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Feasibility of maternity record standardization on the example of midwives' free text entries

Master's thesis

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Rasedakaardi standardiseerimise teostatavus ämmaemandate vabateksti sissekannete näitel

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Author's declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

Background: The Paper Maternity Record has been a successful and essential tool in maternity shared-care environment. In Estonia, prenatal documentation in healthcare institutions is duplicated in electronic and paper-form. Electronic Maternity Records are commonly hospital based and the information can only be accessible by healthcare specialists of that specific hospital during pregnancy. Nevertheless, information and data about pregnancy is not made available in ENHIS during pregnancy, as no valid standard exist for pregnancy information, which is the reason why data during pregnancy is not sent to Estonian National Health Information System.

Aim: The aim of the thesis is to investigate feasibility of standardizing the electronic maternity record in the form of structuring midwives free text entries using the programming language Grammatical Framework and The Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT).

Method: Action research method was used which included three different parts. For the practical experiment, an analysis was first performed, in which three sentences were selected based on the free text entry templates of midwives to be structured. This was followed by a practical experiment, where midwives free text entries were structured with Grammatical Framework and SNOMED CT and thirdly, a questionnaire was conducted to receive feedback from midwives on practical experiment testing the prototype.

Results: As a result of the analysis, three sentences about hemoglobin, fetal movements and complaints were selected. The sentences were structured using Grammatical Framework and Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT). This was followed by a practical experiment in which midwives were asked to fill a questionnaire and try a prototype for entering sentences in a structured form. The results of the questionnaire showed that midwives are rather satisfied with the existing duplicated maternity record solution but consider real-time data exchange with other healthcare professionals important and the prototype for entering sentences in a structured form would be beneficial in documenting entries during pregnancy.

Conclusion: Midwives are ready to use modern systems and it can be concluded that the standardization of the maternity record with programming language Grammatical Framework and The Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) is feasible but needs further research and analysis. In order to reach a solution that benefits more people, the results of this study need to be broadened with research and development on national level, involving more midwives, hospitals and national stakeholders.

This thesis is written in English and is 65 pages long, including 5 chapters, 22 figures and 3 tables.

Annotatsioon

Rasedakaardi standardiseerimise teostatavus ämmaemandate sissekannete näitel

Paberkandjal rasedakaart on olnud edukas ja hädavajalik vahend raseduse jälgimisel. Rasedusaegne dokumentatsioon Eesti tervishoiuasutustes on duplitseeritud elektrooniliselt ja paberkandjal. Elektroonsed rasedakaardid on tavaliselt haiglapõhised ning raseduse jooksul on raseda andmetele ligipääs ainult selle konkreetse haigla tervishoiutöötajatel. Sellest hoolimata, ei tehta raseduse ajal teave saadavaks tervise infosüsteemis, sest rasedakaardi teabe kohta pole kehtivat standardit, mis on ka põhjus, miks raseduse ajal kogutud andmed tervise infosüsteemi ei jõua.

Käesoleva magistritöö eesmärk on uurida rasedakaardi standardiseerimise teostatavust, struktureerides ämmaemandate vaba teksti sissekanded, kasutades programmeerimiskeelt Grammatical Frameworki-i ja The Systematized Nomenclature of Medicine – Clinical Terms-i (SNOMED CT-d).

Magistritöös kasutati tegevusuuringute (*action research*) meetodit, mis hõlmas kahte erinevat osa. Praktilise eksperimendi jaoks viidi läbi esmalt analüüs, kus ämmaemandate vabateksti sissekannete põhjade alusel valiti välja kolm lauset, mida eksperimendi käigus struktureerida. Sellele järgnes praktilise eksperimendi läbiviimine ämmaemandate vaba teksti sissekannete struktureerimise näol kasutades programmeerimiskeelt Grammatical Framework-i ja The Systematized Nomenclature of Medicine – Clinical Terms-i (SNOMED CT-d). Praktilise eksperimendi järgselt viidi läbi küsimustik ämmaemandate seas, kus ämmaemandatel paluti proovida lausete sisestamist struktureeritud kujul Grammatical Framework-i prototüübiga.

Analüüsi käigus valiti välja kolm lauset hemoblogiini, looteliigutuste ja kaebuste kohta, millele järgnes lausete struktureerimine Grammatical Framework-i ja The Systematized Nomenclature of Medicine – Clinical Terms-ga (SNOMED CT-ga). Küsimustiku tulemused näitasid, et ämmaemandad on hetkel olemasoleva duplitseeritud rasedakaardi

lahendusega pigem rahul, kuid peavad reaalajas andmete vahetust teiste tervishoiutöötajatega oluliseks ning praktilise eksperimendi käigus proovitud prototüübist oleks neile kasu sissekannete kirjutamisel ning raseduse andmete dokumenteerimisel.

Ämmaemandad on valmis kaasaegseid süsteeme kasutama ning võib järeldada, et rasedakaardi standardiseerimine GF-i ja SNOMED CT abil on teostatav, kuid vajab täiendavat edasi uurimist ja analüüsi. Selleks, et jõuda lahenduseni, mis on kasulik laiemale hulgalge inimestele, tuleb riiklikul tasandil läbi viia ulatuslikum uurimis- ja arendustegevus, hõlmates rohkem ämmaemandaid, haiglaid ja riiklikke sidusrühmi.

