

Design of a Web-Based Clinical Decision Support System for guiding Patients with Low Back Pain to the Best Next Step in Primary Healthcare

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Abstract: Low back pain (LBP) is the most common cause for activity limitation and has a tremendous socioeconomic impact in Western society. In primary care, LBP is commonly treated by general practitioners (GPs) and physiotherapists. In the Netherlands, patients can opt to see a physiotherapist without referral from their GP (so called 'self-referral'). Although self-referral has improved the choice of care for patients, it also requires that a patient knows exactly how to select the best next step in care for his or her situation, which is not always evident. This paper describes the design of a web-based clinical decision support system (CDSS) that guides patients with LBP in making suitable choices on self-referral. We studied literature and guidelines on LBP and conducted semi-structured interviews with 3 general practitioners and 5 physiotherapists on the classification of LBP with respect to the best next step in care: visit a GP, visit a physiotherapist or perform self-care. The interview results were validated by means of an online survey, which resulted in a select group of key classification factors. Based on the results, we developed an ontology and a decision tree that models the decision making process of the CDSS.

1 INTRODUCTION

Low back pain (LBP) is the most common cause for activity limitation in people, and has a tremendous socioeconomic impact (Hill, 2011) (Ung, 2012). More than 80% of all persons experience low back pain in their lifetime (Balagué, 1999). A distinction is made between specific low back pain and non-specific low back pain. Most cases of low back pain are non-specific (Ehrlich, 2003). Non-specific low back pain is defined as "*pain symptoms anywhere in the lower back between the twelfth rib and the top of the legs, with no recognizable, specific pathology such as infection, tumour, osteoporosis, fracture, radicular syndrome, or cauda equina syndrome that is attributable to the pain sensations*" (Rolli Salathé, 2013).

Most people who suffer from non-specific low back pain recover within six weeks, but about 10-15% develop chronic symptoms (Balagué, 1999). It is not always clear why some people with non-specific low back pain develop chronic low back pain. In literature, multiple risk factors have been identified, including abnormal course of the low back pain, patients' belief and expectations about recovery, anxiety, distress and depression (Weiner, 2010). Patients with increased risk to develop chronic low back pain should be identified and supported by the most relevant healthcare professional at the earliest possible stage of non-specific low back pain, thereby reducing the development of a chronic condition (Childs, 2015), while patients who do not have increased risk profiles, may do well with self-management.

In the Netherlands, patients with musculoskeletal disorders can make use of so-called 'self-referral'.

Patients' self-referral, or direct access, means that patients can be examined, evaluated and/or treated by a physiotherapist without the requirement of a physician referral (APTA, 2012)(Swinkels, 2014). Although self-referral has improved the freedom of choice of care for patients with musculoskeletal problems, it also requires that a patient knows exactly what is the best care for his or her situation. This, however, is not always evident, especially for those patients that are new to musculoskeletal complaints.

Swinkels et al (2014) showed that people who directly access the physiotherapist receive less treatment than patients who are referred by their GP. Next to this, Bornhöft, Larsson and Thorn (2014) concluded that patients referred to physiotherapists required fewer GP visits or received fewer musculoskeletal disorders-related referrals to specialists/external examinations, sick-leave recommendations or prescriptions during the following year, compared to patients that were referred to GPs.

Although it may seem that a patient with a musculoskeletal complaint is served best with referral to a physiotherapist, there are also situations in which a patient should go to the GP. Alternatively, it might also be sufficient to perform self-care. For example, in case of the presence of so-called 'Red Flags', indicating a serious condition, the patient should contact his or her GP (Staal, 2013). Therefore, a correct referral for patients with low back pain is essential for effective treatment of patients, leading to fewer instances of chronic low back pain. Moreover, efficient treatment alleviates the burden on healthcare. In this paper, we describe a study that identifies key classification factors to be used as the basis for the development of a web-based clinical decision support system (CDSS) that guides patients with low back pain to the best next step in healthcare by advising the patient to 1) see a GP, 2) see a physiotherapist, or 3) perform self-care.

2 RELATED WORK

2.1 Classification of patients with low back pain

In order to enable an appropriate decision for the next step in the care of low back pain complaints, the nature of the pain should first be classified correctly (Hill, 2011) (Koes, 2010). Classifying patients is, however, a difficult task, due to the high degree of diversity of patients and risk factors.

Literature on the classification of low back pain is extensive. This has, for example, resulted in guidelines for GPs as well as physiotherapists for the classification and treatment of patients with low back pain (Chavannes, 2009) (Staal, 2013). In all guidelines patients are classified and stratified into groups for further treatment. A recent study showed that stratified care for back pain implemented in family practice leads to significant improvements in patient disability outcomes and a halving in time off work, without increasing health care costs (Hill, 2011)(Foster, 2014).

