

# Chronic pain registry development: A web-based approach

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## ABSTRACT

**Introduction:** Chronic pain is a significant clinical problem in the world. There is not quite effective treatment for chronic pain due to its complex nature. However, timely retrieval of accurate and comprehensive information through organized clinical and epidemiological studies is an essential prerequisite for providing high-quality clinical care and more accurate health care planning. This can be achieved by the creation of an electronic registry system as a strong source of information. The purpose of this study was to develop and evaluate a chronic pain registry for patients with chronic pain syndromes.

**Material and Methods:** In this study, Onion architecture with the MVC design pattern was selected in design phase. Using onion architecture leads to more flexible and reusable codes and results in easier development and maintenance. In the development phase, MYSQL DBMS and the PHP programming language, which are suitable for developing the web-based system, were used.

**Results:** The minimum data set was determined in the previous study. This dataset covered six areas: demographic information, initial pain assessment, medical history, mental health and well-being, diagnostic measures, and diagnosis and treatment plan. A web-based pain registry system was developed based on the minimum data set.

**Conclusion:** There are many studies for development of web-based pain registries in the world but there is a few information about technical architecture and structure in design phase. In this study, we focused on the technical architecture design of system. Using onion architecture leads to more flexible and reusable codes and results in easier development and maintenance. In the current study, it was chosen to use MYSQL and the PHP programming language, which is suitable for developing the web-based system. Finally, a web-based registry system was developed to store and report on the information of patients suffering from chronic pain. It can manage and control chronic pain and facilitate future research.

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## INTRODUCTION

Chronic pain is one of the significant clinical problems in the world, due to the complex nature of pain; less treatment is effective in relieving it. Chronic pain has involved hundreds of millions of people around the world with support, mental and emotional problems and has reduced their quality of life due to the effects it has on people's ability to perform daily activities [1]. Recent studies indicate that more than 1.5 billion people worldwide suffer

from chronic pain and the prevalence of these pains is increasing due to changes in lifestyle and the increase in the age pyramid of the population [2]. Therefore, the discussion of quality control and management of chronic pain has become important today. On the other hand, obtaining accurate and complete information in a faster time through organized clinical and epidemiological studies is a prerequisite in providing better quality clinical care and more accurate planning of health indicators. This is possible through recording and monitoring

information.

Considering many problems and limitations of recording and monitoring information using traditional and paper-based methods, the use of systems for electronic recording and monitoring of information will be very helpful. Therefore, proper control and management of pain in the clinic and pain operating rooms are possible with the establishment and implementation of the pain registration system and create the background for future studies and research.

Chronic pain registry systems collect, store, process, and distribute information related to patients suffering from various types of chronic pain by collecting diagnosis and treatment data, prevention and follow-up of these types of pain, a better understanding of the causes and factors of pain, diagnosis and intervention to time, analysis and discovery of more suitable treatment options, monitoring of the performance of instructions and measures taken for patients helps and leads to improving the quality of patient care and providing long-term planning [3].

Pain registration systems with different goals and based on different methods have been designed and created in the world: web-based chronic pain registry systems with general goals, such as the first registration system in Sweden [4]. The pain registration system in Europe, Canada, Great Britain, America, and Norway [5-8] or web-based registries with specific and limited goals that were created using existing applications, such as the registry of pain after knee and hip joint implantation in Spain or the pain registry of patients who underwent surgery in Germany [9-12].

In Iran, studies have been conducted with limited goals or in a short time, such as a cross-sectional study in 2015 to investigate the prevalence of chronic pain, identify risk factors, and the impact of pain on daily life and activities [13]. The registration system for the training of nurses in chronic pain management, the registration system for fibromyalgia patients, or a system to detect the type and amount of pain in patients with spinal cord injury was done [14].

Due to the large number of patients visiting pain clinics and operating rooms in Iran and despite significant progress in the field of interventions and multi-modality treatments, there has not been a suitable infrastructure for a population pain registration system in Iran. In addition, in the review of similar studies and research in Iran, despite many efforts and successes in the field of creating registration systems, there is no evidence of creating and evaluating a comprehensive system for registering patients with chronic pain. Therefore, this research has been conducted to develop the hospital

chronic pain registration system at Rasool Akram Medical Complex Clinical Research Development Center (RCRDC), in Tehran, the capital of Iran.