Lõputöö on kirjutatud inglise keeles keeles ning sisaldab teksti 65 leheküljel, 5 peatükki, 22 joonist ja 3 tabelit.

List of abbreviations and terms

PMR   Paper Maternity Record

EMaR   Electronic Maternity Record

HWISC   Estonian Health and Welfare Information System Centre (TEHIK)

ENHIS   Estonian National Health Information System

GF   Grammatical Framework

SNOMED CT   Systematized Nomenclature of Medicine – Clinical Terms

EHR   Electronic Health Record

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INTRODUCTION

One of the biggest challenges in the organization of modern healthcare is to reduce the fragmentation of digital information collected about the patient in the exchange of information between different healthcare institutions. It is often difficult for a physician to get an overview of a patient's condition, since the data is in different databases and the doctor or other healthcare specialist has to log in to several information systems to view it [1].

The Paper Maternity Record (PMR) has been a successful and essential tool in maternity shared-care environment. The implementation of the Electronic Maternity Records (EMaR) aims to reduce the effort required for data transmission and access by involved healthcare professionals, as well as to minimize the rate of errors due to missing information in the clinical decision-making process. The patient's ability to relocate to various healthcare providers and institutions is resulting in a highly dispersed collection of data and a greater need for data exchange [2], [3]. Many countries, such as Finland, England and Australia have taken the first steps in developing and implementing EMaRs at national level [4], [5], [6].

The Estonian Health and Welfare Information Systems Centre (HWISC) has developed and is responsible for a central environment for publishing medical classifications and standards, which are necessary to compile and forward summary documents to the Estonian National Health Information System (ENHIS) [7]. In Estonia prenatal documentation in healthcare institutions is duplicated in electronic and paper-form, one of which is in the hospital and another in the hands of a pregnant woman. Paper-form document PMR, is formalized by the healthcare professional monitoring the pregnancy, from the date of registration of the pregnancy, and is carried by a pregnant woman throughout the pregnancy [8]. Although PMRs are useful, they have been shown to have several shortages, including deficient accessibility, easy to lose and they may contain inconsistent information. The electronic form of prenatal documentation, EMaR, is formalized by the healthcare professional monitoring the pregnancy from the date of

registration of the pregnancy and the form is chosen by the healthcare provider. EMaRs enable obstetricians, midwives and other healthcare specialists to exchange pregnancy data and therefore provide more efficient prenatal care [8], [9]. Nevertheless, EMaRs are commonly hospital-based and the information is accessible only to healthcare specialists of that specific hospital during pregnancy.

Midwives have a professional, legal and ethical responsibility to profoundly and precisely record the care provided, hence, the midwifery documentation is multi-dimensional and complex [10]. In Estonia, midwives are responsible for documenting pregnancy visits on PMR and into EMaR in the hospital's information system and the structure of documentation varies according to the hospital's regulations. Notwithstanding that the data composition of maternity record is set out in legal acts, no national digital solution in Estonia for EMaR has yet been developed. Maternity hospitals in Estonia use their own EMaR forms and no information is sent or made available in the ENHIS during pregnancy. There is no valid standard for sending pregnancy information to the ENHIS.

The aim of this thesis is to investigate feasibility of standardizing the electronic maternity record in the form of structuring midwives' free text entries in maternity record using Grammatical Framework (GF) and The Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT). GF is a programming language for grammar-based applications and SNOMED CT is a tool for translating clinical information into a computer-readable form [11], [12]. For the master's thesis, the author aimed to choose the tools to structure the free text entries of midwives and therefore GF and SNOMED CT were selected.

The thesis is divided into five chapters. The first chapter addresses the digitalization processes of EMaR, the EMaRs in other countries and in Estonia, health information exchange principles in Estonia, the role of midwives and importance of documentation and principles of GF and SNOMED CT. The second chapter describes the aim and sub-aims of the thesis. The third chapter explains method and materials, proposing specific tools for structuring midwives' free text entries and describing the principles and participants of the questionnaire. The fourth chapter gives an overview of performed research results to understand the feasibility of standardizing the maternity record and suitability of the proposed tools. The fifth chapter discusses the results, limitations and suggestions for further research.

1 THEORETICAL BACKGROUND

This section explains the overview of digitalization processes of EMaR and the EMaRs in other countries and in Estonia. In addition, principles of health information exchange principles in Estonia, the role of midwives and importance of documentation and principles of GF and SNOMED CT are described.

1.1 Overview of maternity record digitalization processes

The following subsection describes in general the trends of maternity record digitalization processes.

Increasing usage of e-health, including electronic health records (EHRs) and internet-based health awareness, has made information available online by healthcare professionals and patients an essential foundation of today's delivery of healthcare. Internationally a lot of effort has been made evaluating the adoption of EHRs in several health settings. Standardization of processes, promotion of evidence-based practice, safety and security, usability, reduction of workload and using less paper records have all been key components in the implementation processes. The EHRs significantly improve the quality and timeliness of available health information and are beneficial for healthcare providers to enhance clinical information sharing [13], [14].

