

DEVELOPING A CONTEXTUAL MODEL TOWARDS UNDERSTANDING LOW BACK PAIN

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Abstract

Recent advances in mobile computing and sensor technology have provided new opportunities in data collection and analysis, especially in the medical fields of research. Low back pain is a key area within chronic pain management. It is a widespread problem and a major contributor towards disability worldwide. Researchers have concluded that pain can be an individualistic experience. Evidence from other fields of research show that studying the context of the phenomena can allow for a better understanding of its nature. Existing studies may not consider the full context of the patients' pain, and collect data infrequently (e.g. monthly or yearly). An explanation for this could be due to the cost and difficulty of collecting such data in the past. In this research, we propose a descriptive contextual model that extends a current low back pain model, with contextual attributes and factors. The goal of this research is to provide researchers with a descriptive contextual classification of variables into their respective factors, and to guide future studies in collecting such data, by utilizing advances in mobile and sensor technology.

Keywords: low back pain, contextual model, context factors, mHealth, eHealth

1 Introduction

In recent years, advances in mobile computing and sensor technology have provided researchers with new opportunities in data collection and analysis (Bonato 2005). This is particularly true in medical fields of research, where there has been a gradual shift towards the inclusion of such technology into medical care (Kulkarni and Öztürk 2007). There now exist new areas of research such as Mobile Health (mHealth), which was created to support the use of mobile technology in healthcare (Kumar et al. 2013). However, there still exist some fields of research in medicine that been observed as being slow to adopt such technology, of which one such field is chronic pain.

Chronic pain has been defined as pain experienced that lasts for more than 3 months (Merskey 1986), and is a widespread problem. Chronic low back pain (cLBP) is a leading chronic pain condition, and an important cause of disability worldwide (Hoy et al. 2014). In Australia, one in five of the population suffer from chronic pain, with a yearly cost of \$34 billion to the economy. Low back pain studies typically are longitudinal studies as they monitor a population of individuals over a period of time, and collect repeated measures of data. Many approaches to studying cLBP exist, and the predominant approach involves studying the relationship between cLBP and its contributing factors. These studies focus on one factor and assess if there is a relationship between the factor and cLBP. These factors can be described as being contextual to cLBP, and studies commonly analyze the entire population at once, rather than individual episodes of cLBP in attempts to find correlations. Research suggests that pain is an individualistic experience, thus no two patients would experience the same pain (Olson 2014).

The study of context is not new to the field of research on the whole, and has been used to great effect in fields such as psychology and behavioural sciences (Green et al. 2009). There is evidence that suggests there is a need to obtain a shared perspective on the experience of the patient's pain in order to better understand the nature of cLBP and its factors (Howarth, Warne, and Haigh 2014). Existing research shows that there are factors that can be associated with cLBP, but not much is known about the extent and what specific factors these can contribute towards cLBP. In the majority of existing cLBP cases, it is unclear what caused the episode of pain, and therefore referred to as 'non-specific' cLBP. We suggest that the study of the context of the pain episode itself will provide a better understanding of the nature of a patient's pain. Unfortunately, no such framework or model currently exists to understand the context of a patient's cLBP experience. Existing models for cLBP are either focused on a single factor, with variables hypothesized to contribute towards it (Leboeuf-Yde 1999; Maul et al. 2003), or attempt to elicit risk factors of cLBP for a specific population (Bergström et al. 2007; Kovacs et al. 2003). Another study has categorized variables contributing to the burden of cLBP into factors (Buchbinder et al. 2011). None of these studies consider the context of the patient's pain during the data collection and analysis, nor do they attempt to study multiple factors at once.

This research will address the lack of consideration for the patient's context by extending a current cLBP model with contextual attributes and factors, with the goal of enabling a better understanding of cLBP. We will propose a contextual model which will guide and enable researchers in collecting data on cLBP. This research focuses on chronic low back pain and will refer to it as cLBP throughout the paper.

2 Methodology

This research is based on a literature review using the SCOPUS database and through Google Scholar. We searched for papers describing longitudinal studies in low back pain. The initial search from SCOPUS returned a total of 43,726 publications. The filtered results were about 4,000 publications, which were then read and analyzed to determine the current status of the field. Publications found mainly were from

the Spine, European Spine, BMC Musculoskeletal Disorders, Pain, Pain Physician, among other highly ranked journal outlets. The snowballing technique using the references in each paper, was used to discover other papers of interest.

