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EXCHANGE OF OCCUPATIONAL HEALTH ASSESSMENT SUMMARIES BASED ON THE EN 13606 STANDARD

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The globalization of world economy stimulates large number of people to search abroad for better employment opportunities. This is the reason to consider the exchange of occupational health assessment summary (OHAS) content from cross-border view point. It is a problem of larger social-significance than the cross-border exchange for International Patient Summary (IPS). While the IPS dataset is well studied in the framework of an international standard, the OHAS remains rather insufficiently explored in the existing literature. This paper proposes a novelty systematic approach to provide a practicable solution to this problem by ensuring semantic interoperability in the exchange of OHAS. It starts by presenting a description of the use case for cross-border exchange. Next, the OHAS dataset is defined on the basis of exploring common data requirements the national legislation of EU countries. The final step of this approach is the design of an EN 13606 archetype of OHAS satisfying all the requirements for semantic interoperability in the exchange of clinical data. Further on, the static, non-volatile and reusable information model of OHAS is used to create EN 13606 instances that are valid with respect to the Reference model and the datatypes of this standard. Finally, this paper demonstrates the software implementation of basic activities in the OHAS use case in a fully functional web application, where the EN 13606 instances are managed by means of a native XML database.

Keywords: eHealth, occupational medicine, occupational health summary, use cases, semantic interoperability, EN 13606, workplace hazards, occupational disease, proactive prevention

2020 Mathematics Subject Classification: 68P05, 68-04

CCS Concepts:

• CCS∼Software and its engineering∼Software creation and management∼Software development techniques∼Software prototyping;

• CCS∼Information systems∼Information systems applications∼Enterprise information systems∼Enterprise applications

1. Introduction

One of the primary tasks of occupational health is to provide public health services for maintenance of the workers' health state by continuous health assessment of their capacity to execute the professional duties of the assigned them job position. These services aim to protect the health and well-being of employees and workers as well as to improve the productivity and quality of work [29]. It is widely recognized that the conditions in the workplace environment significantly impact human's health state and contribute to contracting illnesses caused by exposure to risk factors accompanying the execution of work activity [12]. Prolonged exposure to hazards in the workplace environment, such as interaction with dangerous chemical or biological agents, radiation or even continuous stress at work stimulates the development or progression of occupational diseases [7].

Occupational diseases, unlike other illnesses, have causal relationship with specific hazards established in the workplace environment or specific occupations. Therefore, such diseases are most often referred to as occupational diseases [23]. The International Labor Organization (ILO) acknowledges occupational diseases as a serious world-wide problem having significant burden on the economy [11,25,30]. According to public statistic data the expenses on occupational diseases are increasing every year and besides, exceed the costs spent on treating other socially significant diseases like cancer and diabetes [5,21]. The medical costs associated with occupational disease treatment appear to be quite significant. Additionally, productivity losses resulting from work-related ill health or disabilities generate another substantially larger fraction of these costs. These costs are partially covered by private and social insurance funds due for occupational disease. However, a major part of these expenses is paid by the workers and their families suffering from occupational disease. Thus, occupational diseases have many associated costs that cannot be expressed just in financial terms. These diseases impact the employee, the employer and the whole society, while recent statistical data suggest the need for improving the existing approaches and public services for prevention of occupational diseases.

A starting point for successful management and prevention of occupational diseases is the identification of these diseases. According to the ILO, there are four groups of internationally recognized occupational diseases [15]. The diseases in the ILO list are rather generally described in that list without a reference to dangerous levels of workplace hazards, duration or type of exposure allowing to establish a link between a risk factor in work activities and the observed health disorders. Besides, this list had been revised for the last time 10 years ago and the representation of occupational diseases needs to be updated in order to be used efficiently with modern information technologies. More detailed classification of occupational diseases accompanied by related descriptions of risk factors may be discovered at national level [2,14].

