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DEVELOPMENT OF WORKFLOW-BASED GUIDELINES FOR THE CARE OF BURNS IN SCOTLAND

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ABSTRACT

Burn injuries are considered complex because they require a variety of treatments and continuous healing. Moreover, due to the relatively small number of burns patients per year in Scotland, clinicians may lack sufficient experience and familiarity with the care process, leading to errors and omissions. In this work, we captured the necessary knowledge for the first 24 hours of burns treatment for adult patients in the form of structured workflows. Our aim is to construct visual workflow guidelines that can be easily read and understood, irrespective of any workflow expertise, and can be used as a guide in every day care. Preliminary evaluation results from burns care clinicians in the Glasgow Royal Infirmary are positive and will guide our future work. We believe workflow models can be an effective methodology to document and share guidelines for patient care provided they are developed in close collaboration with clinical stakeholders.

KEYWORDS

healthcare, burns care, knowledge acquisition, intensive care unit, knowledge representation, workflow modelling

1. INTRODUCTION AND MOTIVATION

Healthcare processes are increasingly complex, as clinical staff are required to engage with long series of activities and a growing amount of information in a risky and time-pressured work environment. This is particularly the case for burns care, where patients may have different conditions and symptoms that require different treatments by a multidisciplinary team of specialist, theatre, and Intensive Care Unit (ICU) staff. The first 24 hours after a burn injury are especially critical and may reflect the degree of morbidity and mortality [Alharbi et al, 2012].

The Care Of Burns In Scotland (COBIS) network recorded an average of 340 adult burn patients per year (2010-2014), less than 7% of which were referred to the ICU. Based on this, it is difficult for ICU clinicians, who may rotate posts every few months, to develop experience in the treatment of such cases, resulting in unfamiliarity or omissions when it comes to some of the critical procedures.

Workflow models can help manage the complexity of care practices [Bastian et al, 2016]. They allow the formal representation of knowledge regarding the appropriate clinical procedures as step-by-step processes with related conditions and resources. As such, they provide a visual model of care that can facilitate decision making by forecasting what-if scenarios and reliably evaluating effects of different elements.

Such process-based analysis and improvement of medical practices is not new (see for example Marcos et al, 2002; Russo and Mecella, 2013) and there are multiple tools implemented for such purposes (such as Shahar et al, 1998; Fox et al, 2006; Papapanagiotou and Fleuriot, 2014). This not only enables the better understanding and optimisation of everyday practices based on the aforementioned parameters, but also allows the automated coordination of clinical activity in medical teams through the computer-based execution of the modelled workflows. For example, human-based processes can be integrated and coordinated through electronic checklists [Manataki et al, 2016], whereas an electronic system can send reminders and notifications to ensure the appropriate steps are performed at the right time and in the right order. However, this assumes that the appropriate knowledge is recorded in a structured way, which requires a considerable and collaborative effort.

In this particular paper, we describe our efforts to acquire and record knowledge on the treatment of adult burns patients during the first 24 hours into structured workflow-based guidelines. We aim to design workflows that:

1. are easily understandable, irrespective of any workflow expertise.
2. accurately capture the knowledge of the appropriate treatment procedures.
3. help clinicians understand and consistently deliver the treatment plan.

Our approach includes a systematic methodology, in close collaboration with a variety of medical staff involved in burns care at the Glasgow Royal Infirmary.

2. METHODOLOGY

The conceptualisation of our process-based model requires the systematic capture of medical knowledge and experience in burns treatment. For this purpose, we adjusted the Mixed-Method Research framework [Bastian et al, 2016]. Compared to other knowledge capture methodologies, it focuses on process analysis and improvement across different healthcare settings, using a broad and lean assessment and multiple stakeholder perspectives. As such it fit well to the needs of this work. In addition to the qualitative and quantitative analysis, we have extended the methodology with structured knowledge capture in the form of workflow models that have the potential for further systematic testing, simulation, and formal verification.

Our approach includes 3 phases: stakeholder analysis, process design, and model improvement. The stakeholders, including expert burns clinicians, nurses, surgeons, and ICU consultants, iteratively validate the outputs of each phase.

2.1 Phase 1: Stakeholder analysis

This phase aims to capture the needs of stakeholders, identify the state of the current protocols for burns treatment and define the scope of the problem.

We accomplished this through unstructured interviews and multidisciplinary meetings, combining years of experience in burns care from the COBIS network with process modelling expertise from the University of Edinburgh, in a small group of 6, and for a total of 6 hours. We recorded information about typical clinical procedures, common problems and patient complications, the roles involved, and the existing IT infrastructure. We also shared medical literature, including COBIS documents and notes on standard practices. These helped establish a common understanding of the terminology and familiarity with burns treatment procedures (e.g. Hettiaratchy and Papini, 2004; Alharbi et al, 2012; COBIS, 2016).