Basically, literature shows that the classification of patients with low back pain is mainly based on looking for the presence of so-called "Red Flags" and "Yellow Flags". "Red Flags" are considered to be serious conditions, such as trauma, cancer, and herniated discs. "Yellow Flags" are psychosocial factors complicating the condition as anxiety, distress and depression. Some papers categorize "Yellow Flags" into further detail, calling these "Blue Flags" (factors about work that may lead to prolonged disability) (Weiner, 2010), "Orange Flags" (psychiatric factors), and "Black Flags" (contextual factors as a compensation system under which workplace injuries are managed) (Nicholas, 2011).

Flags can be used as decisive factors in the decision process for further referral, also called 'triage', to determine whether the patient has to go to the GP or to the physiotherapist, or can perform self-care. Furthermore, flags can also be used as decisive factors at a later stage in the healthcare process, for example after anamnesis and physical examination of the patient with low back pain to determine the treatment path.

2.2 Clinical decision support systems for healthcare professionals as well as patients

Over almost half a century, clinical decision support system (CDSSs) have been developed to support healthcare professionals during the clinical decision process. The term CDSS is defined as "*any computer program designed to help healthcare professionals to make clinical decisions*" (Musen, 2014). One of the key decision support functions is to provide patient-specific recommendations that cover assistance in making a diagnosis, providing advice on therapy, or both diagnostic assistance and therapy advice (Perreault, 1999).

CDSSs on the management of low back pain have also been developed. These CDSSs were mainly developed to improve uptake of guideline recommendations on low back pain by healthcare professionals (Peiris, 2014). Next to this, CDSSs

were developed to assist healthcare professionals in making a diagnosis on low back pain, like detecting chronic low back pain by the evaluation of MRI images of the brain (Ung, 2012), classifying low back pain when dealing with uncertainty (Lin, 2006), and stratifying patients in risk groups on the development of a chronic condition based on questionnaires (StarTBack and Örebro) (Hill, 2008)(Linton, 2003).

Besides for supporting healthcare professionals, systems have also been developed to aid patients in decision support. These computerized patient decision aids range from general home healthcare reference information to symptom management and diagnostic decision support (Jimison, 2007). For low back pain, computerized patients decision aids have been developed for patients facing a surgical treatment decision (Deyo, 2000)(Knops, 2013). No systems have been identified in literature that support patients in the classification of their own low back pain prior to contacting a primary healthcare professional. However, such a system will be very helpful to support patients in the determination of a correct self-referral, an essential prerequisite for an effective treatment of patients with low back pain.

3 METHODS

The first steps in the development of a web-based clinical decision support system that guides low back pain patients to the most relevant healthcare professional is finding those factors that can classify these patients for further referral. To find these factors, the following steps were taken:

1. Studying physiotherapist and general practitioner guidelines on the classification and treatment of patients with low back pain;
2. Performing in-depth, semi-structured interviews with a group of 3 general practitioners and 5 physiotherapists;
3. Performing a thematic analyses on the interview transcriptions;
4. Validation of the results gathered thus far by means of an online survey among the interviewees.

3.1 Studying guidelines on low back pain

During this step, the Dutch physiotherapist guideline on low back pain (Staal, 2013) and the Dutch GP guideline on low back pain (Chavannes, 2009) have been studied. The main goal of this step was to gain a good understanding of the low back pain domain, the terminology used in this domain by GPs as well as by

physiotherapists, and the methods used to stratify patients with low back pain into profiles for further treatment.

3.2 Setting up and analysis of the interviews

Knowledge gained from the previous step was used to set-up the interviews. These were semi-structured interviews, based on the following themes:

- Demographics of the interviewee (e.g., age, specialisation);
- Expertise of the interviewee on classifying and treating low back pain (e.g., how often the healthcare professional sees a patient with low back pain, how knowledge on low back pain is kept up-to-date);
- Steps in the clinical evaluation and classification, and management of low back pain by questioning the healthcare professional about specific patient cases on self-referral (see Appendix);
- Definitions on low back pain concepts (e.g., the differences between specific and nonspecific low back pain);
- Future expectations of a CDSS that supports healthcare professionals and patients in the classification, treatment and management of low back pain.

The interviews were held among 3 GPs and 5 physiotherapists. Afterwards, the interviews were transcribed verbatim and analysed by means of thematic analysis (Braun, 2006).

3.3 Validation of the identified decision factors for classifying low back pain by means of an online survey

The previous steps resulted into a large number of decision factors for classifying low back pain related to further referral in care (GP, physiotherapist, or self-care). These factors were resubmitted to the interviewees to be validated by means of an online survey, and by assessing:

1. The importance of being questioned during initial triage;
2. The importance to be included into the decision for further treatment interventions.