The increased globalization of the workforce market requires deeper harmonization of international standards, national legislation and practices aiming to achieve effective preventive and protective measures [16]. For example, the European Union

(EU) has introduced lists of indicative limit values for occupational exposure to hazardous chemical agents during work activities [8], where agents are accurately described in terms of their Chemical Abstract Service (CAS) registry number [1]. Similar EU directives establish limit values for exposure to physical hazards, biological agents as well as provisions on avoiding other risks in the workplace environment like psychological, workload, or ergonomical risks. While this approach for quantitative exposure assessment aims to ensure a safer workplace, lately employers prefer to apply a proactive approach to occupational diseases prevention. Diagnosis, early discovery and avoiding the progression of occupational diseases are in the focus of this approach. At the same time, employees often change job positions or workplaces, each one of which, impacts the employee's health in one or another way. Therefore, a proper diagnosis of occupational disease needs to take into account information from the occupational history of the employee relating quantitative exposure assessments with observed clinical symptoms and hazards in the workplace as well as conclusions from occupational health assessments for fitness to execute work activities.

Such information is usually recorded in the occupational health assessment summary (OHAS) of the employee. It is not just a single medical record, rather a summary of medical assessments accumulated during the occupational history of the worker. The OHAS is applicable in use cases similar to those of the International Patient Summary (IPS) [9]. Although OHAS and the IPS serve different purposes, both of them have similar use cases that involve exchange of clinical data both at national and cross-border level. The EN ISO 27269 [6] standard introduces a uniform structure for the IPS dataset and EN 13606 [17,18] enables semantic interoperability of IPS exchange [20, 27]. Unlike the similarity in use cases and the importance of proactive strategies for prevention of occupational diseases, currently, there is no international standard for representing the OHAS of workers and employees. This complicates a lot the development of services for sharing of information from the OHAS between the various professionals. Typically, the issues of medical confidentiality and privacy of data are underestimated in practice. Studies of existing literature sources show that only few countries have provisions in their legislation for management of occupational health assessments in relation to the occupational history of the employee or worker thus, limiting significantly the information required for decision making regarding surveillance and prevention of occupational disease disorders [10,16,26]. For example, the French Law No. 2021-1018 of August 2, 2021 makes medical records a major preventive tool in occupational health part of the French "Dossier Medical Personel" (DMP) that is equivalent to the Patient's Summary in other countries, while Decree No. 2022-1434 of November 15, 2022 specifies in particular the content and the conditions of transmission.

The focus of this paper is two-fold. The first objective is to outline the typical use cases of OHAS involving exchange of clinical data for the purpose of proactive prevention of occupational diseases. Secondly, it considers the French and Bulgarian OHAS [22, 26] in a case study aiming to demonstrate semantic interoperability in exchange of OHAS instances compatible with an EN 13606 archetype. Both the use cases and the representation of an OHAS in the reference model of EN 13606

are novelties in the existing literature, while the results from computer experiments prove that the exchange of OHAS has a practicable solution with significant number of applications in occupational health.

The structure of this paper is organized as follows. The following section describes the use cases for exchange of OHAS and the EN 13606 archetype representing OHAS according to the provisions of the Bulgarian national legislation. In section 3 we consider a typical case study for the implementation of the use cases. For this purpose we demonstrate exchange of valid instances of the EN 13606 archetype by means of a native XML database. In conclusion, we discuss the applicability of the obtained results and our plans for future research.

2. Methods

Proactive prevention of occupational diseases relies on the ability to make decisions employing clinical data collected systematically from occupational health assessments conducted during the occupational history of the employee or worker. We refer to this dataset as occupational health assessment summary (OHAS). Unlike the IPS, data entries in the OHAS are provided by occupational physicians or by health professionals from the multidisciplinary occupational health team of experts during health surveillance visits or during health assessment for job position fitness. Its structure and scope are usually established by provisions in the national legislation of each country with the primary objective of providing continuity of care and coordination of efforts in surveillance and prevention of occupational diseases. Therefore, without loss of generality we assume that management of OHAS is strictly defined by the national legislation. On the other side, the globalization of the workforce market requires taking into consideration the case of cross-border exchange of OHAS. From this viewpoint, it follows that OHAS must be also cross-border accessible both for viewing and updating content, subject to the existing norms for medical confidentiality and data privacy. The use case to communicate OHAS and its content is introduced in Subsection 2.1 as an initial step that motivates the need for the standardization of OHAS content. Apparently, this use case requires a more detailed presentation that exceeds the scope of this paper. Its description brings up the outstanding problem of semantic interoperability of clinical data in OHAS exchanges. Therefore, in Subsection 2.2 we focus the attention on building a real-life case study for semantic interoperability exchange of OHAS content [22] represented in terms of the dual reference model of EN 13606 [18].