During pregnancy, women are able and have a free choice of visiting several healthcare professionals and institutions to monitor the growth and development of the fetus and the pregnant woman's health. During examinations, entries are made in the medical record of the pregnant woman and the fetus and a summary of relevant data is written on the maternity record. The PMR has been a successful and essential tool in maternity shared-care environment. The PMR is issued by the healthcare professional from the date of registration of the pregnancy and is advised to be carried by the pregnant woman throughout the pregnancy. The PMR remains the primary source of information in a maternity shared-care environment and has many beneficial features but since the information is written in free text, it may not be retrieved efficiently if the PMR is missing

or not available to several healthcare professionals concurrently. In addition, the disadvantages of the PMR are poor readability and unavailability in emergency situations [2], [3].

The implementation of the EMaR aims to reduce the effort required for data transmission and access by involved healthcare professionals, as well as to minimize the rate of errors due to missing information in the clinical decision-making process. The ability to relocate to various healthcare providers and institutions is resulting in highly dispersed collection of data and a greater need for data exchange. An EMaR enhances data exchange and availability among different healthcare professionals and institutions. Having relevant clinical data accessible as required is a critical component of integrating clinical care across different institutions and healthcare providers. Accessibility to accurate, reliable and up-to-date information is fundamental for enhancing patient and healthcare coordination and patient safety [2], [3]. In the interest of exchanging and comparing the information, standard data descriptions and structures are essential for producing data in maternity care. Standardization supports semantic interoperability, or the capability of data to be exchanged across various healthcare information technology systems. The need for standardization to obtain consistent data integration between various healthcare providers must be acknowledged. Customizing the EHR systems that would benefit a single group of interest leads to communication issues and lack of care coordination, which are not beneficial to the patients. The use of standard data elements and validated definitions enables a common language and facilitates data exchange [15].

Hawley et al [2] carried out a study in Australia with the aim to describe and compare completeness of recorded information in the PMR and EMaR. Neither the PMR nor the EMaR had full recording of variables, reflecting a clear lack of best practice guidelines for prenatal care. Nevertheless, a comparison of the two types of recording showed a significant advancement in the completeness of the data collected using the EMaR. The study found that PMR variables were entered unsystematically, resulting in inconvenient information retrieval, both from the main PMR data fields and the free text fields. PMR has been recognized as a valuable tool for data exchange between pregnant women and healthcare professionals, but the study indicates concerns in the quality of important prenatal information, that PMR is intended to include. EMaRs improved the completeness of documented prenatal records, with meaningful improvements in important examinations, such as prenatal examinations and Glucose Tolerance Tests results. EMaRs

offer an opportunity for different healthcare professionals to acquire more comprehensive access to prenatal records, although the availability of data fields to reflect all best practices, may be short-lived if they are not programmed into the system, as the study showed [2].

1.2 Digital maternity records in other countries

1.2.1 EMaR in Finland

In Finland, the PMR has been replaced by an EMaR called IPana Maternity. It contains the same information in electronic form and enables data retention as well as real-time data transfer between pregnant woman and hospital. The EMaR service includes pre-service questionnaires, information about pregnancy with timelines, home measurements and electronic messaging with the clinic. Real-time data transfer is expected to lead to more reliable data and double entry is eliminated through the integration of the patient information system [4].

The pregnant woman can record their home measurements and monitoring in EMaR that are visible for healthcare professionals. Home monitoring includes blood glucose, blood pressure measurements, medication intake, food, and exercise diaries. Through the EMaR service, the healthcare professional can comment on patient outcomes and provide instructions for follow-up treatment without remote consultation or telephone connection. Aforementioned functions make the service more patient-centred, and if necessary, risk groups can be monitored more closely as well as more often. The aim of the EMaR service is to support the waiting time of a pregnant woman and expand e-services and data transfer possibilities between pregnant woman, clinic, and maternity hospital. IPana Maternity enables comprehensive pregnancy monitoring where there is no interpretability of the data and no risk of data loss or distortion. The expectant mother recognizes the entries made by healthcare professionals by different color codes. IPana Maternity is free of charge and can be used from any device, including mobile phones [4], [16].

1.2.2 EMaR in England

In England, an EMaR "The Women's Digital Care Records" has been implemented by NHS Digital and NHS England as a part of Digital Maternity Interoperability program. The aim of The Women's Digital Care Records was to provide an interoperable maternity

record with access to comprehensive digital sources of information and to enable a more personal approach to the pregnant women. Furthermore, a digital tool or personal health record that connects with EMaRs will be provided so that women can access their data and receive individualized information. The availability of technological solutions for women, families, and professionals, particularly outside of the hospital setting, is critical to providing the best care possible. The first phase of implementing Digital Maternity Interoperability started in 2018 and involved the development of agreed standards, that enables all maternity hospitals systems to systematically capture the data understandable and retrievable for all important parties. Secondly, standard terminology within the EMaR needed to be validated to ensure that different systems can share and interpret the information in the record (using SNOMED CT terminology and Fast Healthcare Interoperability Resources – FHIR). Consequently, that facilitates healthcare professionals and women to have access to a standardised set of paperless EMaRs. Lastly, development of interoperability allows healthcare professionals to search for and retrieve maternity records in settings where EMaRs are available at the point of service. "The Women's Digital Care Records" aims to offer all pregnant women in England the access to their digital care records by the year of 2023/24 [5], [17].