3 Longitudinal Studies of Low Back Pain

Low back pain is a field that has experienced enormous growth, with almost 57% of existing research being published in the last ten years (Elsevier 2014). As mentioned previously, there are a large variety of approaches, which includes investigation into causes and treatments for specific pain, along with research towards understanding the nature of pain itself, which is made difficult by the fact that clinical pain is subjective in nature (Abu-Saad and Holzemer 1981; McGuire 1984).

There are a percentage of cLBP cases that can be attributed towards medical causes such as spine injury, genetic conditions and the like. This research focuses on non-specific cLBP, which refers to cLBP that cannot be pin-pointed to a specific cause or set of causes. Initial research in cLBP included targeting pain receptors to reduce or numb pain, but did not contribute to better care that lead to long term cure or effective treatment (Johnson 1974; Spiegel and Bloom 1983). Currently, the most common approaches in studying factors of cLBP fall into two main paths. The first being longitudinal studies in analyzing possible variables that are able to be related to a specific factor, such as the psychological factor, for a specific population; and the second being studies that conduct systematic reviews or theory building activities to elicit variables that relate to a factor of interest. Studies focusing on analyzing possible variables include research on weight lifting (Chaffin and PARK 1973), between occupations such as nurses (Maul et al. 2003), and populations such as children (Szpalski et al. 2002) or adolescents (Burton et al. 1996). Systematic reviews that attempt to establish if specific factors contribute towards cLBP have identified factors such as smoking (Leboeuf-Yde 1999), body weight (Leboeuf-Yde 2000), psychosocial factors (Hartvigsen et al. 2004; Hoogendoorn et al. 2000) and psychological factors (Pincus et al. 2002). There have been studies that describe these factors as risk factors towards cLBP, which include Smedley et al. (1995)'s work on specific manual nursing activities in relation to the risk of cLBP for nurses, and Kovacs et al. (2003)'s work on risk factors in a population based study of schoolchildren and their parents.

Current research focuses on the factors that contribute or have some relationship with cLBP itself. There are limited successes in identifying these factors within specific populations, but these do not consider the patient's context of pain. These studies typically collect data using traditional methods such as paper questionnaires and in-person interviews. The frequency of data collection seen in these longitudinal studies are also typically of an in-frequent nature, with monthly, 3-monthly and yearly collection being common. This is a problem as there is evidence that the accuracy of patient recall over an extended period of time has been shown to contain bias information, although this is not an issue with shorter periods of a week or less (Schneider et al. 2011; Turk and Melzack 2011). To some extent, part of the reason for this in-frequent data collection is due to the cost of obtaining such data, along with the logistical issue of conducting several hundred interviews or questionnaires every week for an extended period of time.

Experts in the field have identified the need to understand pain and its nature (McCracken, Vowles, and Eccleston 2004), or rather, the need to obtain a shared understanding of the patient's pain experience itself (De Souza and Oliver Frank 2011; Thastum and Herlin 2011). De Souza and Oliver Frank (2011)'s work analyzed patient experiences on the impact of chronic pain, and concluded that their findings were of limited generalizability as the patients' pain experiences changed as the pain varied with their lifestyles and context of the people around them. This suggests that the context of the patient's pain will contribute towards the understanding of the nature of pain itself.

Currently, a large amount of studies in cLBP use statistical analysis on entire populations. There are

currently no studies that conduct statistical analysis on an individual's pain to identify correlations before extending these correlations to the analysis of a population, that is to say, studies typically attempt to analyze the entire population without taking into consideration any, or all of the context available (Cook 2003; Dunn, Jordan, and Croft 2006; Dunn et al. 2011). It is important to then be able to understand the context around the patient's pain experience, and to be able to classify the contextual data in a unifying, coherent manner.

With advances in mobile and sensor technology over the last two decades, it has been possible to collect data in a more efficient manner at lower cost, by conducting questionnaires administered over the Internet, or through a mobile application. There are newer methods of collecting contextual data about the patient's thoughts, feelings and surroundings by using mobile diaries that a patient can enter information on. The same application is also able to collect data about the patient's pain (Gaertner et al. 2004). Apple Inc. (2015)'s ResearchKit platform allows researchers to obtain more data from participating patients in a patient-centered manner. It uses mobile devices which contains a suite of advanced sensors in both active and passive modes. These sensors, along with the mobile device enable the collection of real-time data at large volumes about the context around the patient, along with the pain experience that can be described by the patient in a diary format on the mobile device.

This research will discuss in the following section, contextual data, and propose a contextual model for studying cLBP.