2.1. Use case

The here considered use case describes the different ways the OHAS and its content are communicated among the occupational health agencies and participants in the international workforce market. People are free to get employed in the country of their origin (Country A) or abroad (Country B). The appointment of employees without knowledge about their occupational health background is risky, especially,

when it concerns job positions involving exposure to known hazards in the workplace environment. Therefore, in most cases of employment benefits for proactive prevention of occupational disease and also for the well-being of the worker can be gained, provided the exchanged data in the OHAS is up to date and besides, interpreted semantically correct, by the respective occupational health professional (OHP). The following use case proposes a solution to this problem. Its scope could be cross-border, national or regional.

Participants in this use case are the employee/worker, the OHP in the employee/worker's country of origin (Country A) and the OHP in the country of employment (Country B). In a particular case, Country B could designate Country A or a region of Country A when the use case scope is national or regional.

Important prerequisites for executing the functional requirements include the following observations. Different countries and even, different occupational agencies in the same country operate heterogeneous software systems and may use different informational technologies for representing the OHAS content. Moreover, OHAS content may be recorded in different languages, clinical vocabularies or measurement systems. All of it presents challenges including semantic interoperability in the practical implementation of sharing OHAS content between various professionals.

Typically, the OHAS dataset contains at least the following sections:

- A section with medico-administrative data.
- An ordered group of sections recorded during the occupational history of the employee/worker where each record contains data about:
- Workplace activities relevant to job position.
- Hazards specific to the workplace environment.
- Risks based on formal quantitative exposure assessment procedures.
- Established occupational diseases (diagnoses), documented disabilities, existence or absence of a pathology possibly linked to occupational exposure.
- Medical conclusions and medical contraindications for job position fitness.

There are two distinct versions of the use case depending on the actors involved in the exchange activities. The first version is the case when the employee/worker works occasionally or regularly in Country B, whereby he may already have an OHAS stored in Country A. This describes the Use case of the employee/worker working abroad. The second use case considers exchange of OHAS when employment occurs in the country of origin, i.e. when Country B coincides with Country A. This describes the Use case of the native employee/worker. In terms of cross-border exchange of OHAS, the first use case is the Primary use case (Figure 1).

Because of the absence of a standard for a comprehensive definition of the OHAS dataset at the EU level, the implementation of the Primary use case is accompanied by significant semantic interoperability problems. Without loss of generality we

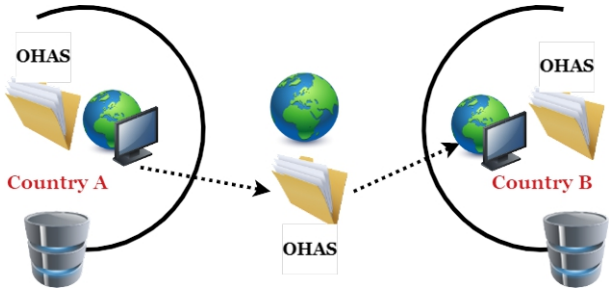

Figure 1. Primary use case for cross-border exchange of OHAS (employee/worker working abroad)

assume at this point that compliant implementations are feasible at national or regional level, although there remain serious obstacles to overcome at this level as well. Therefore, a consensus agreement is getting growing support on the need to develop an international standard allowing to overcome the semantic interrogability problems in use cases of OHAS.

Provided the use case prerequisites are satisfied, then the main activities during the exchange of OHAS content execute in the following order:

1. The employee/worker contacts an OHP in Country B.
2. The OHP is identified, authenticated and authorized.
3. The employee/worker is identified by the OHP to have OHAS data in Country A.
4. The OHP informs the employee/worker what part of the OHAS will be retrieved.
5. The employee/worker authorizes the OHP to extract and use data from his OHAS.
6. The OHP provides the employee/worker with the requested occupational health service.