## MATERIAL AND METHODS

Based on the minimum data set that was determined in the previous study. This dataset covered six areas: demographic information (8 elements), initial pain assessment (12 elements), medical history (8 elements), mental health and well-being (6 elements), diagnostic measures (3 elements), and diagnosis and treatment plan (4 elements) [15]. At this stage, the functional needs of the system were identified, through consultation with a clinical specialist and based on the expected activities of the system and its capabilities. According to the existing software and hardware needs, it was chosen to use MYSQL and the PHP programming language, which is suitable for developing the web-based system. Onion architecture with the MVC design pattern was selected as the first step in the design phase, then each layer was designed.

### Onion architecture

Palermo [16] has introduced a new architectural style called onion architecture (Fig 1). These architecture results bringing the dependency inversion principle (DIP) into the system architecture level. As the components like UI, Database, web services, messaging infrastructure, etc. change most often, the changes do not effect on the core [17]. The layers in Onion architecture are domain model layer, domain services layer, application services layer, and user interface [18]. Using onion architecture leads to more flexible and reusable codes and results in easier development and maintenance. This architecture is described completely in below section. MVC design pattern is an architectural pattern for user interface (UI) implementation.

The application is built around an independent object model. The definition of interfaces is in inner layers, the implementation of interfaces is in outer layers. All application core code can be compiled and run separately from infrastructure (Fig 1).

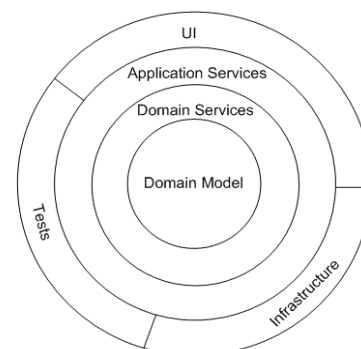


Fig 1: Onion architecture [19]

Flexibility and reusability of codes in onion architecture results in easier development and maintenance.

### Domain model layer design

In this phase, use cases Entities and their properties and behaviors were designed and implemented, after data elements identification. Then each entity transforms to one or more tables of the database and for each table, relative fields with their limitations were designed and implemented.

Domain service layer design: in this step, the operations include, create, read, edit, and delete (CRUD) were designed and implemented. Data validation operations were investigated and controlled on the server side.

### View model layer design

In this phase, views related to the user interface were designed and implemented.

User interface design: the system appearance in user view and compatibility with the view model layer was designed and implemented and different levels of access and their appropriate permissions were identified. In the user interface implementation MVC design pattern was used.

### Model view controller (MVC)

MCV is an architectural pattern for user interface implementation (Fig 2). In this pattern, an application is divided into three interconnected parts to separate internal representations of information from information that is viewed by the user. The MVC design pattern decouples these major components allowing for efficient code reuse and parallel development [20-22].

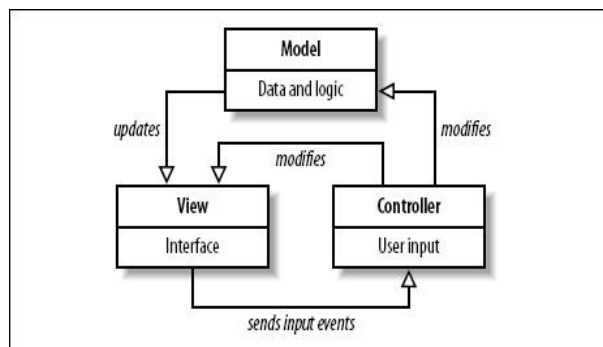


Fig 2: Model view controller (MVC) [19]

## RESULTS

At this stage, the expected capabilities of pain specialists, as the main users of the registration system, were collected and the functional needs of the system were identified and listed. The most

important requests were to register, search, edit, delete, and display the patient's demographic and clinical information. In addition, the ability to get reports from the system was considered another important thing for specialists. Therefore, according to the experts' opinions and taking into account the patient's need for their clinical information, the functional needs of the system were identified (Table1). Finally, Technical design and implementation were done. A mental map of the registration system was drawn (Fig 3).

After designing with the MVC architecture and creating the database with My SQL, the system was developed with the PHP programming language. This system was implemented in Persian but translated to English for this research. Some of the system screen shots are shown below (Fig 4, 5, 6).

