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Interactive Dialogue-Based Patient Education for Juvenile Idiopathic Arthritis Using Argument Theory

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Abstract. Families of children with Juvenile Idiopathic Arthritis need a way to interact with Patient Education Materials (PEM) so that learning occurs at their own pace, on topics that are relevant to them. This paper proposes a novel, dialogue-based approach to address these needs. Using an extended version of Toulmin's model of argument as a theory-based classification method, we digitized paper-based PEM to render an interactive dialogue. The dialogue allows the user to explore a topic with respect to their interests and apprehensions as opposed to providing a static, generic document.

Keywords. Argument Theory, Patient Education, Juvenile Idiopathic Arthritis

1. Introduction

Juvenile Idiopathic Arthritis (JIA) affects approximately one in every 1000 children and adolescents in Canada [1]. JIA is a life-long disease with outcomes that can include pain, prolonged use of medications, and disability [2]. In addition to the physical burden of the disease, families often feel overwhelmed by the volume of information [3]. These issues are compounded by the scarcity of accurate online information about JIA [4].

Families need a way to interact with Patient Education Materials (PEM) so that learning occurs at their own pace, on topics that are relevant to them, and in a format that they can understand. This requires organizing and selecting the information from PEM so that patients can interact with the relevant PEM information. We believe that the family can better understand the condition, therapy options, risk, and recovery trajectories if they can have an interactive and intelligent dialogue/conversation with content delivery system to find the information they really need, as opposed to simply receiving a static PEM. In this paper, we present a novel, dialogue-based patient education approach, implemented as the **J**uvenile idiopathic **A**rthritis **D**ialogue-based patient **E**ducation (JADE) system. JADE uses an artificial intelligence based argument model to establish an interactive dialogue with the user, where, in an interactive manner, the user can ask questions, seek clarifications about responses/findings, learn about the evidence supporting the response and seek alternative findings. In our work, we extended

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the Toulmin model of argument [5] by including a knowledge model to formally digitize PEM given to patients with JIA and their families at the Rheumatology Clinic at the IWK Health Centre (IWK). By reasoning over the argument model, JADE can select and deliver information to the user as per the discourse of their educational dialogue. JADE is being evaluated, as a prototype, at the IWK to test its capabilities.

2. Representing JIA Education Material Using an Argument Model

To develop a patient education system that includes an interactive dialogue to respond to queries posed by the patient/family, we have extended and implemented Toulmin's model of argument [5] that represents the different educational aspects of PEM. This flexible model [5] provides six elements to describe an argument: Claim, Data, Warrant, Backing, Qualifier, and Rebuttal [6]. The main assertion of the argument is the *Claim*, this is the statement that the argument is trying to support [7]. *Data* represents the supporting information that defends the Claim [6]. The *Warrant* represents how the Data logically leads to proving the Claim [6]. The *Backing* represents the objective support for the Warrant in the form of statistics or publications [6]. *Qualifiers* are words or phrases that limit the effectiveness of the Claim, such as perhaps or possibly [7]. Finally, the *Rebuttal* represents a situation which either refutes the claim or offers an exception to it [6]. When digitizing PEM, all the argument's elements need not be used since the corresponding information may not be available.

Toulmin's model has been used in the field of patient education before, mainly as an assessment framework. For instance, Wolfe et al. used Toulmin's model to score the responses of users of their tutoring system as part of their study to determine which features of the system best facilitated learning [8]. As a knowledge management tool the model has been used to give context to breast cancer risk assessments, by displaying how the user's profile (Data), medical literature (Warrant), and missing data (Rebuttal) affect their risk (Claim) [9], and deliver coping strategies in genetic counselling letters, by identifying the Warrants that link the user's profile (Data) to coping strategies (Claim), that can then be included in counselling letters generated by their system [10].

To better capture the information contained in the PEM, we extended Toulmin's argument model to better express arguments pertaining to health education. With this extended model we are now able to model (i) multiple warrants in a single argument [11]—an example case with multiple warrants is: *if a child is taking prednisone* (Data) *they should have their eyes checked regularly* (Claim) *because prednisone's side effects include glaucoma* (Warrant 1) *and cataracts* (Warrant 2), (ii) Elaborations that add details to other elements [12]—an example case requiring elaboration is: *patients taking Ustekinumab* (Data) *very rarely* (Qualifier) *develop a rare brain problem called RPLS* (Claim) *whose symptoms may include: headache, seizures, confusion, and vision trouble* (Elaboration), and (iii) chain arguments together as the claim of one argument can be an element in another argument [11]. We have also renamed Rebuttal as Exception because, as PEM are trying to communicate the consensus of evidence-based medical findings, rebuttals exist not to attack but to exclude scenarios from the argument.

3. Methodology: Modelling Educational Arguments from JIA PEM

Paper-based PEM, distributed by the IWK Rheumatology Clinic, are given to families in packages on topics such as general JIA information, self-management, and specific medications. There were 100 PEM ranging from 40-page brochures to 1-page leaflets. We outline our methodology to model the available PEM, beginning with PEM selection.

