Implementing a Case-Based Reasoning System for End-of-Life Cancer Care: Improving Palliative Care Planning for Pain and Symptom Management

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In palliative medicine, health care professionals aim to provide end-of-life cancer patients with a plan of care to minimize pain and manage symptoms, while providing psychosocial and educational support to patients and their families. Unfortunately, it has been reported that terminally ill cancer patients often experience unnecessary suffering due to ineffective symptom management as they near end-of-life. Recent advances in health informatics have motivated health care institutions to take advantage of decision support systems that assist health care professionals with evidence-based decision making. In this paper, we present a clinical decision support system that incorporates case based reasoning. Case based reasoning is a unique problem-solving methodology that is predicated upon reusing previously solved patient cases to formulate solutions to new, unsolved patient cases. This reasoning methodology emulates the human problem solving process, and has been highly valuable for medical problem solving. Patient cases \((N = 277)\) for this research were provided by the Victoria Hospice Society and the University of Victoria, Canada. It is anticipated that this user-friendly, web-based CBR system will improve decision making for pain and symptom management for end-of-life cancer patients.

Keywords
Case Based Reasoning, Cancer, Clinical Decision Support Systems, Palliative Care

Introduction

According to the Canadian Cancer Society (2006) [1, 2], cancer is currently the leading cause of premature death in Canada. Mainly due to an aging population, and based upon current cancer incidence rates in Canada, it is expected that 38% of women and 44% of men will develop cancer during their lifetimes [1]. Patients with advanced cancer frequently experience an array of physical and psychosocial symptoms when they near end of life. Their symptoms may include pain, dyspnea, nausea, fatigue, anorexia, cachexia, anxiety, and depression. Most often, pain and symptoms intensify during the last days of life [1, 3, 4, 5].

During the end-of-life phase, approximately 30% of advanced-cancer patients access palliative care programs, primarily for pain and symptom management [3, 4, 5, 6, 7]. Palliative care intends to “improve the quality of life of patients and their families facing the problem associated with life-threatening illness, through the prevention and relief of suffering by means of early identification and impeccable assessment and treatment of pain and other problems, physical, psychosocial and spiritual” [8]. Unfortunately, the envisioned goal of providing effective pain and symptom management during end-of-life palliative care has been reported to be suboptimal and largely unsuccessful, resulting in diminished quality of life for terminal patients. Recent studies have attributed this inadequate care to health care professionals’ lack of knowledge and training concerning pain and symptom management for palliative cancer patients [1, 4, 9, 10, 11].
Several studies have suggested that pain and symptom management in palliative care could be improved through the implementation of clinical practice guidelines (CPGs) and locally created clinical pathways. At present, a few CPGs and clinical pathways exist for palliative and end-of-life care; however, many of these guidelines are in the early stages of development and do not consider the multitude of symptoms that are often experienced by end-of-life cancer patients [1, 10]. Moreover, it has been recommended that clinical decision making for advanced-cancer patients could be improved when health care professionals obtain a better understanding of the symptoms experienced by patients [12] and secondly, when decision support systems are implemented to assist with clinical decision making.

**Research Objective**

In this paper, we present a clinical decision support system (CDSS) for health care professionals in palliative care who are involved in planning pain and symptom management for end-of-life cancer patients. This CDSS takes advantage of artificial intelligence (AI) technology by utilizing case based reasoning (CBR) to support evidence-based decision making in palliative care. Case based reasoning is a problem solving methodology that capitalizes on reusing past patient cases to assist health care professionals in solving a new patient case [14, 15]. Our case based reasoning system incorporates a case library, comprised of 277 patient cases and their simulated case solutions, a case based reasoning engine, and a web-based user interface.

**Research Hypothesis**

We believe that our CBR system will facilitate knowledge sharing in palliative care, thereby increasing health care professionals’ knowledge of effective pain and symptom management; thus, improving their ability to make patient-appropriate clinical decisions in planning palliative cancer care.

**Case Based Reasoning System Architecture**

The design of the presented case based reasoning system was motivated by Aamodt and Plaza’s (1994) [14] case based reasoning cycle, whereupon the case based reasoner must perform four sequential processes: case retrieval, case reuse, case revision, and case retention. To enable these processes, there are four main tasks that must be employed: (1) case representation, (2) case indexing and storage, (3) case retrieval, and (4) case adaptation and learning.

**Case Representation**

The Victoria Hospice Society, Victoria, Canada, provided a database of palliative care patient cases, admitted to their palliative care unit, between March 3, 2000 and August 9, 2002. From this database we extracted a subset of records consisting of cases for which symptoms were recorded and some form of cancer was present ($N = 277$).

A case is represented by several feature attributes that describe a problem (problem description) and a solution. In this system, the feature attributes that form the problem description are: gender, age, cancer type, palliative performance scale (PPS), palliative
performance scale-level, and the symptoms that were experienced by advanced cancer patients while in the Victoria Hospice Society (VHS) palliative care unit. For this research, case solutions were not available from the VHS, and therefore simulated case solutions were created from existing palliative care pathways and evidence-based literature. Case solutions consist of: patient assessment, pharmacological considerations, pharmacological therapy, non-pharmacological therapy, patient activity, psychosocial considerations, and patient/family education.

**Case Indexing and Storage**

Patient cases (N = 277) were stored in a MySQL database (case library) and were indexed to speed up database searching. Additionally, predictive feature attributes were indexed (assigned weighted indices) to ensure that the most relevant set of cases, which are similar to the new case, would be retrieved from the case library.

**Case Retrieval**

In this CBR system, users (health care professionals) are able to interact with the system via a web-based user interface. Users can easily enter the feature attributes of a new patient case on an electronic web form, and then perform a search query to retrieve the 10 most similar patient cases that are stored in the case library. The resultant set of cases is presented to the user in order of descending similarity. During case retrieval, similarity computation is calculated by applying the nearest neighbor algorithm to find the most similar cases from the case library.

**Case Adaptation and Learning**

At present, this CBR system does not incorporate case adaptation; however, end users can store a new case into the case library (case learning) using an electronic web form. Users simply select the relevant boxes on the form that pertain to the treatment decisions they made for the new patient case, and then they submit this form to the database. Upon submission, this information is stored as a new case in the case library, and so it would be available for future case queries.

**Conclusion**

Case based reasoning is a promising AI technique that is being increasingly adopted for medical problem solving. There is general consensus among medical experts that case based reasoning offers many advantages for organizing experiential and domain knowledge that is generated in the complex and knowledge intensive field of medicine.

This paper presented a case based reasoning system that can assist health care professionals with planning palliative care. It is anticipated that this user-friendly, web-based CBR system will improve decision making for pain and symptom management for end-of-life cancer patients. Future research will include a chart audit review of the palliative care that was provided to the 277 patients during their stay at the Victoria Hospice Society. With these real case solutions the practicality of implementing the presented CBR system would be realized.
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References