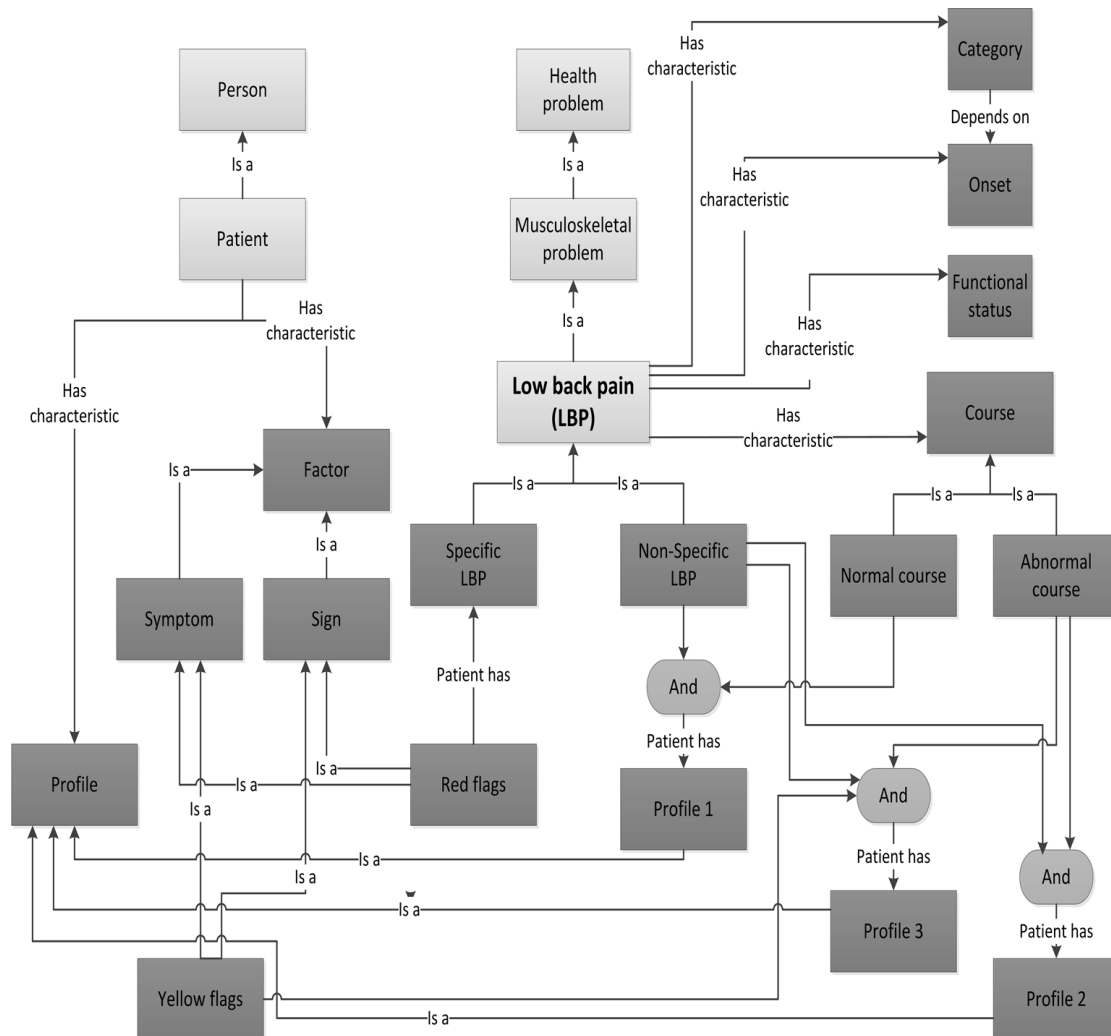


Figure 1. The knowledge model (ontology) on the classification of patients with low back pain, as deduced from guidelines on low back pain (Chavannes, 2009) (Staal, 2013).

4 RESULTS

Studying literature and guidelines resulted in a clear global overview of possible classes of patients with low back pain, and the possible prognosis and potential risks these patients face according to these classes. The focus of the guidelines was mainly placed on nonspecific low back pain, but factors related to specific low back pain were also found. We made a visual overview of the knowledge, gained during this step. This overview is shown as an ontology in Figure 1. In Figure 1, the light blocks refer to knowledge classes that are general to knowledge

concepts in the health care domain, the dark grey blocks refer to knowledge classes that are needed to describe the knowledge classes needed to classify patients with low back pain. This figure also shows three patient profiles to stratify patients with non-specific low back pain. Profile 1 is a patient with non-specific low back pain (no “Red Flags”) with a normal course. Profile 2 is a patient with non-specific low back pain with an abnormal course, but no psychosocial factors (“Yellow Flags”). Profile 3 is a patient with non-specific low back pain with an abnormal course and psychosocial factors.