Table 1: Functional requirements of the registration system for patients with chronic pain

Ability to register, edit, search, display and delete demographic information
Ability to register, edit, search, display and delete clinical information
The possibility of registering, editing, searching and deleting treatment plan information
Ability to register, edit, search, display and delete imaging and laboratory information
The possibility of preparing reports and displaying statistical charts with the help of predefined filters
The possibility of preparing a summary report of each patient's case and making it available
The possibility of recording information related to the patient's referral to another specialist and the follow-up date
Ability to create a new user, delete, display and edit user information
Define access levels according to user role

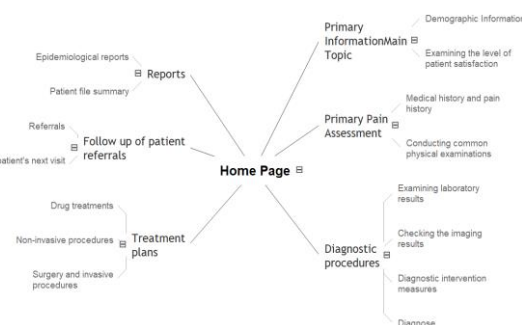


Fig 3: Mind map of system

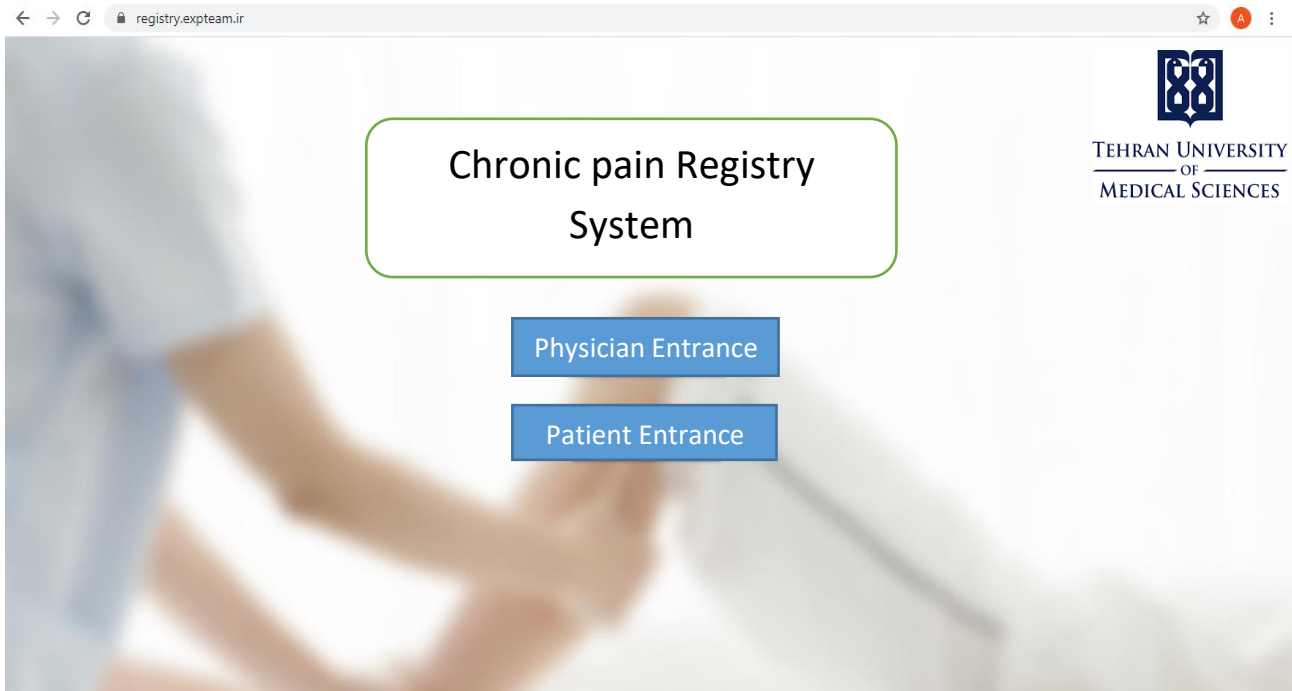


Fig 4: System homepage

Tehran university of medical sciences				
Patient name: Sara Karimi Visit Time: 11-5-2020 Sex: female marital status: Married Address: Tehran Type of insurance: Health service		National code: 1243234678 Birth date: 02-07-1990 Employment status: part time Tel: 12345431		Father name: Karim Physician name: Ali Ahmadi Level of education: Ph.D Weight: 75kg
Primary assessment of pain	Therapeutic actions	Diagnostic actions	Medical history of pain	Initial assessment of pain
<b>Initial assessment of pain</b> The main complaint of the patient: Right arm radiating pain  location of pain:		One-way or two-way: One-Way Pain Quality: Burning How the pain starts: Gradual		
Recurring in the last 7 days: Often The maximum time of pain intensity in a day: Night Pain reducing agents: Pain type: Musculoskeletal pain		Duration of pain: Ongoing Duration of pain in a day: 24 hours intensity of pain: 7 Pain aggravating factors: During activity underlying cause of pain: Neck		

Fig 5: A view of system information



Fig 6: A view of system reports

## DISCUSSION

In recent years, web-based registry systems have received a lot of attention due to their accessibility without time and place restrictions. Web-based registration systems have increased the accuracy and speed of data registration. They are also suitable for collecting patient data, especially for multicenter registry systems. Data are collected from all centers in the same way. In general, the use of web-based registration systems can make it easy to update information, create complex reports, and share information. Analysis of the findings of the comparative phase of chronic pain registration systems identified in different countries showed that most of these systems are web-based [23-26].