1.2.3 EMaR in Australia

Australian Government and Australian Digital Health Agency are leading the development and delivery of National Digital Pregnancy Health Record. Strategic targets for implementation include digitally enabled care models that promote accessibility, quality, safety, and efficiency. The intention of the Digital Pregnancy Health Record is to create a nationwide digital version of paper-based pregnancy records that are shared between pregnant woman and healthcare professionals to increase the ability to migrate between different healthcare providers. The availability of all necessary information at the point of service improves overall safety and quality of care. [6], [18].

1.3 Health Information Exchange in Estonia

The e-health system has been developed in a way that the state develops a central database and applications, and each healthcare provider develops the information system of its own institution at its own discretion. According to both, Estonian hospitals and the Estonian Society of General Practitioners, fragmentation is detrimental to the functioning of the e-

health system. The summaries entered in the health information system are visible to healthcare professionals as separate documents and therefore it is difficult to get a quick overview of the patient's state of health and there is also duplication of data entries. The physician does not have the opportunity to obtain an overview of the patient's vital signs, risk factors and the test results in a time series that would provide a quick overview of the patient's condition change. Finding information is still inconvenient and time-consuming for physicians and data is sometimes incomplete. The possibilities of displaying and sorting the data of the health information system depend to some extent on the development of the hospital information system, but most of all on the basic data sent to the information system. If they are structured and machine-readable, then it is possible to create automatic summaries in the system and reduce the need to search information manually [19].

ENHIS, established in 2008, managed and developed by the Estonian Health and Welfare Information Systems Centre (HWISC), is a cooperation model of the health sector covering various solutions, an important part of which is the database belonging to the state information system. ENHIS is a central national database through which healthcare providers can exchange and access health data sent about the patient by other service providers. The data in the ENHIS is also visible to the patient itself via the patient portal (*Digilugu*). It is mandatory for healthcare professionals to follow the documentation requirements, use the classifications, manuals and health information system standards defined in the state information system, when documenting the provision of healthcare services. The main task for HWISC is to provide up-to-date information on health information system standards and classifications used in the ENHIS [7], [20], [21].

The expectations for a new ENHIS stand for, that instead of the existing local databases, the updated ENHIS should be turned into the main work environment for the healthcare professionals, to which healthcare institutions integrate through interfaces using common standards. All entries should be visible immediately to healthcare professionals of the same patient throughout Estonia. There is a need for an efficient and flexible search and query capability across different entries, time frames and data fields. The new generation ENHIS should become the primary and main work environment for the healthcare professionals, where all collected health data about the patient would be stored and used in real time and the collected data must be actively systematized and presented [22].

1.4 Overview of maternity record in Estonia

In Estonia prenatal documentation in healthcare institutions is duplicated in electronic and paper-form. The prenatal documentation must be provided in at least two copies, one of which is in the hospital and another in the hands of a pregnant woman. Paper-form document, PMR, is formalized by the healthcare professional monitoring the pregnancy, from the date of registration of the pregnancy, and is carried by a pregnant woman throughout the pregnancy. The electronic form of prenatal documentation, EMaR, is formalized by the healthcare professional monitoring the pregnancy from the date of registration of the pregnancy and the form is chosen by the healthcare provider [8].

The data composition of maternity record is regulated with the act of "Conditions and procedure for documenting the provision of healthcare services" (*Tervishoiuteenuste osutamise ja dokumenteerimise tingimused ja kord*) [23] and the prenatal record requires to include the information that is described below.

The following information shall be entered into maternity record:

- information of a healthcare service provider;
- information about patient's personal data;
- information concerning the father of the child;
- information on previous pregnancies and childbirth;
- information concerning registration of pregnancy;
- information about each visit during pregnancy;
- information about tests and examinations, the frequency of which are set out in the Pregnancy Monitoring Guideline [23].

In addition to the above, consultations of other doctors and specialists are entered on maternity record: general practitioner, internal doctor, ophthalmologist, dentist, psychologists, and others. The data of the gravidogram are entered on maternity record: biparietal size (mm), height of the uterus (cm). The following data for monitoring vaginal status is entered in maternity record: the date, week of pregnancy and a description of the finding. The maternity record includes treatments, doctor's orders and recommendations for the pregnant woman. The date of birth, sex of the child, body weight (g), height (cm) and Apgar grade are entered on the maternity record. The maternity record also contains

information on counselling regarding the registration of a pregnant women, during the first, second and third trimesters of pregnancy [23].

In cooperation with the Estonian Association of Midwives and the Estonian Society of Gynecologists, improved PMR was issued in 2014, the use of which is recommended in all institutions monitoring pregnant women. The women-held PMR consists of the following segments: personal information about pregnant woman and the father of the child; pregnancy information, examinations and laboratory test results; risks of pregnancy and childbirth, comorbidities and treatment history; previous pregnancies, childbirths, postpartum period, course and complications of breastfeeding; monitoring during pregnancy; ultrasound specification and gravidogram; examinations, consultations, outpatient treatment and certificate of incapacity for work; inpatient treatment summaries; pregnancy and birth plan; notes; scheduled visits and important contacts; information about healthcare institution and service provider [24].