4 Proposed Contextual Model for studying Low Back Pain

In the domain of cLBP, there is no standard methodology used to develop or design a contextual model. There are studies that have conducted systematic reviews to elicit variables related to a factor from existing research which was then used to develop a model. We have taken a different approach where we have examined existing literature as far back as the year 2000 and identified variables that could be grouped into factors, factors themselves that could be related to the context of the patient's pain, or provide important background data that have been used in statistical analysis of cLBP. Our review shows that there exists some models that are built up around specific factors (Leboeuf-Yde 2000; Pincus et al. 2002), and there are studies that consider single or multiple factors that can be contextual in nature (De Souza and Oliver Frank 2011; Karoly et al. 2014; Shaw et al. 2011, 2013). Through the literature review, a paper was identified that discusses development and validation of a model for the burden of cLBP (Buchbinder et al. 2011). The study identified six factors that contribute towards the burden of cLBP, presented as a hierarchical model. Their work also included validation of the naming of these factors. We will extend this model with contextual attributes which will be discussed below.

Context is not a new concept to research, but it is only in the last decade that it has really evolved. There exist many definitions of context, but we adopt Dey's definition as "any information that can be used to characterize the situation of an entity, where an entity can be a person, place, or physical or computational object" (Dey 2001, p. 304). The use of context in research is predominant in fields such as psychology and behavioural sciences, where the study of context is recommended in understanding a situation, in providing critical data about the mechanisms of the phenomena being studied (Green et al. 2009).

In this study, we consider the context of cLBP to be information about the environment surrounding the patient, information about the mental state of the patient, and information about the patient's current activity. Accompanying the context of cLBP is the information of cLBP itself, which primarily refers to the pain intensity, and type of pain; and the information that are the quantifiable statistics in classifying the patient into a population, which are demographical data including age, gender and country. As mentioned previously, existing research already consider some contextual factors. A sample of these studies are

shown in Table 1, along with the study's frequency of data collection. In Table 1, "Pain" refers to the factor of "Pain Characteristics".

Study	Factors	Frequency
Macedo et al. (2014)	Demographics, Physical, Psychological, Treatment, Pain, Medical History	Monthly
McGorry et al. (2000)	Pain, Disability, Medical History	Daily
Dunn, Jordan, and Croft (2006)	Demographics, Employment, Psychological, Pain, Disability	Monthly
Henschke et al. (2008)	Demographics, Employment, Physical, Psychological, Treatment, Pain, Disability, Medical History	Irregular Intervals (Week 6, Month 3, Month 12)
Dunn et al. (2011)	Demographics, Physical, Psychological, Pain, Medical History	3-Monthly
Dunn, Campbell, and Jordan (2013)	Demographics, Psychological, Pain, Disability	Monthly
Steffens et al. (2014)	Demographics, Pain, Psychological, Physical, Environment	Once
Edefonti et al. (2012)	Pain, Psychological, Environment	Daily

Table 1. Contextual factors in a sample of cLBP research

In the following subsection, we propose a set of identified factors from existing literature, of which a sample has been shown in Table 1, and include them in a contextual model.

4.1 Factors of Low Back Pain

Factors of cLBP can be considered as categories of variables which are contextual or non-contextual data. The data can be collected from a variety of sources, which includes sensors and direct input from the patient. Recent growth and advances in mobile technology present an unprecedented opportunity for collecting patient data using mobile and sensing devices. The use of such devices can also reduce the cost of data collection, especially since a large proportion of the urban population owns a smartphone. The sensors built into mobile devices are able to provide a rich source of contextual information about the user's current situation and surrounding environment.

As mentioned previously, studies of cLBP have considered single context factors, and to some extent multiple factors, but are limited in that they only consider specific dimensions to the data rather than the entire situation around the pain experience. An example of such a factor is demographics, which are most commonly collected and include variables such as age, gender, and country (Dunn, Campbell, and Jordan 2013; Dunn, Jordan, and Croft 2006; Dunn et al. 2011). Some other factors include disability (Henschke et al. 2008; Smeets et al. 2006), physical (Adamson et al. 2007; Dunn et al. 2011), and environment (Steffens et al. 2014). In this research, we have selected Buchbinder et al. (2011)'s work on the development of a model to understand the burden of cLBP, where they identified six factors that contribute towards the

burden of cLBP, and presented them as a hierarchical model. Their work also included validation of the naming of these factor names. We will extend this model with contextual attributes.

