Portable Work Stations for Ambulance Workers: CURE (Community Urgent Response Environment)

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Abstract

The Community Urgent Response Environment (CURE) concept is a new technology system developed to support the work of Emergency Care Practitioners with portable pods and packs and mobile treatment units. This paper describes a project to transfer research outputs from an academic setting into practice through a collaboration between 2 universities, 2 manufacturers and the United Kingdom (UK) National Health Service. An iterative prototyping process was used with 12 Emergency Care Practitioners evaluating prototypes in 2 user trials by carrying out 4 clinical scenarios in 3 simulated environments (confined domestic, less confined public space, and vehicle). Data were collected with video recording, field notes and post-trial debriefing interviews and analysed thematically. The final prototypes (pod/pack 1.3 and vehicle 1.6) have potential to support a new way of working in the provision of non-critical, pre-hospital care. The user trials also identified possible efficiencies through the use of CURE by providing support for a wider range of assessment, diagnosis and treatment.
Key Words

Emergency Medical Services, Portable Equipment, Ambulance Design, Iterative Prototyping, Knowledge Transfer, Urgent (pre-hospital) Care

Key Points

1. The Community Urgent Response Environment (CURE) concept is a new technology system developed to support the work of Emergency Care Practitioners
2. CURE has 2 components: (1) portable pods and packs and (2) mobile treatment unit.
3. This knowledge transfer project supported collaboration between academics, manufacturers and the ambulance service.
4. The iterative prototyping process used design, test and evaluation cycles with trials to test prototypes in simulate clinical practice.
5. The final prototypes (pod/pack 1.3 and vehicle 1.6) have potential to support a new way of working in the provision of non-critical, pre-hospital care.
6. CURE also offers possible efficiencies by providing support for a wider range of assessment, diagnosis and treatment.

Word count = 2,298
1. Introduction

About 40% of the 10.3 million visits to National Health Service (NHS) emergency departments in England in 2009/10 are recorded as ending with the patient just needing advice and no actual specific treatment (HESonline, 2011). It has previously been suggested that these needs could be met in the community through the delivery of urgent (or pre-hospital) care (Department of Health, 2005) by Emergency Care Practitioners (ECPs; Department of Health, 2004).

An ECP may encounter a wide range of presenting complaints in varying situations requiring different equipment and consumables. Reynolds (2008) found that ECPs made individual decisions about both the contents and transportation methods of their kit, including using bag systems ranging from rucksack to ice cream tubs. A previous project, "Smart Pods", explored the technical requirements for ECP work by collecting data about pre-hospital care using stakeholder workshops, portable technology audits, treatment observations and design decision groups with 125 staff and 88 patients (Hignett et al, 2010, 2011). The results were design specifications for modular treatment units as personal kit, assessment pods and packs and a new design for the clinical work space (Hignett et al, 2010, 2011). This project aimed to take these outputs and develop them into a Community Urgent Response Environment (CURE) as:

1. Portable component (pods and packs) to provide pre-hospital (urgent not emergency) care and treatment in the home and/or other environments e.g. static vehicles, emergency dept., minor injuries units and other community services.

2. Mobile (vehicle-based) treatment environment in which care can be delivered including a sterile work space, bi-directional infection control and diagnostic facilities e.g. x-ray. To control the cost, the mobile treatment unit was designed for pedestrian access (no wheelchairs or stretchers) and limited to treatment with no facility to transport patients.

This paper describes the design, testing and evaluation cycles to develop the CURE technology system through a knowledge transfer collaboration of 2 universities.
2. Method

The project protocol used an iterative prototyping approach (figure 1).

**Figure 1. Iterative prototyping process**

For the first activity the research team reviewed the outputs from Smart Pods (Hignett et al, 2010, 2011) and transformed them into functional design requirements as prototype pod/pack 1.0 (table 1). This resulted in a core assessment pod (to be used for every patient) and supplementary pods for specific presenting complaints. Individual pods had detailed content design, for example the Wound Care Pod has 4 internal packs to group functional equipment and consumables.