The Pregnancy Monitoring Guideline (*Raseduse jälgimise juhend*) is the treatment guideline of the Estonian Society of Gynecologists, which was adopted in 2011 and approved by the board of the Estonian Society of Gynecologists, the Estonian Association of Midwives and the Estonian Society of General Physicians. The purpose of the guideline is to ensure that all pregnant women receive uniform principles and evidence-based pregnancy monitoring in Estonia. The guideline provides recommendations for monitoring normal pregnancies by encouraging collaboration between different service providers [25]. The guideline provides principles of monitoring normal pregnancy:

- the effect of factors influencing the course of pregnancy;
- physiological changes in the woman's body during pregnancy and possible problems arising therefrom;
- counseling during pregnancy;
- recognition of conditions requiring medical intervention and initial treatment;
- timing and recommended content of prenatal visits [25].

Documentation of prenatal visits and data is largely duplicated. In the EMaR, the same data points and results are written in different fields and in addition, the information is also entered on the PMR. Furthermore, documentation includes making entries in EMaR about every visit in written free text form.

There is no nationwide EMaR in Estonia, that is standardized, usable in all hospitals and clinics and what enables real-time data transfer to the ENHIS. East-Tallinn Central Hospital implemented a pregnancy application in 2018 that allows pregnant woman to monitor their pregnancy, get information about changes during pregnancy, prepare for the birth and record all observations related to pregnancy. The data must be entered into the application by the pregnant woman herself and it is not compatible with the HIS or ENHIS [26].

1.5 The role of midwives and importance of documentation

Midwifery and midwives' work overall play a vital role in pregnancy planning, pregnancy, childbirth, and motherhood. The midwife has the necessary knowledge and skills in social sciences, public health and ethics, which is a basis for providing high-quality and culturally appropriate care for women, newborns and expectant families [27].

Midwives have a professional, legal, and ethical responsibility to profoundly and precisely record the care provided, hence, the midwifery documentation is multi-dimensional and complex. Midwifery documentation provides a concurrent and retrospective record of experience, detailed sequence of events and clearly explains the pregnant woman's care plan. In the interest of providing the best care for patients and to improve the transfer of data between different institutions, healthcare professionals need to develop and use contemporaneous medical records that would provide a platform for communication. Clear and effective record-keeping, along with the needs of the pregnant woman and the child contributes to the experience and safety of the patients, precise auditing processes, clinical reviews and promotes the investigation of the provision of care at individual, departmental, hospital and national levels. Reviews of critical clinical occasions additionally support the service development and demonstrates accountability and transparency in service provision. Keeping and making entries in medical records provides midwives an overview of potential courses of action and consider the most relevant care plan for the pregnant woman. Therefore, healthcare professionals understand the circumstances and clinical conditions of the pregnant woman that would provide possibility of effective individualization of services [10].

In Estonia, midwives are responsible for documenting pregnancy visits on PMR and EMaR in the hospital's information system, as a routine activity and the structure of documentation varies according to the hospital's regulations.

In 2012 and 2015, the audit of "Quality of Independent Prenatal Midwifery Care" was performed in cooperation with the Estonian Health Insurance Fund and the Estonian Association of Midwives. The purpose of the audits, among others, was to list the shortcomings that appear in the documentation of prenatal monitoring information. The first audit in 2012 revealed that most institutions have prenatal documentation in duplicate (electronic and paper-forms). The audit determined that the duplication of documentation is not practical as it is time consuming, causes inaccuracies and differences in entries. In addition, the audit revealed that information about prenatal status is troublesome to find, poorly monitored and analyzed and does not improve the quality of the system. The audit results also brought up the detail that there is missing or incomplete prenatal monitoring summaries [28], [29]. Following the audit, changes were made to the PMR and the data composition was systematized. All service providers were advised to introduce an updated and improved PMR. A comparative analysis of the results of previous audit in 2015 showed, that the quality of prenatal documentation in the provision of midwifery services has improved. The audit proposed that during the development of digital solutions related to the states healthcare system, the Ministry of Social Affairs and the Estonian Hospital Association must create systematized prenatal electronic documentation and support the introduction of a unified system in all institutions providing prenatal monitoring services [29].

Nevertheless, such changes have not been made yet, the information is not sent and made available in ENHIS during pregnancy and midwives still have a large amount of the documentation in the form of free text. Furthermore, there are no valid standards for documenting and transferring prenatal data to ENHIS.

The document of the Estonian Nursing and Midwifery Development Strategy 2021–2030 points out the lack of a unified electronic evidence-based documentation as one of the problems. The development strategy proposes a creation of nationwide electronic midwifery documentation, consisting of the development and implementation of a digital solution for evidence-based documentation and to support the development of a user-friendly interface for building information systems. The expected result of these functions

are measurability and visibility of midwifery activities based on standardized electronic documentation and evidence-based midwifery language, as well as implementation of a user-friendly digital solution which is integrated with multiple systems [30].