Figure 1 shows that the main determining factors in classifying patients are the course of the low back pain (normal, abnormal), the presence or absence of serious factors (“Red Flags”) as specific underlying

serious conditions, and the presence or absence of psychosocial factors (“Yellow Flags”). These observations were also supported by the results of the interviews. The analysis of the interviews resulted in 43 identified factors for classifying low back pain. These factors are shown in Table 1.

Table 1: Classification factors for patients with low back pain, based on literature, guidelines and the interviews. Divided in the groups ‘general’, ‘psychosomatic’, and ‘serious’.

General factors
Patients’ preference for help
Well-being as experienced by patient
Course of the LBP
Sick leave
Earlier hospitalisation on LBP
Working environment
Family history of LBP
Working ergonomics
Psychosomatic factors (“Yellow Flags”)
Depression
Extremely nervous
Extremely worried
Stress (e.g., caused by family or relational problems)
Relationship with colleagues
Irrational thoughts about LBP
Problems with employers occupational insurance
Dysfunctional cognition
Anxiety disorder
Patients’ coping strategy
An ongoing investigation on personal injury
Kinesiophobia
Personality disorder
Borderline disorder
Serious factors (“Red Flags”)
Start LBP before age of 20
Start LBP after age of 50
Response on analgesics
Prolonged use of corticosteroids
Serious diseases, such as cancer, in patient history
Neurogenic signals
Specific pathologies
Problems with moving, shortly after waking up
Continuous pain, regardless of posture and movement
Decreased mobility
Radiation in the leg below the knee
Nocturnal pain
Rapid weight loss, more than 5 kg per month
Loss of muscle strength
No biomechanical pattern
Trauma
Underlying diseases

Failure symptoms during increased pressure (e.g., coughing, straining, lifting gives extra pain)
Possible to walk on the toes and heels?
Incoordination
Stooped posture

The interviewees indicated that in case of the presence of a serious factor (“Red Flag”), patients should be sent to a GP. Next, the interviewees indicated that in case of the presence of a psychosocial factor (“Yellow Flag”), the patient has a risk on the development of an abnormal course on low back pain, possibly resulting in chronic low back pain. In order to avoid the development of a chronic condition, these patients should see the right healthcare professional as early as possible, who can then guide the patient during his or her rehabilitation process. In most cases, this will be a physiotherapist, sometimes working in a multi-disciplinary setting with other healthcare professionals as, for example, a psychologist, with the physiotherapist as head therapist.

For the CDSS, we want to use the lowest number of classification factors for providing the best self-referral advice. This in order to minimize the workload for the patient in answering questions, posed by the CDSS. Therefore, we resubmitted the 43 identified classification factors (Table 1) to the interviewees so that these factors could be validated on two aspects: 1) their importance during initial triage to determine a self-referral advice for the patient, and 2) their importance for the decision process to determine further treatment interventions, also after the first anamnesis and physical examination of the patient with low back pain by the healthcare professional. Six of the 8 interviewees (3 physiotherapists and 3 GPs) responded on the Internet survey. This resulted in an overview of the most important classification factors to determine the advice for self-referral (Figure 2) and the most important classification factors for determining a treatment plan (Figure 3).

Both figures show the results in radar charts. The identified factors are labelled around the circle. The number of times an interviewee marked the factor as important for triage, and for determining a treatment plan (Figure 2 and Figure 3 respectively), is plotted for each factor as a point along a separate axis that starts in the centre of the chart (no interviewee marked the factor as important) and ends on the outer ring (all 6 interviewees marked the factor as important). Connecting these different points results in a quick overview of the most important factors for triage and treatment assessment. For better visibility, we also divided the circle into three pie slices: white represents the “general factors”, grey checked

represents the “psychosocial factors (Yellow Flags)”, and dark grey represents the “serious factors (Red Flags)”.

Figure 2 shows that only general and serious factors (“Red Flags”) are pointed at the 5th and 6th rings, fifteen factors in total. Subsequently, we used these fifteen factors to model the inference process of the CDSS, presented as a decision tree in Figure 4. This decision tree models the process to determine the referral advice (see a GP, see a physiotherapist, or perform self-care). Figure 2 shows twelve serious factors on the 5th and 6th rings: Start of low back pain after age of 50, prolonged use of corticosteroids, serious diseases (e.g., cancer) in patient’s history, neurogenic signals, continuous pain, regardless of posture and movement, radiation in the leg below the knee, nocturnal pain, rapid weight loss (more than 5 kg per month), loss of muscle strength, trauma, and failure symptoms during increased pressure (e.g., coughing, straining, lifting gives extra pain). In

Figure 4, these serious factors are taken together in one block to keep it as simple as possible: “# Red flags ≥ 1 ” means the presence of one or more serious factors.

