, perhaps the messages we provided in our videos and e-therapeutic pathways are not presented in a way that younger children can receive them. Finally, there may be age-related issues with interface and game play design. Each of these possibilities are being explored to inform our next build.

A review of the available data strongly suggests that the anticipated annual spring gastro-enteritis epidemic was either markedly attenuated or simply absent during our data collection period. The absence of gastro-enteritis patients for other studies currently operating in our PED is reflected in low numbers in our ORT cohort. We therefore do not think we had an adequate test of the ORT pathway. Further work in this regard is planned.

Another question is the efficiency of our current workflow. For example, we need to explore the degree to which parents and patients can take control of the data flow. Since data collection has stopped we have been experimenting with self-activation of the iPads, and are exploring the possibility of having the iPads handed out even before the triage process. This would require some automation of the therapeutic video and e-therapeutic pathway selection process, and an assessment of how well parents and triage nurses agree on the needs of patients for these elements. The benefit would be a decrease in health care worker time spent on this aspect of care, while further expanding family autonomy.

Finally, we recognize that there are a number of potential e-therapeutic pathways that can be explored for use in the PED WR, including pathways for asthma, mental health issues, accident prevention and others. We have partnered with domain experts in these areas from within our institution and abroad, and plan the staged, evidence based introduction of new pathways, with evaluation of benefit implicit in implementation at each stage.

This study had a number of limitations. The size of some of our subgroups, particularly children requiring ORT, were small. Our methodology gave us evidence of benefit (or not) but did not permit us to understand the reasons behind some of our findings. Finally, as the initial implementation of a new information system, there were minor issues with stability and workflow that despite our best efforts extended into the trial period.

In response, we observe that this is just the first of what we hope will be several investigations into the value of e-therapeutics and game based systems in the PED. We sought validation for further granting, wanted guidance for



future development, and sought direction in terms of future study design. From that perspective alone, this process has been successful. Future work, will include targeted user studies to evaluate each element of game play and interface, as well as validation and if necessary re-design of our in-game pain and satisfaction scales. We will be assessing the agreement between triage nurses and parents in judging knowledge needs and therapeutic pathway selection for children. We will also validate different workflows in order to minimize health care worker involvement in iPad distribution, system activation and data entry, so as to empower parents to use this system earlier in the WR process, perhaps even before triage. In particular, discussion with our colleagues in Mental Health Services have begun, to explore how we can better serve this patient population.

In summary, we have successfully designed, developed and implemented a game-based information and e-therapeutics system in a tertiary care PED WR. Additionally, we have demonstrated clinically significant preliminary benefits within months of the initial implementation. Our experiences will inform our ongoing iterative improvement and development process. Questions raised by this implementation will be explored, and newer versions will be subjected to equally rigorous evaluation of benefit. *iCare Adventure* improves satisfaction and pain control in the WR and reduces the number of subsequent blood tests. More study is needed.

### Acknowledgements

The authors would like to acknowledge Anne Cox and Megan Peck, Triage and Acute Care nurses, and Cleve Sauer, Child Life staff, whose energy and involvement were critical to the success of this project. We also acknowledge the collaboration of the registration clerks, triage nurses and both physician and nursing leadership in facilitating the implementation of our system, and the critical role of Cliff Gibb in visioning and development.

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