Sweden's national quality chronic pain registry system is a web-based system that was established to create a comprehensive database that records integrated data on disabled patients due to chronic pain. This information includes all the characteristics of patients with pain. Chronic patients who visited the rehabilitation centers of several cities in Sweden, along with all their results and treatment responses to the measures, are stored by a special software program in the local Access database and are

annually transferred to a national central database and by the National Association. Swedish rehabilitation is analyzed and the results of the studies are used to increase the implementation and improve the quality of multi-model rehabilitation programs in rehabilitation clinics [4].

The Pain Out pain system is a web-based registration system for acute postoperative pain, which was created by the European Union and with the support of the European Commission Fund from 2009 to 2012 to prevent the transformation of acute postoperative pain into chronic pain. It includes information on 40,898 patients. It receives data from 60 hospitals in 17 European countries and records the data in a central Oracle web database. Fast online feedback and offline reviews with detailed analysis, implementation of a decision support system (DSS) that allows all doctors and researchers to use real-time data, as well as having a large digital library with the purpose of transferring information through detailed summaries prepared from pre- and post-operative pain management is one of the unique features of this system. Realization of the capabilities intended for this system, especially providing online feedback; required the use of a programming language and a database capable of running on any operating system and through any platform.



Therefore, the Java programming language has been chosen for coding, and the Oracle web-based central database that uses IMISE technology for information security [5]. This registry was the basis for the formation of many similar registries in other countries, including Spain (pain registry after knee and hip joint implants) and the QUIPS pain registry in Germany [10]. Today, the QUIPS national post-operative pain registration system collects the data of patients who have undergone surgery from 180 hospitals across Germany and registers it in a central database on the web.

In 2008, the Quebec Pain Registry was created nationally in Quebec, Canada. Between 2008 and 2013, this registry recorded information on 6,900 patients and received permission to use their information for research purposes from almost 90% of them [27]. This system is a large web-based research database that collects all patients who refer to multi-specialty centers and clinics on an outpatient basis due to suffering from various types of chronic pain syndrome to retrieve information to achieve goals. It stores in the SQL Server database provided by Dacima software. Dacima is a software company in the state of Quebec that provides software for creating registries for organizations without the need for basic designs and computer programming, and the facilities for development, maintenance, creating electronic forms, determining the level of access, providing Provides access permissions to the registry system.

In 2011, a web-based computer system for collecting and monitoring chronic pain called PACS was created by pain specialists in the United Kingdom (UK). This system registers patient information in a central Access database that is linked to the databases of hospitals across the UK and aims to calculate the success rate of treatment strategies in addition to obtaining accurate epidemiological statistics and the basis of this success considers the amount of relief in the initial intensity of pain [7].

In 2016, a chronic pain registration system named CHOIR was created in the United States to track the progress of patients with chronic pain and the results and consequences of actions and interventions that have been carried out in this regard. CHOIR registry is an open-source and standard web-based application that uses an Oracle database with the Java Runtime Environment (JRE) programming language and can run on any virtual or physical server and any platform with a variety of Run Windows, Android, and IOS operating systems that support Java Script language and create many nodes that have access to a certain amount of RAM [6]. A secure web server is considered the host of the CHOIR application, where users with assigned permissions can access the application through the web browser installed on the platform. This system is also connected with the

electronic health record and can receive part of the information in this way.

Germany is another advanced industrial country that has made extensive use of information technology in managing and increasing the quality of pain care. And by creating an online application program that can be implemented on personal computers, tablets, and smartphones, providing the possibility of communication between the patient and the doctor in a safe way and through a browser and online. When they complete the questionnaires, doctors can review this information and suggest the appropriate treatment plan. Finally, all this data is stored in a web database called the German Pain Practice Registry, which is called GPR for short. are stored and then used to conduct research in the field of medical care and their results.