**Table 1. CURE equipment and consumables**

<table>
<thead>
<tr>
<th>Assessment Pod including individual hygiene packs</th>
<th>Oxygen Pod (with masks and nebuliser equipment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound Care Pod</td>
<td>Maternity Pod</td>
</tr>
<tr>
<td>o Wound Cleaning Pack</td>
<td>Drugs Pod</td>
</tr>
<tr>
<td>o Dressings pack</td>
<td>IV access Pod</td>
</tr>
<tr>
<td>o Wound closure – Non-suture Pack</td>
<td>o IV access pack</td>
</tr>
<tr>
<td>o Wound closure – Suture Pack</td>
<td>o Fluid giving pack</td>
</tr>
<tr>
<td>Catheter Pod</td>
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</tbody>
</table>
The initial pod/pack prototype concept (1.0) was built by one of the manufacturing research team members (Openhouse Products Ltd.) as pod/pack prototype 1.1 for user trial 1 (figure 2a). After trial 1 the results were reviewed and incorporated in the iterative prototyping process as pod/pack prototype 1.2, with the final version (pod/pack prototype 1.3) built after trial 2 (figure 2b).

Figure 2. Pod/pack Prototypes

2a. Pod/pack prototype 1.1

2b. Pod/pack prototype 1.3

The trials were carried out in simulated settings to represent a bedroom (confined household environment), and a public location in trial 1. For trial 2, the vehicle (mobile treatment unit) interface was built by the second manufacturing research team member (WAS Vehicles (UK) Ltd). Five paper-based prototypes were reviewed and re-designed before the full scale mock-up was constructed (vehicle prototype 1.5, figure 3).
Participants

Twelve ECPs participated in the 2 user trials (6 participants in each trial). A randomised repeated measures design was used with the condition exposures (presenting complaints) split across the scenarios. Virzi (1992) and Lewis (1994) suggest that 5 participants should identify 80% of the usability issues. One way to enhance the discovery of usability issues and maximize the likelihood of achieving problem identification is to improve participants' knowledge (Lewis, 1994; Kanis, 2011). This was achieved by providing detailed information to the participants before and during the trials and ensuring repeated exposures to the tasks and equipment through the design of the scenarios.

Scenarios

Clinical scenarios were selected from a review of patient notes (DC) and developed (JB, DC, MF, SH and NM) to ensure that participants would experience a wide range of equipment and consumables from the CURE pods and packs. Four scenarios were used to test the systems; head injury, paediatric febrile convulsion, chest pain / respiratory and collapse from an unknown cause (table 2). The clinical information was delivered as a simple radio
communication template (pre-arrival at scene) and as a set of test results as appropriate during the scenario to respond to the clinical tasks undertaken with by each participant.

Table 2. Simulation scenario examples

<table>
<thead>
<tr>
<th>Condition</th>
<th>Presentation and history</th>
</tr>
</thead>
</table>
| **Scenario 1** Head Injury    | **Patient definition:** Elderly 70+ years female  
**Symptoms:** Open wound above left eyebrow, significant bleeding has stopped, some headache, minor level of disorientation  
**History:** Mechanical fall, remembers tripping over, hit head but nothing specific, just ended up on the floor.  
**Expected ECP action:** Full patient assessment, Blood Pressure, temp, blood sugar monitoring, to establish reason for fall. Two stitches above eye |
| **Scenario 2** Paediatric Febrile Convulsion | **Patient definition:** 2 year old child male, pre-verbal presents with distraught mother  
**Symptoms:** Febrile convulsion not witnessed, good recovery (Glasgow Coma Scale normal)  
**History:** Normal behaviour until 2hrs ago, warm red cheeks went to sleep, had single convulsion  
**Expected ECP action:** Full patient assessment, urine test, blood testing for sugar level etc. |
| **Scenario 3** Chest Pain     | **Patient definition:** Female late 40s known chronic respiratory condition  
**Symptoms:** Shortness of breath on exertion  
**History:** Long term Chronic Obstructive Pulmonary Disorder, deterioration over 2 weeks  
**Expected ECP action:** Full patient assessment, ECG and respiratory assessment, nebulisers with oxygen therapy |
| **Scenario 4** Collapse ? Cause (Gastroenteritis) | **Patient definition:** 30s petite female  
**Symptoms:** Few days history of Diarrhea & Vomiting.  
**History:** Few days history of Diarrhea & Vomiting  
**Expected ECP action:** Full patient assessment, rehydration and drug therapy |
NHS ethics committee (NHS REC 10/H0406/81) and research governance approvals were granted. Written informed consent was obtained from each participant.