1.6 Grammatical Framework (GF)

Grammatical Framework (GF) is a functional programming language for developing multilingual applications and controlled natural languages. The GF development started in 1998 with the intention to achieve productive building of controlled-language translators and multilingual authoring systems. Typical applications are in natural language generation, dialogue systems, machine translation or the question-answering systems, where a limited coverage of language can be expected. In such scenarios it is possible to design a controlled language that can be effectively covered with formal grammar. A typical application development begins with identifying the relevant data subjects and outline the specified variables within that data subject in different languages. Every grammar is divided into an abstract syntax and one or more concrete syntaxes. An abstract syntax represents what is being expressed by defining the parts of logical sentences and the relationships and functions of those parts, and a concrete syntax represents how the logical sentences are being expressed in terms of specific language (either human or technical languages) [11], [31].

1.7 Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT)

Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) is a tool for translating patient clinical data into a computer-readable form, which has the largest list of clinical terms in the world, containing 350,000 terms and about 1,000,000 relationships between the concepts. SNOMED CT is the most detailed and reliable multilingual health terminology in the world, which supports with the electronic exchange of information about clinical health. SNOMED CT fills the need for consistent exchange of clinical information by allowing semantic interoperability and facilitating the sharing of scientifically validated health data between various healthcare providers, researchers and others [12], [21], [32].

Information technology tools consisting of clinical nomenclatures and classifications are being developed for the systematization and computer processing (coding) of the huge amount of data generated during treatments. The term nomenclature refers to a set or a list of terms. Clinical nomenclature is a set of terms describing the most detailed possible data for electronic medical records. The purpose of using clinical nomenclatures is to combine the richness of the nuances of free text expression traditionally used in medical history with the computing power and accuracy offered by computational techniques. In the context of medical history databases, nomenclatures can be referred to as input system tools, as they are designed primarily to enter detailed clinical data into databases, which makes it possible to compile queries. The general principle of implementing nomenclatures is that data is collected once but used repeatedly for different purposes [12].

2 AIM OF THE STUDY

The aim of this thesis is to investigate feasibility of standardizing the electronic maternity record in the form of structuring midwives free text entries using GF and SNOMED CT.

Sub-aims:

- To analyze the templates that the midwives use as basis for making free text entries in maternity record and select three sentences to structure for the practical experiment.
- To construct a practical experiment by structuring midwives free text entries in maternity record using GF and find their corresponding semantical SNOMED CT codes.
- To conduct a questionnaire among midwives to get feedback on documentation and practical experiment testing the prototype.
- To analyze the results of the questionnaire for the feasibility of standardizing maternity record.

3 MATERIALS AND METHODS

For the purpose of achieving the aims, action research method's principles were used in the thesis. Action research is a method frequently used for enhancing conditions and practices in a variety of settings. For instance, the methodology is used in the fields of education, business, management and human resources [33], [34]. The action research method is also used to plan and implement changes in the field of healthcare. In particular, it includes healthcare professionals conducting systematic inquiries helping to improve their practices, which thereby can advance their work environment, including clients, patients and users involved. Action research aims to generate change in specific and practical contexts. Action research is based on generating knowledge and the method is as a continuous cycle, where the data and knowledge after the first cycle are collected, a new plan is executed and a new cycle is initiated with improved plan and steps [35]. The action research consists of the following steps, as can be seen in Figure 1:
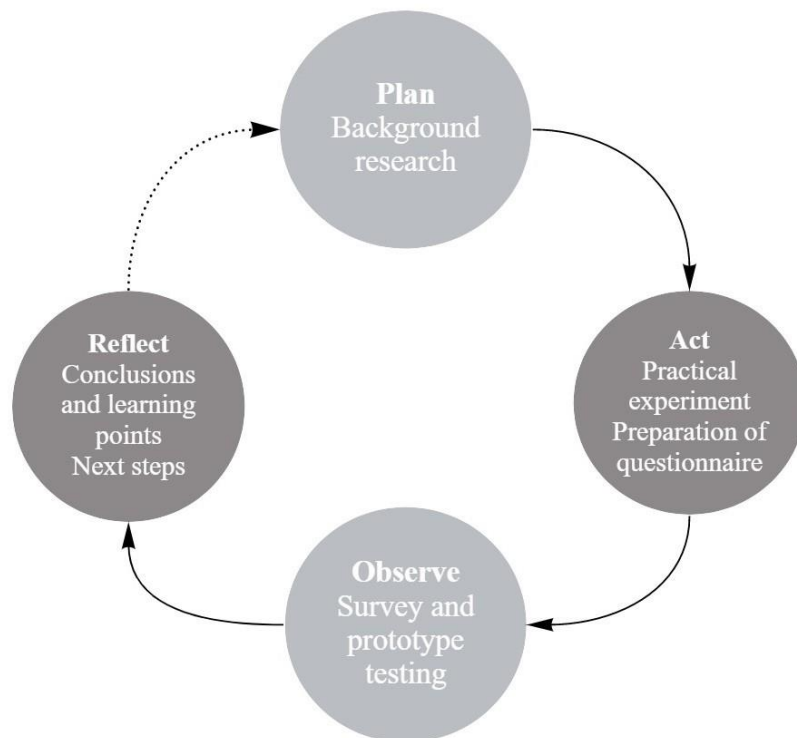