An essential quality requirement in the use case execution is the correct semantic interpretation of the clinical aspect contained in the OHAS regarding language, medical diagnoses and conclusions, terminologies and vocabularies, measurement units. The following subsection proposes a methodology that transforms this quality requirement into a software solution.

2.2. Common OHAS dataset model

The standardization of both the OHAS dataset structure and contents is an essential prerequisite for achieving interoperability among the heterogeneous information systems participating in the exchange of data. In order to develop the common information model of the OHAS dataset, we reviewed the existing practices in the area of occupational health of EU countries like France, Bulgaria and

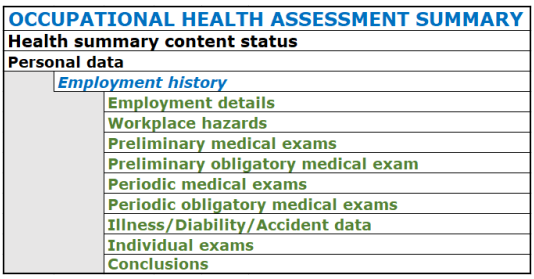

Figure 2. The major data sections of the OHAS dataset

Belgium [22, 26]. Thus, the obtained OHAS dataset is built on the data discovered typically in the national legislation of these countries, although such data are found in these documents in terms of different notations. A high level hierarchical organization of the major data sections is represented in Figure 2.

The root of this hierarchy contains data fields describing the identity of the employee/worker in terms of Personal data (identity code, names, local address and general practitioner contact details) and a conditional field (health summary content status) controlling access to this dataset (Health summary content status). An ordered list below this root is used to store the Employment history where each record of the Employment history has nine sections of data:

Employment details. It is a required section with data fields describing the employer's contact details, job position and the period for employment of the employee/worker.

Workplace factors for health disorders. This section has a brief description of the job activities and a list of the factors in the workplace environment that might cause health disorders. There are several internationally recognized factors such as noise, vibrations, lightning at the workplace, dust, chemical agents, biological agents, ionizing and nonionizing radiation etc. The levels of these factors at the workplace are qualified as Recommended exposure limits, Threshold limit values (close to the upper recommended exposure) or Immediately dangerous to life limit values (significantly exceeding the recommended exposure) [8]. With respect to exposure duration each such factor is identified as long-term (repeated exposure) or short-term (accidental exposure). The development of a common job classification system relating job encodings to known hazards in typical workplace settings would provide a standardized framework for cross-border interoperability in management of this kind of data.

Preliminary medical exams. These exams are represented in **two sections**, a section for obligatory or a section for nonobligatory preliminary exams. The obligatory exams are done by a commission of experts in occupational health and concludes with a statement for fitness to execute job activities or to be exempted from executing certain activities, while the nonobligatory exams are done by a single occupational health professional who issues a diagnose confirming or rejecting an occupational disease. These sections of OHAS make references to diagnoses and symptoms for occupational diseases.

Periodic medical exams. Data about the periodic exams is recorded at regular intervals during the employment of the employee/worker. Similarly by content to the preliminary medical exam sections, there are **two separate sections** dedicated to recording periodic nonobligatory and periodic obligatory exams.

Illness/Disability/Accident data. This section records documented events of this nature registered during the employment period.

Individual exams. This section contains records about medical exams undertaken by the employee/worker himself.

Conclusions. This section contains records of positive/negative conclusions about the ability to execute job activities done by commissions on occasions different than obligatory preliminary and periodic exams.

It is noteworthy, that the composition of the OHAS dataset shown in Figure 2 can be extended to a folder of OHAS generated in a single country. Thus, in the implementation of the primary use case in Subsection 2.1, one folder can be dedicated to store OHAS data composed in Country A and eventually, multiple folders for representing compositions of OHAS data in case of employment in a set of countries referred to as Country B in that use case.