Next, we decided that the factor “Asking patients’ preference” cannot be used in the decision process itself, because it is no indication of patients’ condition. Therefore, the block “Asking patients’ preference” is not a part of the decision tree. However, the healthcare professional certainly wants to know the patient’s preference for help. Therefore “Asking patients’ preference” is at least part of the triage process, and will be sent to the healthcare professional to be used during the first anamnesis, when the patient is referred to a healthcare professional.

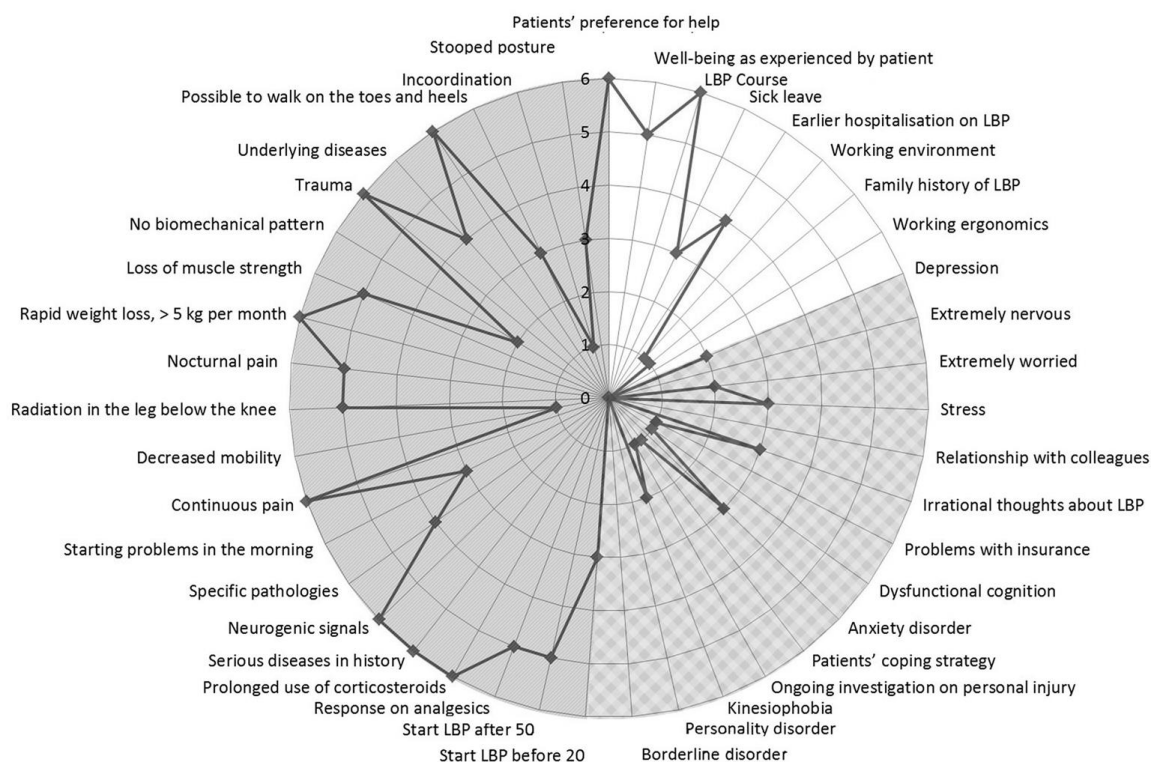


Figure 2. An overview of the identified factors to classify patients with low back pain, and their importance related to initial triage of patients with low back pain.