Figure 1. Research approach. Source: author and the principles from "Action Research in Healthcare" [35]

The master's thesis applies the action research method as follows: the "Plan" step focuses on background research and is described in the first chapter of the thesis, the "Act" step focuses on creating a practical experiment and compiling a questionnaire, the "Observe" step includes answering of the questionnaire and prototype testing among West-Tallinn Central Hospital Pregnancy Centre midwives, and under the "Reflect" step, conclusions are drawn and the next steps are outlined to plan improvements and opportunities for further research. The research method is as a continuous cycle and in the master's thesis it is applied as a single cycle, which is demonstrated with an intermittent line, as it is seen in Figure 1.

3.1 Experimental part: structuring free text entries with Grammatical Framework and SNOMED CT

The aim of the practical experiment was to structure free text entries for the purpose of simplifying midwives everyday work and to enable the automatic transmission of data to the ENHIS. To identify which three sentences to be structured for the practical experiment, an analysis was performed of one midwife's free text entry templates. The selected sentences from midwives' free text entries templates were aligned with their SNOMED CT counterparts expressing correct semantics and structured with GF in cloud-based website "GF online editor for simple multilingual grammars". The practical experiment was created in cooperation with the supervisor of the master's thesis, Kristian Kankainen, to compile and combine structured sentences and the prototype can be found on the following website:

http://cloud.grammaticalframework.org/gfse/ by choosing "Midwife". The instructions on how to reach the prototype for entering sentences can be found in Appendix 2.

As first step for the analysis, samples were collected of one midwife's free text entry templates at the West-Tallinn Central Hospital's Pregnancy Centre. The purpose of the analysis of free text entry templates was to identify three important sentences that correspond to the importance of the "Pregnancy Monitoring Guideline" and whether the sentences would be easy to use and structure for the initial experiment. Based on the analysis, sentences on hemoglobin, fetal movements and complaints were selected. The entries of West-Tallinn Central Hospital were used as a basis for the practical experiment, due to the fact that the hospital is one of the largest maternity hospitals in Estonia and

author of the thesis has previous experience with the maternity record solution of that hospital. After analysing the texts, the sentences were structured using GF and SNOMED CT.

3.2 Questionnaire

The questionnaire was composed by the author based on the practical experiment, the results of the audit "Quality of Independent Prenatal Midwifery Care" [28], [29], author's personal experience working with West-Tallinn Central Hospital's maternity record solution and "The Handbook of Midwifery Research" [36]. Due to the specificity of the topic, there was no possibility to use similar existing questionnaires, however the principles of conducting the questionnaire in "The Handbook of Midwifery Research" [36] were taken into account. The questionnaire was formed in Google Forms and consisted of 12 questions. The questions were about the prenatal documentation and the feedback from prototype testing. The questionnaire was created in Google Forms for the reason, that the questionnaire was sent to a specific group of respondents and the method simplified the questionnaire distribution and receiving feedback. An initial prototype of structured free text entries was also added to the questionnaire to receive preliminary feedback and user experience from midwives. The answers to the questions were analyzed in Microsoft Excel.

The questionnaire included 10 close-ended questions and 2 open-ended questions. One section of the questionnaire was an explanation of the prototype and a web link to test the prototype. The 10 close-ended questions included one list-type question, where all possible options had to be chosen, four category-type questions, where one option had to be chosen, five rating-type questions, where semantic rating scale was used where pairs of opposite adjectives were listed and one option had to be chosen [36]. Questionnaire and the instructions on how to test the prototype can be seen in Appendix 1. The questionnaire included a cover letter, stating that the prototype was not a final version but an initial test version to identify, whether such solution would be beneficial for midwives.

After the questionnaire was composed, the author of the thesis forwarded the application to the board of West-Tallinn Centre Hospital, for conducting and approving the research. Once approval was obtained, the questionnaire was sent to the head midwife of the hospital. It was not necessary to apply for the permission of the Ethics Committee to

conduct the questionnaire among midwives, as personal data was not collected or analyzed. The questionnaire was voluntary and anonymous for the midwives.

3.2.1 Questionnaire participants

Participants were the midwives of West-Tallinn Central Hospital's Pregnancy Centre, who are working with pregnant women in daily basis and are making entries in the maternity record into HIS. The head midwife of West-Tallinn Central Hospital forwarded the online questionnaire link to all midwives working in the Pregnancy Centre via e-mail. The questionnaire was sent to 20 midwives.