2.3. OHAS archetype in EN 13606

Unlike other application domains, the healthcare domain requires clinical data to be exchanged together with the semantic context in which the data values are created and remain valid. The correct interpretation of the semantic context in the OHAS dataset is vital for the evaluation of the worker's health state, determining a diagnosis or identifying symptoms for related complications and, in particular, for proactive prevention of occupational diseases. Therefore, the implementation of the use case for exchange of OHAS must rely on standards and technologies supporting the application of common vocabularies and terminologies for representing the semantic context in the process of communication between different computer systems. The most notable example for such a standard is EN 13606 [17, 18].

EN 13606 is a complete international standard for semantic interoperability in the exchange of extracts of electronic health data such as OHAS. This standard uses a dual architecture model and object oriented technologies, combining a static Reference information model (RM) with an Archetype object model (AOM) quite similar to those discovered in the openEHR specification [24]. The classes in its reference model, shown in Figure 3, are employed to represent the non-volatile structure of clinical concepts, while the archetype model serves to express specific knowledge constraints on instances of the underlying reference model [4].

In contrast to the alternative implementation of this approach in FHIR [13], all the EN 13606 archetype instances are validated against one and the same RM. Additional advantages of EN 13606 archetypes are their support for visualization, composition, specialization and redefinition, enabling reusability and participation of clinical domain experts in their development. Updating clinical content in EN 13606 requires no change in the RM rather adding new or extending existing archetypes.

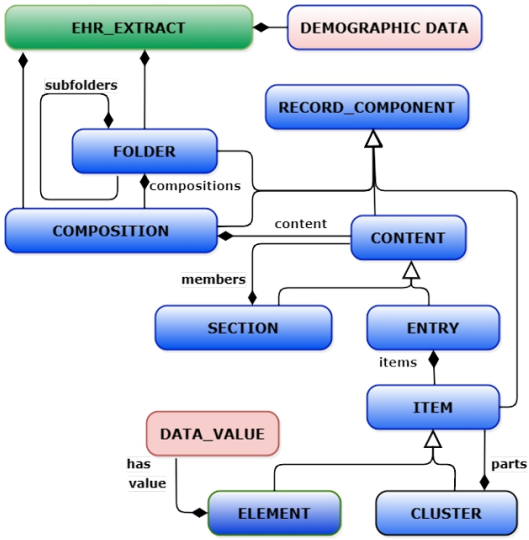

Figure 3. UML class diagram of the EN 13606 Reference model

In FHIR it means the development of new software for each new resource. Therefore, the EN 13606 standard is selected in this paper as the primary means for building a long-term open health platform for cross-border exchange of OHAS.

The EN 13606 archetype of the OHAS shown in Figure 4 allows to accurately represent the constraints in the clinical domain that are discovered in the use case described in Subsection 2.1. It is a COMPOSITION archetype developed employing LinkEHR Studio [19, 28]. The archetype is composed of an ENTRY for Personal data and a SECTION holding the Employment history. The Employment history is represented in terms of an ordered sequence SECTIONs with ENTRY datatypes describing the employment from the occupational health perspective outlined in Subsection 2.2.

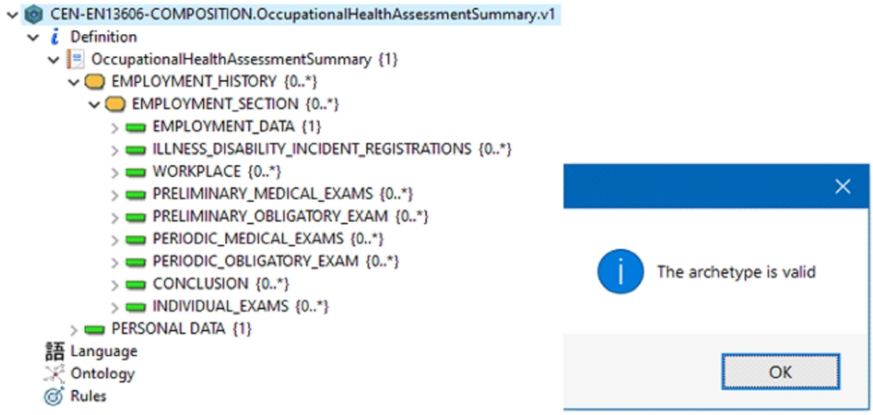

Figure 4. The EN 13606 archetype of OHAS

An important feature of LinkEHR Studio is that it allows to validate the archetype with respect to the RM datatypes of EN 13606 as well as in relation to the datatypes of the AOM. These are two kinds of datatypes that serve different purposes.