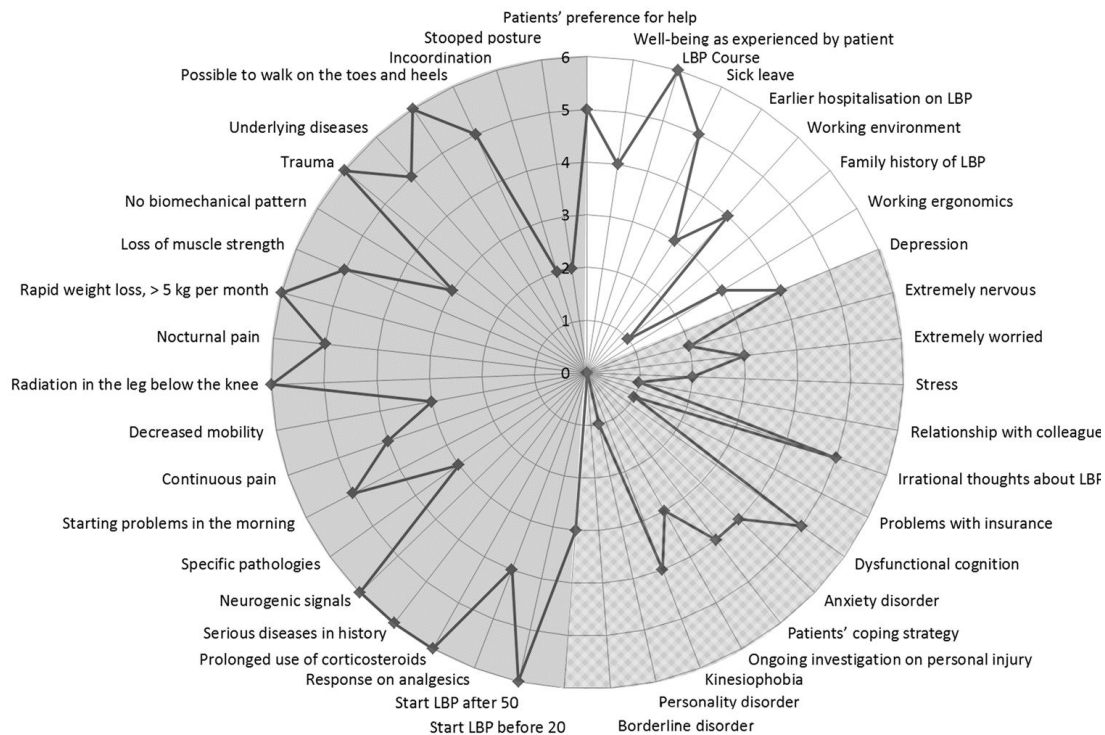


Figure 3. An overview of the identified factors to classify patients with low back pain, and their importance to determine further treatment plans.

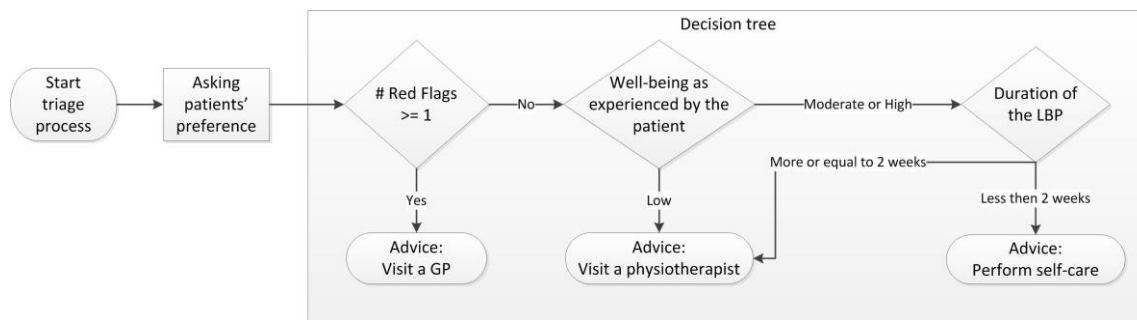


Figure 4. The triage process for providing advice on further referral of patients with low back pain.

5 DISCUSSION

By means of studying literature, and interviews and an online survey among 3 GPs and 5 physiotherapists, we identified 43 decision factors to classify low back pain for determining the best next step in primary healthcare. Fifteen of these identified

factors have been used to model the triage process as the basis in the design of a web-based clinical decision support system (CDSS) that supports patients with low back pain in making a decision on self-referral. That is advising the patient 1) to see a GP, 2) to see a physiotherapist, or 3) to perform self-care. A correct self-referral is an essential prerequisite for an effective treatment of patients with low back pain.

The identified classification factors correspond to classifications factors also found in literature (Ehrlich, 2003)(Koes, 2010)(Weiner, 2010)(Hill, 2011). In our study, one new identified factor emerged compared to factors found in literature, namely the general factor “Patients’ preference for help” (Table 1). Almost all study participants indicated the importance of this factor in triage, because healthcare professionals want to know the preferences of the patient with respect to the management of his or her low back pain complaints. Therefore, although the factor “Patients’ preference for help” is not an indication of patients’ condition needed for determining the advice for further referral, we included this factor into model of the triage process (Figure 4).

The identified classification factors appear to be evidence-based, which is supported by the great overlap between our study results and the factors found in literature. This means that the identified factors can be used in the decision process to determine a self-referral advice for patients suffering from low back pain. As no other systems have been found in literature to support patients in the classification of their own low back pain before contacting a primary healthcare professional, we cannot compare our found identified factors to other similar studies.

Looking at the classification process itself, there are CDSSs that stratify patients in risk groups on the development of a chronic condition based on questionnaires as the StarTBack screening tool (Hill, 2008) and the Örebro tool (Linton, 2003). These CDSSs, however, are intended for use by healthcare professionals and are not used to triage a patient for further referral, but for further treatment.