OPR, or Oslo University Pain Registry, is a web-based hospital registry that is the most comprehensive chronic pain registration system in Norway. This system is provided by the University of Oslo, which is the largest and most prestigious university in Norway. To record the data of patients who refer to multidisciplinary care pain clinics and affiliated hospitals of Oslo. In 2015, it started recording the data of patients suffering from chronic pain and records about 1000 patients annually. The information collected in this system provides a complete picture of the person's demographic information and characteristics, the quality and type of performance, the assessment of the degree of disability and the effect of pain on the person's moods and spirits, and the overall assessment of the person's level of satisfaction with life and the measures and interventions made for him. It provides and is the best option for obtaining information to manage pain from many aspects. These data are collected by filling in standard questionnaires that are designed electronically and usually take 20 to 45 minutes to complete in the first session before the clinic visit. After completing the last questionnaire, a report of the scores obtained by the patient in each test is provided to the doctor. The information related to the consequences and results will be obtained through the self-report of the patient in the next visits and during the follow-up process of the patient, and this system can be used in the field of research, management, and health policy-making [28].

In similar studies conducted in Iran by Zakerabasali et al. [24], Noori et al. [29], and Nasrheidarabadi et al. [14] to create a registration system similar to the current registration system, web technologies were used and most important factor of using this method is speeding up and reducing the limitation in access to information, with the difference that in the above researches, to achieve this Asp.net technology and C# programming language and SQL Server database is used for the purpose, while Oracle database and

JavaScript programming language are used in most chronic pain registration systems in other countries. In this research, the high-level PHP programming language and My SQL database, which is more compatible with this language, were used. The use of this language has caused the removal of software and hardware limitations for the implementation of this system. So that the user can easily log in to the system at any time and place through any type of device including mobile phone, tablet, laptop, and with any type of operating system such as Android, Mac, Linux, Windows, and IOS and perform the desired operation.

Eliasi also mentioned that the reason of popularity of the Oracle database in other countries is the empowerment against a large amount of information, issues of implementation, and security. On the other hand, limitations such as the lack of educational resources in Farsi, high cost of purchasing this software, high cost of software programming, and the need for foreign experts in addition to internal experts in the installation and commissioning phase [30].

Most of the above registries are web-based but implemented in different programming languages and different Database Management System (DBMS) that each one has some limitations. There are many studies for development of web-based pain registries in the world but there is a few information about technical architecture and structure in design phase. In current study, we focused on the technical architecture design of system. In the current study, Since the MYSQL database does not have the limitations mentioned about Oracle and is an open source and in other hand, it has high compatibility with the PHP programming language, it is getting more and more attention nowadays. In the current study, it was chosen to use MYSQL and the PHP programming language, which is suitable for developing the web-based system. In the design phase, Onion architecture with an MVC design pattern was selected. Using onion architecture leads to more flexible and reusable codes and results in easier development and maintenance. Finally, a web-based registry system was developed to collect and stores the information of patients suffering from chronic pain to manage and control chronic pain and facilitate future research.

### Limitations of the study and potential future developments

Because of time limitation in this study, some Suggestions for completing the study or developing it in other studies are provided:

1- Holding training workshops in order to inform and attract the participation of system users in order to increase the quality of the processes of collecting, analyzing and interpreting essential data.

2- Using the minimum data collection of the chronic pain registration system in other specialized pain centers to create uniformity in data collection and interaction between different systems.

3- The use of warning and reminder facilities in the chronic pain registration system in order to inform care providers in the field of follow-up of patients' referrals and non-receipt of care.

4- Using the results of the current research as a model to create a national registration system for chronic pain in the country.

5- Using management and information dashboards with wider facilities in the mentioned system to increase the participation of stakeholders.

6- Communicating the chronic pain registration system with the hospital information systems system and the hospital's HIS system in order to integrate information and save information registration time.

7- Designing and creating applications based on mobile phones and connecting with this system to facilitate communication for doctors and patients.

8- Designing and implementing decision support systems in the chronic pain registration system to help specialists make clinical decisions.

9- Conducting research to evaluate the chronic pain registration system in the field and to improve and develop it for use in a wider range

## CONCLUSION

In this study, the stages of web system design and development were discussed using onion architecture and MVC design pattern. According to the mentioned architectural features, their advantages were clearly seen in all aspects of the system, so we suggest using this architecture in the design phase of the web-based system.

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## AUTHOR'S CONTRIBUTION

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

## FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

## ETHICS APPROVAL

This study was approved by the researcher's institute review board at Tehran University of Medical Sciences. The approval code number was IR.TUMS.SPH.REC.1398.039.

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