The purpose of the AOM datatypes is to wrap attributes and values of the RM datatypes with properties allowing to impose on them constraints discovered in the application domain. Besides, both kinds of datatypes are expressed in terms of primitive XML datatypes like Integer, Real, String, Boolean or Date/Time/DateTime employing the respective XML schemes accompanying the EN 13606 standard.

Important constraints that are directly related to achieving semantic interoperability of OHAS in the clinical domain (occupational health) are bindings to systemized nomenclatures as SNOMED-CT (Figure 5), international classifications of diseases as ICD-10, encodings of hazardous factors in the workplace environment or measurement system standards for identification of units used to describe quantitative exposure assessment values. Other examples are the cardinality constraints in AOM on instances of classes from the RM, shown in curled brackets in Figures 4 and 5, or using regular expressions, assumed and default values for controlling the intended clinical meaning of values stored in the instances of that archetype.

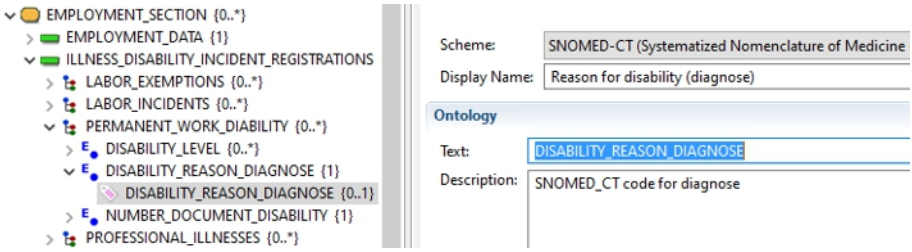

Figure 5. Binding diagnoses to SNOMED-CT in the OHAS archetype

3. Results

The creation of valid instances of EN 13606 archetypes is an essential requirement for using the archetypes in practice. It is common to obtain these instances in XML format. Besides, the archetype instances must be valid with respect to the XML scheme of classes and datatypes in EN 13606 like EN 13606-RM.xsd depicted in Figure 6. Unlike openEHR, building instances of EN 13606 archetypes is not a straightforward process because it involves the development of custom software utilities. Note that validating the archetype instance by taking in consideration just the primitive datatypes in the XML standard does not make it a valid EN 13606 instance. This difficulty appears to be one of the major obstacles for a broader recognition of EN 13606 in exchanging extracts of electronic health records.

Another important decision is the choice of the platform for management of the EN 13606 instances of the OHAS archetype like the one displayed in Figure 6. At

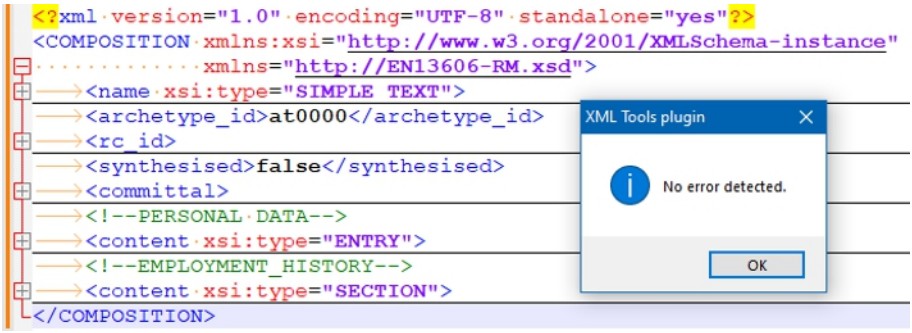

Figure 6. Archetype instance of OHAS validated against EN 13606 classes and datatypes

this point ,we can take advantage of the proven validation of the archetype instance against the XML scheme of the EN 13606 standard RM and employ as a platform a native XML database like BaseX [3].