Through the review of existing literature, we have identified ten contextual factors that are described as follows, separated into the three categories of contextual data that was mentioned previously. Buchbinder et al. (2011)'s six factors are Physical, Psychological, Social, Employment, Treatment and positive effects. We have adopted the first five factors, and merged the variables under positive effects into the Psychological factor. The model is extended with a further five factors, which are Environment, Medical History, Pain, Demographics and Disability. We describe the factors below in four categories, which are about the external influences, internal influences, current activity and other information relevant to the condition. We also describe some suggested methods of obtaining such data.

Factors about the external influences:

Employment - Employment is defined as occupation related details, and includes the type of work, which describes the nature of work being done, for example physical work or office work. Other points are the effects on the employment situation, and the effects on the workplace. Variables here can be collected using a questionnaire or survey implemented online or within a mobile application. Information such as the occupation details can be obtained once and updated as necessary, but the information on the patient's perceived effects on their employment or workplace can be provided in the form of guided questions in a mobile diary.

Environment - Environment includes data about the context of weather, e.g. the temperature, and extends to wind chill, wind speed, wind direction, wind gust, air pressure, precipitation and relative humidity. We suggest that such information can be collected from available sensors on the device or via bluetooth, or from third party sources such as the local meteorological station using an API by obtaining the location data from the GPS sensor on the mobile device.

Factors about the internal influences:

Social - Social refers to the extent which the patient is interacting with other people around him or her. This includes psychosocial aspects at home, or negative reactions about the pain that are expressed towards others. Data in this category can be collected using questionnaires or diaries on the mobile devices or over the web.

Psychological - Psychological discusses aspects such as disempowerment, effort of living, negative mental effects, worries, life satisfaction, and depression. A majority of the aspects in this category are typically collected via questionnaires. These questionnaires can be conducted over the Internet in a browser or on the mobile device, and other information such as the feelings and thoughts of the patient can be derived from diary entries on the mobile diary.

Factors about the current activity:

Physical - Physical refers to the exercise and activities that are being carried out by the patient. It includes the exercise, or physical maintenance, or lack thereof, body functioning, participation in physical activities, and the current activity context. Some variables here can be collected via questionnaires or questions that the user answers, which includes information about their participation in physical activities. Other variables such as the current activity context can be obtained by using activity algorithms over accelerometer data collected from the sensors on the mobile device or wearable sensors such as fitness trackers.

Accompanying these are the factors containing other information relevant to the condition:

Pain Characteristics - Pain Characteristics refers to attributes that discuss the actual pain, or recovery of pain that the patient is experiencing. This can be collected using the mobile diary, or with simple questionnaires that can be also implemented on the mobile device or over the Internet in a web browser.

Demographics - Demographics are the quantifiable statistics of the patient to a population. Examples include age, gender, ethnicity, country and suburb. These data are typically collected once at the start of the study, and usually are obtained using questionnaires.

Disability - Disability is defined as information about the patient’s disabilities. This information can be either collected from the patient’s medical records or provided by the patient in a questionnaire.

Medical History - Medical history contains information about the patient’s medical records and previous history. This is typically provided by a third party (secure) data store, or by the patient.

Treatment - This factor discusses the current treatment services received or the burden of such treatment, and can be collected from questionnaires or cross-referencing data from medical secure databases, for example the hospital that the patient is receiving treatment from.