This difference in usage compared to our CDSS probably also explains the difference in classification factors used. For example, the StarTBack screening uses 8 prognostic factors for low back pain: two items for functioning, and items on radiating leg pain, pain elsewhere, depression, anxiety, fear avoidance, catastrophizing, and bothersomeness (Foster, 2014). These are mainly psychosocial factors, so called “Yellow Flags”, while the identified factors in our study for usage during initial triage are only general and serious factors (“Red Flags”). However, the results in our study also show the importance of psychosocial factors (“Yellow Flags”) in the classification process of patients with low back pain for assessing further treatment, thus after initial triage (Figure 3). Here, our study identifies the psychosocial factors “Irrational thoughts about LBP” and “Dysfunctional cognition” as most important.

5.1 Study limitations

In our study, we used the Dutch physiotherapist guideline on low back pain (Staal, 2013) and the Dutch GP guideline on low back pain (Chavannes, 2009). This may be considered a limitation of our study, especially because of the unique situation of self-referral in the Netherlands. However, Koes et al. (2010) compared international clinical guidelines for the management of low back pain. This study showed that there are some differences between international guidelines, which may be due to a lack of strong evidence regarding these topics or due to differences in local health care systems. But, in general, diagnostic as well as therapeutic recommendations are similar among these guidelines. This indicates that using only Dutch guidelines will not substantially affect the results as presented in this paper.

Next to this, the interviews and the online survey were held among a small group of GPs and physiotherapists. Each interview was transcribed verbatim and analysed by means of thematic analysis. After a couple of interviews, no new themes had to be added meaning data saturation was achieved. A low variance in the answers on the interview questions could be expected, because the participants all work according to the same guidelines. Next to this, all interviewees were experienced healthcare professionals on low back pain. That is four of the five interviewed physiotherapists had also a background as manual therapist, and all GPs had more than 10 year experience in primary care. Because of the achieved data saturation after a few interviews, but also because interviews are labour-intensive, the number of interviews was kept low.

5.2 Future work

In future research we aim to evaluate the process model, as shown in Figure 4, in more detail. By means of a vignette survey, also called factorial survey (Taylor, 2006), we will present cases (vignettes) to a group of more than 500 GPs and physiotherapists. This vignette survey will evaluate the importance of the presence or absence of the 15 classification factors as identified most relevant for initial triage as described in this paper. The outcome of the vignette survey should lead to a smaller set of classification factors that is an optimum between the factors necessary to determine a correct referral advice, while minimizing the workload for patients in answering questions.

We will relate the remaining factors to questions to be posed to the patients by the CDSS. For most of the identified classification factors in our study,

validated questionnaires exist that also can be used in the CDSS. Commonly used questionnaires in low back pain research are, for example, the Visual Analog Scale (VAS) for Pain (Crichton, 2001), and the Oswestry Low Back Pain Disability Questionnaire (Intensity, 1980).

Based on the results of the vignette survey, and the usage of validated questionnaires that determine the presence or absence of a factor, the CDSS will be developed. Subsequently the CDSS will be evaluated with patients in primary healthcare.

Figure 5 shows an overview of the intended future utilization of the CDSS in the further referral of a patient. The patient answers triage questions posed by the CDSS. The entered information is used by the CDSS to advise the patient on the best next step in healthcare 1. visit a GP, 2. visit a physiotherapist, or 3. perform self-care. The idea is that in all cases the primary healthcare centre will be notified about the CDSS advice provided to a patient. When desired by the primary healthcare centre, an extra check on the self-care advice is possible, for example, by the medical assistant. Next to this, the CDSS will check the self-care process outcome after two weeks. This

is different from the current healthcare process in which a patient can notify the primary healthcare centre on his or her self-care progress, but which is not usually the case when the patient becomes free of low back pain.

The CDSS retrieves healthcare information from the patient. This information can also already be available within the electronic health record (EHR) of the patient. Therefore, interoperability between the CDSS and the healthcare information system is desired. Advantages of interoperable systems are that already known information does not need to be requested from the patient by the CDSS. Next to this, information retrieved by the CDSS can be stored in the EHR so that it becomes available to the healthcare professional, to be used during a consultation with the patient.