Based on this, burns care was broken down into 4 stages:

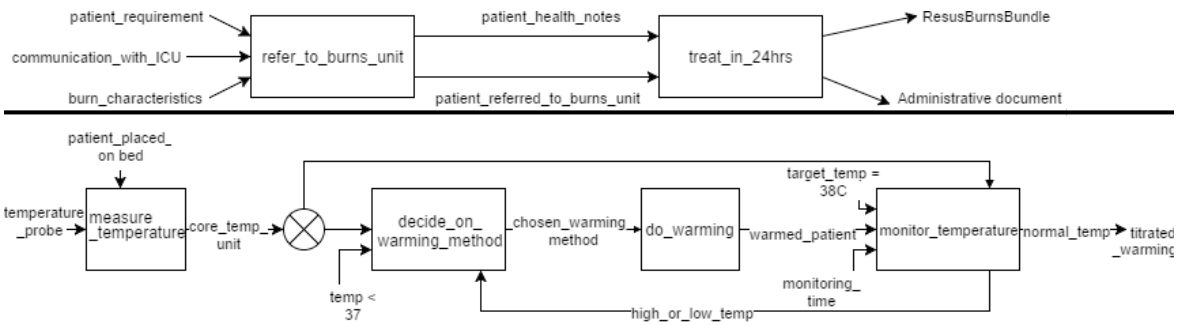
1. Patient referral
2. The “ABC of burns care”, including: Airways (A), Breathing (B), Circulation (C), Disability status (D), Exposure to external environment (E) (e.g. wounds and temperature treatment), and Fluid resuscitation (F)
3. Monitoring
4. Documentation, including the so-called Resuscitation Burns Bundle.

The outputs of the stakeholder analysis phase were (a) an activity map of burns treatment processes and (b) a table of inputs and outputs for each process.

2.2 Phase 2: Process design

In this phase, we broke down the general processes of Phase 1, adding more detailed tasks and focusing on the information flow, interactions, and dependencies between them. The output was 10 workflow diagrams at 3 different levels of abstraction, starting with a 2-step, high-level plan down to the detailed processes of the ABC of burns care. A sample output of this phase is shown in Figure **1**.

Figure 1. Sample output from Phase 2: Top level burns care (top) and temperature workflow (bottom)



The workflows reflect the considering factors at each decision point, such as the extent of burns, blood pressure, heart rate, etc. They also show the dependencies between processes so that the entire care pathway is visualized.

2.3 Phase 3: Model improvement

This phase aims to improve the developed workflows in terms of **(a)** the validity and completeness of the captured knowledge with respect to actual medical practices, and **(b)** their understandability and usability as guidelines.

In order to improve the quality of the captured knowledge, we shared the models and collected feedback from numerous different clinical roles in burns care, including nurses, surgeons, and ICU consultants. This helped us incorporate different perspectives of the treatment plan and clarify aspects that the different roles have expertise in.

We evaluated the understandability and usability using a questionnaire, which we adapted from the System Usability Scale (SUS) [Brooke et al, 1996]. This included a general case scenario of the first 24 hours of care of a burns patient, a brief explanation of the workflow notation, the set of 8 developed workflows, and 2 sets of 6 questions each to assess the understandability and usability of the presented workflows. We surveyed 15 clinical participants at the Glasgow Royal Infirmary, covering all the different roles involved in burns treatment.

3. RESULTS AND LESSONS LEARNED

Preliminary survey results suggest that we acquired sufficient domain knowledge to represent the treatment of burns as a formal workflow; the majority of clinicians found the workflows clearly conveyed knowledge and complied with their experience of burns care. However, the survey identified that for the workflows to be used in clinical practice, additional knowledge about the individual patient context (e.g. medication, other medical conditions, risks) will be required.

Evidence of the understandability of our workflows was also found in every interaction with the clinical staff. During the iterative knowledge capture and model validation, the workflows were used to effectively communicate and discuss the medical practices without the involvement of the workflow experts.

We found the close collaboration between process modelling experts and clinical stakeholders to be a key challenge in the knowledge acquisition effort. Medical knowledge needs to be recorded in a way that is understandable among all involved parties. Well-organised meetings and several iterations of the model can help maximize the input provided by clinical staff given their busy schedules. Flexible activity maps and a

simplified workflow notation are key elements towards communicating the results in a straightforward way to a clinical audience. The process modelling experts were required to obtain a good enough understanding of the involved practices and conditions and keep the balance between a superficial and trivial model and the years of studies and experience that the stakeholders put into practice on a daily basis. In contrast, the clinical stakeholders were required to rethink their practices and how these comply to the medical guidelines, systematically review even the parts that are well integrated and sometimes ignored as trivial, and challenge their assumptions and biases for their own line of work. These challenges were only tackled thanks to the close, devoted and open-minded collaboration between both parties, consistently through the duration of the project.

We plan to extend our work by further evaluation and refinement of models to include perspectives from different clinical roles and sites. Additionally we will investigate the representation and integration of contextual patient information in our models. Our methodology can benefit from first-hand shadowing and observation of burns treatment in practice and the use of formal methods to eliminate errors and further optimize the modelled practices [Papapanagiotou and Fleuriot, 2014]. Finally, workflow deployment, e.g. in the form of integrated checklists [Manataki et al, 2016], can help evaluate the captured knowledge towards supporting day-to-day care provision.

In summary, we believe that the Mixed-Method Research is an effective methodology for knowledge acquisition of medical procedures in a formal, structured way. Using this methodology, we can produce workflow-based guidelines with the potential of supporting clinicians to do their job effectively and consistently. Such results can only be achieved through focused and sustained collaboration between the clinical stakeholders and the process modelling experts.

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