This database provides access to data stored in XML format through RESTful web services. Besides, management of XML data is done in terms of XQuery as a substitute for the absence of support for a query language in EN 13606. The static non-volatile nature of the OHAS archetype translates to static non-volatile structure of all the instances of that archetype. Therefore, likewise the EN 13606 archetype, the XPath-s in XQueries are also reusable. It allows to create a stable API for management of XML data in native XML databases.

In order to prove this concept, we have developed a three-tier application comprising BaseX, an Apache 2 web server and a desktop client application. The application demonstrates the execution of the main activities in the OHAS use case such as exporting and storing valid EN 13606 instances of OHAS. Figure 7 demonstrates a case study for management of real-life data by means of RESTful web services for accessing OHAS instances stored in BaseX.

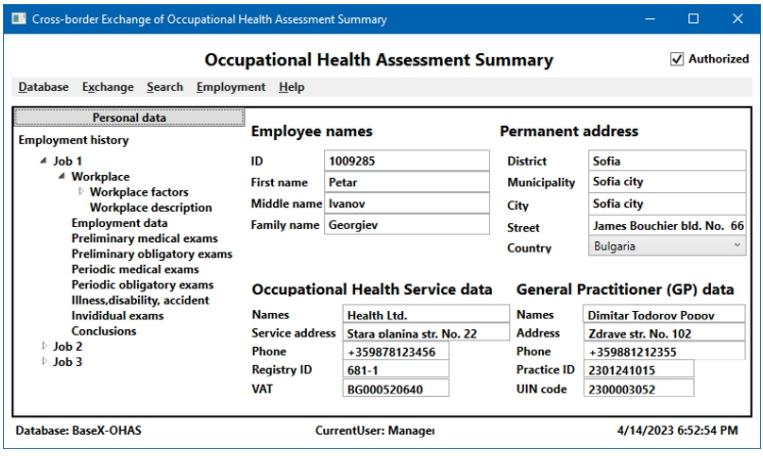

Figure 7. Case study: Data management of exchanged EN 13606 instances of OHAS

4. Conclusion

The exchange of OHAS is essential requirement for proactive prevention of occupational diseases as well as for ensuring the health of employees/workers in executing job activities. Exercising professional activities in most cases is accompanied with the development of occupational diseases that in certain cases lead to disabilities. Treatment of occupational disease costs a lot to the industry, the national budget and above all, causes sufferings and loss of jobs. Therefore, regular medical exams and early discovery of symptoms is a key prevention strategy. Apparently, changing workplaces might cause deterioration of worker's health, provided records from previous medical exams are not taken into consideration, especially, when the employee has been exposed to harmful health factors in former workplace environments. The purpose of OHAS is to reduce the uncertainty in making decisions about fitness to execute job activities or in evaluating the health state of the employee/worker.

The globalization of world economy stimulates a large number of people to search abroad for better employment opportunities. This is the reason to consider the exchange of OHAS content from cross-border view point. It is a problem of larger social-significance than the cross-border exchange for International Patient Summary (IPS). The IPS standard concerns most of all people travelling abroad, while the OHAS affects all the employed people. While the IPS dataset is studied better within the framework of an international standard, the OHAS remains rather insufficiently explored in the existing literature.

This paper proposes a novelty systematic approach to provide a practicable solution to this problem by ensuring semantic interoperability in the exchange of OHAS. A description of the use case for cross-border exchange is pre3sented. Next, the OHAS dataset is defined on the basis of exploring common data requirements the national legislation of EU countries. The final step of this approach is the design of an EN 13606 archetype of OHAS satisfying all the requirements for semantic interoperability in the exchange of clinical data. Further on, the static, non-volatile and reusable information model of OHAS is used to create EN 13606 instances that are valid with respect to the RM and the datatypes of this standard. Finally, this paper demonstrates the software implementation of basic activities in the OHAS use case in a fully functional web application, where the EN 13606 instances are managed by a native XML database.

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