Data Collection
Each trial was recorded simultaneously by up to three digital video cameras. The data files were coded to maintain anonymity. At the end of each scenario (and each trial) a debriefing interview was used to discuss key issues with the participants (audio–recorded). For user trial 1 additional data were collected using post-trial interviews (audio–recorded) by asking the ECP to give a commentary (narrate) the last two scenarios from their trial to describe their interaction with the work station. They were asked to explain their chosen methods of use and give their opinion about the functionality of the pods and packs in relation to their work. Where appropriate, prompts were used to encourage the participants to verbalise their thoughts.

3. Results

Twenty-four data sets were collected in trial 1 from 6 ECPs each completing 4 scenarios. The 72 video datasets (3 camera positions) were individually scrutinized for actions and behaviours relating to the use of the pods/packs to capture the main activities. These data were amalgamated with the 24 post-scenario de-briefing interviews and verbatim transcriptions from the 12 post-trial interviews. For trial 2, 23 data sets were collected with 5 ECPs completing 4 scenarios and 1 ECP only completing 3 scenarios due to time constraints. The data from the 69 videos were scrutinized and the results amalgamated with the de-briefing interviews (n=23).

The analysis involved iterative steps to ensure that all data were accounted for and included in the final results. The first stage of data analysis was the identification of preliminary codes (MF). This was followed by a detailed thematic analysis (Robson, 2011) by importing all the data from both trials into NVivo9 (SH; Richards and Morse, 2007). The emergent themes were compared and contrasted across the datasets and between the 2 user trials to
clarify concepts and explore the interpretations for similarities and differences (table 3, figure 4).

**Table 3. Data from User Trials**

<table>
<thead>
<tr>
<th>Higher level code</th>
<th>Individual codes</th>
<th>Data example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bag design</td>
<td>Bag dimensions, design and equipment (assessment)</td>
<td>‘I like the way when you open the wound treatment bag they’re different colours, that’s really good because you can see them straight away’. (ECP 5, trial 1, collapse)</td>
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<td></td>
<td>Extendable flaps (work surface)</td>
<td>‘Bags Brilliant, all labelled, you know exactly what is in each one and can take just what you need, instead of everything just in case’ (ECP 2, trial 2, de-brief)</td>
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<tr>
<td></td>
<td>Opening and closing effort (fastening mechanism)</td>
<td></td>
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<tr>
<td></td>
<td>Colour</td>
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<tr>
<td>Carrying</td>
<td>Equipment taken to the scene</td>
<td>‘most people’s doorways are quite narrow, and that’s quite bulky around your back’ (ECP 1, trial 1, paediatric)</td>
</tr>
<tr>
<td></td>
<td>Carrying effort</td>
<td>‘use of a rucksack for the assessment bag and then that gives you two clear hands as opposed to having them with shoulder straps’ (ECP 4, trial 1, chest pain)</td>
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<td></td>
<td>Stacking pods</td>
<td></td>
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<tr>
<td>Usability in clinical practice</td>
<td>Interaction with Patient Clinical practice (including recording observations)</td>
<td>Notes: Tries to get everything as close as possible to wound area. This is perhaps a clear indicator that more options for lockable trolleys are required to allow movement of work area to patient/wound (ECP 1, trial 2, collapse)</td>
</tr>
<tr>
<td></td>
<td>Changing practice</td>
<td>Locating items: ‘Even in complex situation I know where it all is and I can just go for it’ (ECP 5, trial 2, head wound)</td>
</tr>
<tr>
<td></td>
<td>Locating items within the bag</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contents</td>
<td></td>
</tr>
<tr>
<td>Preparing and using the work station</td>
<td>Pod location Additional worktop Management of kit</td>
<td>Location: ‘It was the best height and the closest to the patient really. Rather than put it on the floor, if the kit’s there it’s right next to the patient, it’s on a good stable platform with lots of space really’ (ECP 6, trial 1, paediatric)</td>
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<td></td>
<td>Worktop: ‘if I was to put the flap covering the middle section it would have been better’. (ECP 4, trial 1, chest pain)</td>
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<tr>
<td></td>
<td></td>
<td>Notes: three choices of where to place pods</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>was good worked well</strong> (ECP 5, trial 2, chest pain)</td>
</tr>
</tbody>
</table>
As part of the iterative prototyping process, the design changes from trial 1 were reviewed (figure 1) and where possible incorporated in the subsequent prototype (pod/pack 1.2). For example:

- Visible fronts for all drugs pods and packs
- Increase size of drugs pods
- Colour/luminous material for pods
- Stronger build, reinforced corners, water resistant, wipe clean
- Work surface with wipe clean top for assessment and wound pods
Some of the feedback could not be addressed within this project and will be taken forward in future research.

4. Discussion

Whilst the ECP role has been developed in different ways across the UK in terms of their location within the NHS (Mason et al, 2012), but the patient group they are intended to serve is well-defined. Although previous research had carefully successfully developed the design specification for the CURE technology (Hignett et al, 2010, 2011), it was found that the participating ECPs also worked as solo rapid responders. This was considered to be a limitation of the research protocol, as some participants had difficulty differentiating between their equipment and consumable requirements for emergency and urgent care responses. This was less of a limitation for the mobile treatment unit, where it was found that the ECP role had potential to be enhanced (including the delivery of a wider range of services) by an improved environment of care.

Although the project focused on the design, testing and evaluation of the 2 components of CURE, some of the de-brief interviews raised operational issues. These were not part of the project’s scope but included: ‘Just-in-Time’ equipment supply and ‘Make Ready’ teams (including carriage of spare pods/packs); standardized labeling for dressing supplies; inaccuracies in service of the radio-communications with respect to selecting which pods/packs to take to the scene; access to the mobile treatment unit for patients with mobility limitations (design specification limitation); and a process for the transport of patients to hospital when required. The response from the research team to this last point was that a second vehicle (emergency ambulance or patient transport vehicle) would have need to be called for transportation to medical facilities where required.

One of the major design innovations of CURE is the incorporation of a work surface into the assessment and wound care pods. Some differences in use were recorded and informed the design development from pod/pack prototype 1.1 to 1.3 (figure 2). It was felt that the final prototype (1.3) would allow all the observed working methods to be supported (particularly
CURE has managed to achieved one of the key design requirement outputs from Smart Pods by achieving-creating a small footprint for the portable systems with improved access to equipment and consumables. Many of the participants also commented that the pod/pack systems might lead to improvements in standardization of equipment and consumables due to the rigidity of the pod envelope (unable to carry additional equipment) and thus also improve storage and transportation by reducing crushing and cluttering etc.

5. Conclusion

The final prototypes (pod/pack 1.3 and vehicle 1.6) have potential to support a new way of working in the provision of non-critical, pre-hospital care. In additional to developing the design specifications from Smart Pods through to manufactured project, the user trials also identified possible efficiencies through the use of CURE by providing support for a wider range of assessment, diagnosis and treatment.

Acknowledgements

GWAS have given generous support to this project with their enthusiasm to test new designs and explore new ways of working. Their input has enabled us to improve the design through several prototype iterations. Our manufacturing partners, WAS Vehicles (UK) Ltd. and Openhouse Products Ltd. have given considerable support to the project by manufacturing the prototypes for user evaluation. We would also like to acknowledge the project’s financial support from the Engineering and Physical Sciences Research Council (EPSRC).
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