The ontology we developed in our study is the first step in the realization of interoperable systems, and this ontology will be further developed during our CDSS project based on further research findings during the design process of the CDSS. Knowing the used knowledge concepts by the CDSS, these can be related to a terminology system, as SNOMED CT

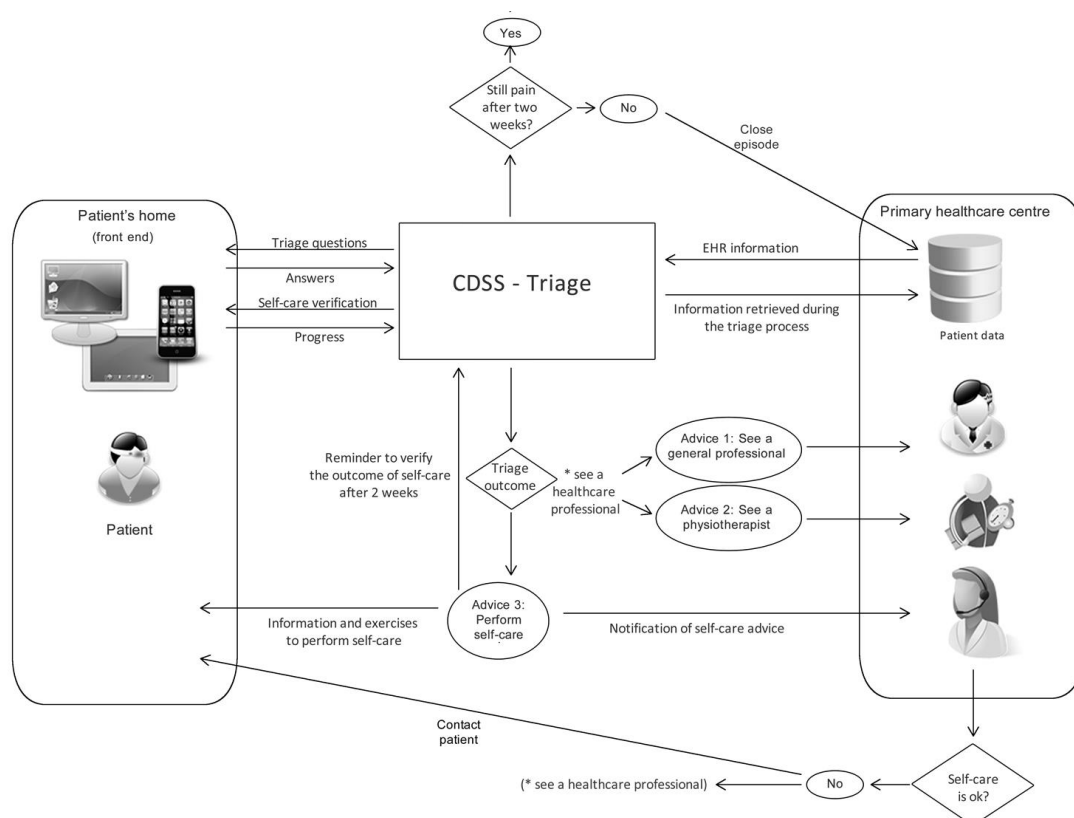


Figure 5. Overview of the future utilization of the CDSS in the further referral of a patient.

(SNOMED CT, 2015), that can on its turn serve as an intermediate terminology system to exchange information among different healthcare IT systems. Next to this, we now focussed on low back pain, because the musculoskeletal disorder domain is a large domain (Oude Nijeweme - d'Hollosy, 2015). By using general approaches to design the CDSS, as building an ontology and a decision tree we expect these same approaches are also applicable to extend the CDSS for self-referral advice on other musculoskeletal disorders.

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More information can be found at: <http://www.caretechnologyresearch.nl/elabel>.

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APPENDIX

During the semi-structured interviews, the following patient cases were presented to the interviewees. For each case, the interviewee was asked about the clinical evaluation and classification, management of low back pain, and the ultimate advice on self-referral: see a GP, see a physiotherapist, or perform self-care.

Case 1

- Male, 53 years, bus driver, married;
- Tennis: 2 times a week;
- Since three weeks, he has a burden of the spine with radiation just above right knee;
- Also low back pain problems in the past;
- Six years ago, some X-rays were made not showing any causes to explain symptoms;
- On sick leave at the moment;
- Worried that something has been broken in his back;
- He avoids pain;
- No pain during lying and sitting down.

Case 2

- Female, 69 years old, divorced;
- Low body weight;
- Sleeps poorly;
- Worrying a lot and feeling nervous;
- Has low back pain complaints since several weeks;
- Continuous pain, independent of posture and movement;
- Walks crooked.

Case 3

- Male, 39 years, bricklayer;
- Wants to visit primary healthcare for the 2nd time in 3 months, because of no improvement in low back pain complaints despite medication and advice;
- Otherwise a healthy person;
- No symptoms below the knee;
- Moves slowly, because of pain presence;
- Only walks short distances;
- Believes that low back pain will never end;
- 100% sick leave.

Case 4

- Female, 15 years old, follows 4th grade high school education;
- Suffers from low back pain since 6 months;
- Unclear start and cause of the low back pain;
- Plays handball;
- Otherwise a healthy person;
- Little pain when lying and sitting;
- Stiffness in the morning.