3.1. PEM Selection

Of the 100 PEM, 52 were excluded as they were forms, which did not aim to educate families. 7 PEM were removed for being duplicates. 9 PEM were deemed too general, such as Canada's Food Guide, which did not contain any information that could be tailored to a specific subset of users. Thus, we selected 32 PEM for our study.

3.2. Argument Extraction and Standardization

Once identified, PEM were coded into the elements of the proposed model according to the following procedure: 1) read PEM for understanding; e.g. a reference guide for a specific medication, 2) divide the PEM into sections relating to a single topic, i.e. taking the drug, side effects, when to call your doctor, 3) further divide into individual arguments, 4) identify argument elements in the following order: claim, data, qualifier, exception, backing, warrant, elaboration, 5) re-read the arguments checking for accuracy [12]. Arguments derived from the 32 PEM were standardized into a total of 931 arguments, which allowed us to aggregate the arguments from different sources.

3.3. Argument Aggregation

Argument aggregation was based on combining arguments with the same claims stemming from different sets of data and arguments with different claims that stemmed from the same data. This allowed the removal of 4 duplicate arguments, the aggregation of 95 arguments with the same claim, and 179 with the same data. The argument aggregation step resulted in a total of 653 arguments.

3.4. Thematic Coding of Arguments

To further subclassify the content of the arguments in terms of salient educational topics, we performed thematic analysis using grounded theory. Based on the data and claims in the arguments, a code book of topics was developed, e.g. Table 1. These codes classify arguments, thus adding another layer of knowledge on top of that provided by the argument model. Thematically coded arguments will allow for the chaining of arguments, to enact a responsive dialogue with the users' questions.

3.5. Ontological modelling of arguments

We developed a high-level argument ontology using OWL with the proposed argument model and subsequently the thematically coded arguments were included as instances to the argument ontology [13]. Using semantic reasoning [14] over the argument ontology, we chain the relevant arguments to realize an interactive dialogue with the user [15].

Table 1. A selection from the thematic codebook

Code	Description	Examples
Event	A time point in the disease or treatment course	At diagnosis, after injuries
Test	A medical investigation used to inform decisions and classifications	Chest x-ray, blood work
State	Defines the acuity of a condition, symptom or side effect	Chronic, well controlled
Outcome	A patient's health status relating to the disease process in question	Slow down overall growth, permanent damage

4. Functional View of JADE

Users will interact with JADE through a synchronous text-based dialogue interface. JADE will leverage the argument ontology, through reasoning, to select and deliver relevant responses to further the dialogue. Forward chaining is used to lead from data relating to the user's query to their respective claim(s). Backwards chaining is also employed to get other argument elements from the claim in question. To demonstrate JADE's functionalities we will use two arguments as examples, they are 1) use heat for 15-20 minutes at a time (Claim) if your child is experiencing morning stiffness and pain or on days when your child is less active due to pain (Data) unless your child is sleeping, feels pain, or skin becomes bright red (Exception) and 2) you may (Qualifier) get better symptom control by taking a warm shower or bath (Claim) if an electric heating pad doesn't work (Data) because moist types of heat tend to be felt more deeply (Warrant). The example below illustrates a user's dialogue, asking for treatment suggestions.

User: My child's knee is very stiff and sore in the morning, what can I do to help?

JADE: Use heat for 15-20 minutes at a time, unless your child is sleeping, feels pain, or their skin becomes bright red. Examples of heat sources: reheatable pack, hot water bottle, electric heating pad, wax bath, shower or bath.

User: The electric heating pad didn't work when we tried it.

JADE: You may get better symptom control by taking a warm shower or bath.

The user's queries are used to search for arguments with matching data, and an argument relating to treatment with data including morning stiffness and pain is found. JADE then uses forward chaining to present the relevant argument elements.

User: Why is that?

JADE: Because moist types of heat tend to be felt more deeply.

In response to the user's 'why' query, JADE uses backward chaining to arrive at the argument's warrant and then displays it.

User: Where are you getting this information?

JADE: This is from "Using Ice and Heat at Home", a pamphlet created by the IWK Health Centre. Click here to view the information pamphlet.

5. Evaluation Framework

To evaluate the ability of JADE to deliver appropriate information based on the user's queries we will use the parameters identified by O'Grady et al. for evaluating the content of interactive web-based applications [16]. A sample of 5-8 healthcare providers from the IWK, with JIA domain expertise and familiarity with the PEM used in the JADE

system, will participate in a Cognitive Walkthrough guided tasks as per a patient education scenario. The participants will evaluate the relevance, completeness, and accuracy of the information provided by JADE. A combined inductive and deductive analysis will be performed (results to be published separately). Deductively, we will use Directed Content Analysis, using the parameters from the O'Grady framework, as predetermined codes [17]. Sub-themes within those categories will be coded using inductively generated themes. The experts' feedback will be used to improve the knowledge structure of JADE. We will also be performing a usability analysis of JADE.

6. Conclusion

JADE demonstrates a novel use of argument theory for digitizing paper-based PEM to render an interactive dialogue for users, which we believe will improve the value proposition for users of PEM. The interactive dialogue allows the user, at the time and place of their choosing, to explore a topic with respect to their own interests and apprehensions as opposed to being provided with a static, generic document. Our approach is generic and can be applied to PEM from other clinical settings.

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