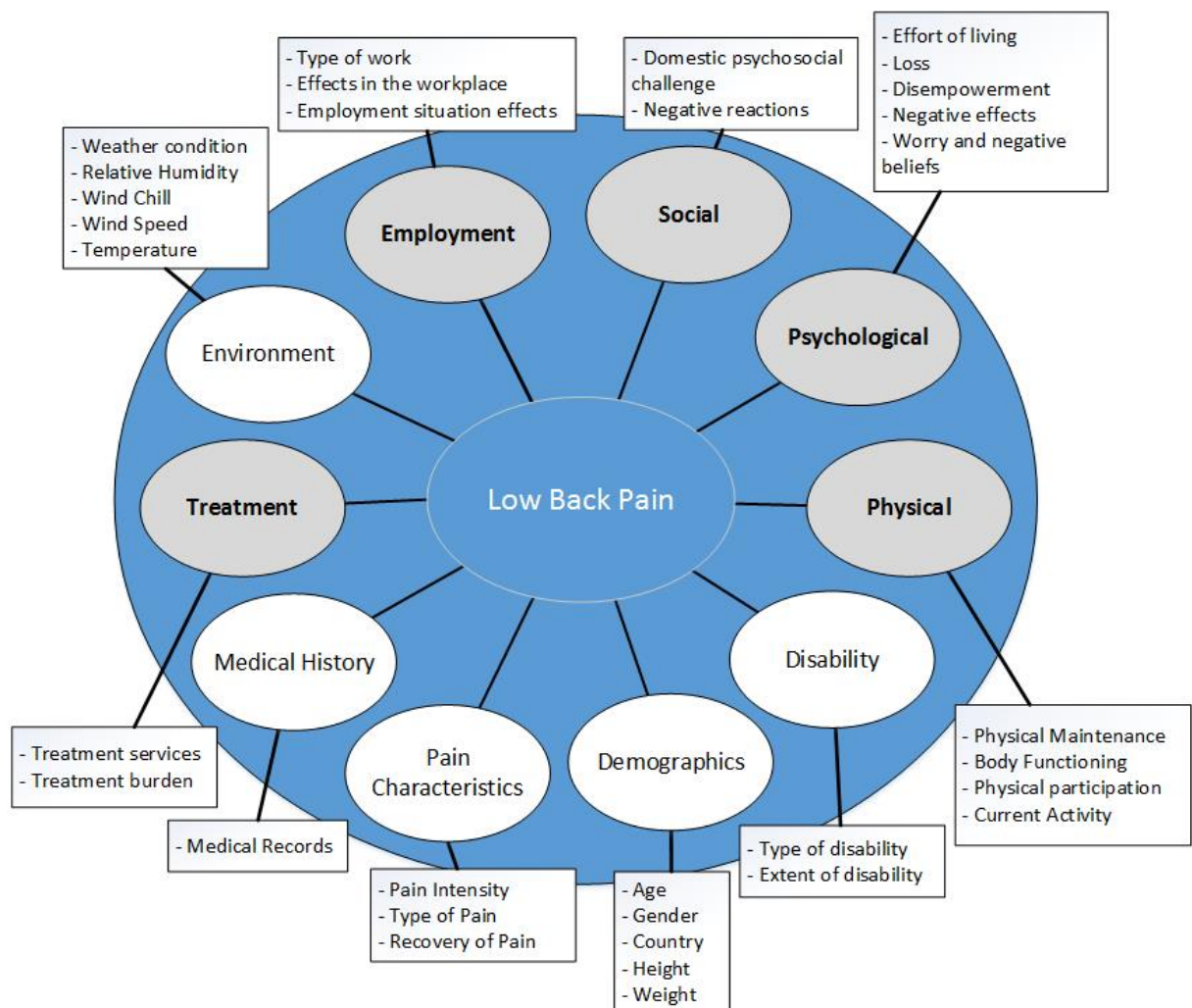


Figure 1. Proposed Contextual Model for Low Back Pain

4.2 Contextual Model

As discussed previously, we have extended Buchbinder et al. (2011)'s work with contextual attributes. The model shown in Figure 1 links the ten factors as described in the previous section, to cLBP. These factors have a sample set of the common variables observed from the literature, attached in the boxes linked to each factor.

The model represents key contextual attributes and factors (illustrated in circles) that may be important to cLBP. The factors shown in shaded circles are from Buchbinder et al. (2011)'s study. Each factor is linked to a rectangle that provides a sample set of variables. These variables have been identified from studying the literature pertaining to cLBP. The proposed additional contextual factors need to be validated through future research and experiments.

5 Conclusion

While there are many studies that investigate the relationship of factors with cLBP, none specifically document and analyze the context of each pain episode. The collection of contextual data in an efficient, cost-effective manner is now available to researchers by using advances in mobile and sensor technology with platforms such as Apple's ResearchKit, or simply by using learning algorithms with the onboard mobile device sensors or wearable sensors. This paper has proposed a contextual model that extends a current cLBP burden model with contextual attributes. The use of this model in providing better depth into data analysis, will contribute towards a better understanding of cLBP by studying the context in which it occurs. An increased understanding of cLBP can then contribute towards better management and treatments for individual patients suffering from such pain.

There are some limitations to the proposed contextual model. First, the relationships between the factors and cLBP are largely untested. Secondly, this research does not form any conclusions on the strengths or extents of the factors and their variables in the contextual model in terms of their respective relationship with cLBP. The future use of the proposed contextual model will lead to a deeper, more complete understanding of chronic lower back pain, which could result in reinforcement, validation and identification of additional factors and relationships.

6 Future Research

This is a work in progress and needs verification and validation by domain experts and patients. There is an opportunity for the model to be used in building an application similar to Apple's ResearchKit where patients are able to opt-in and contribute data to research. The work could lead to better cLBP management targeted at reducing the events that could lead up to pain episodes in some patient populations, and also lead to a better understanding of the causes and contributors to cLBP.

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