3.2.2 Prototype

The questionnaire included a cover letter and link to the prototype where midwives could form any of the three sentence types, as explained in detail in section 4.1. The cover letter introduced the aim of the questionnaire and prototype and its usage for the midwives. The tested prototype displayed as is seen in Figure 2:
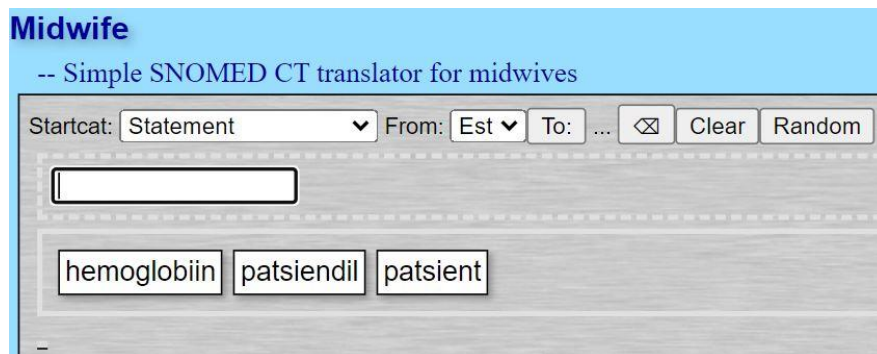

Figure 2. Display of the prototype. Source: GF Online editor [37]

Sentences could be formed either by writing or clicking on words and when the sentence was formed and understood by the computer, it turned blue, as is seen in Figure 3.
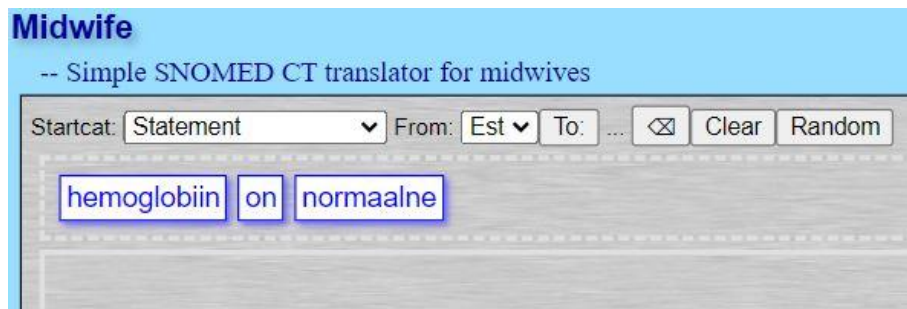
Figure 3. Display of semantically fully formed sentence. Source: GF Online editor [37]

The following link demonstrates a video of how midwives were able to test the prototype:

https://drive.google.com/file/d/1S9kPBQrZNNWnUutz6TwN9jKULTAR4U6k/view?usp=sharing

The video is available from the archived version of the master's thesis available through the Digital Collection of TalTech Library.

4 RESULTS

This section describes the process of the practical experiment and provides an overview of the answers to the questionnaire conducted among midwives.

4.1 Experimental part: structuring free text entries with GF and SNOMED CT

Documenting visits during pregnancy includes, among others, writing entries about pregnancy status in free text. Data insertion is often duplicated between different fields, once as part of a free text narrative and once as a data element value in a separate field. The aim of the experiment is to eliminate duplication and allow data element values to be retrieved from the free text narrative. This is done by structuring the free text sentences, e.g. making them machine-readable.

The first step in performing the practical experiment was to analyse the free text entry templates of the midwives. Each midwife works in a way that they have recorded an entry template for different periods of pregnancy with relevant questions and most typical answers. These templates are then modified according to the content and results of the visit.

The author of the work reviewed and analyzed the templates of one midwife's free text entries, who is working in West-Tallinn Central Hospital and selected three relevant sentences to structure, using GF and SNOMED CT. The analysis of sentences also considered whether the sentences would be easy to use and structure for the initial experiment. The three selected sentences are also relevant and important during pregnancy, according to the Pregnancy Monitoring Guideline, which must be reflected in the midwives' entries [25]. The analysis of the free text entry templates resulted in abstract sentences about hemoglobin, fetal movements and complaints. For the practical experiment, the most common variables for the sentences were selected and used to express specifically structured sentences. The following subsections explain the sentences, their importance and structuring with SNOMED CT and GF in more detail.

The selected sentences from midwives' free text entries templates were aligned with their SNOMED CT counterparts expressing correct semantics and structured with GF. As a last part of the practical experiment, a prototype in GF was created, where selected sentences could be formed by either writing or clicking on words. The prototype was compiled in cooperation with the supervisor of the master's thesis, Kristian Kankainen, by who correspondences between semantic meanings (e.g. the chosen SNOMED CT codes) and midwife's sentences were implemented in GF.

4.1.1 Structured sentences for hemoglobin level

The first sentence chosen is about hemoglobin value of the pregnant woman. According to the Pregnancy Monitoring Guideline, the most common pregnancy disorder is anemia and the level of hemoglobin must be measured at least twice during pregnancy. Likewise, it is also necessary to pay attention to occurrence of anemia during each trimesters of pregnancy [25].

4.1.1.1   Structuring "hemoglobin" in SNOMED CT

In SNOMED CT, the hemoglobin value is expressed as a hemoglobin finding that interprets the measurement of total hemoglobin concentration and where a qualifier value describes the interpretation of the finding as of whether it is within, below or above the reference range, as it is seen in the Figure 4. The following four meanings were chosen for the midwife's sentences: 131141003 |Increased hemoglobin (finding)|, 165399006 |Hemoglobin normal (finding)|, 165397008 |Hemoglobin low (finding)|, 165396004 |Hemoglobin very low (finding)| [38].
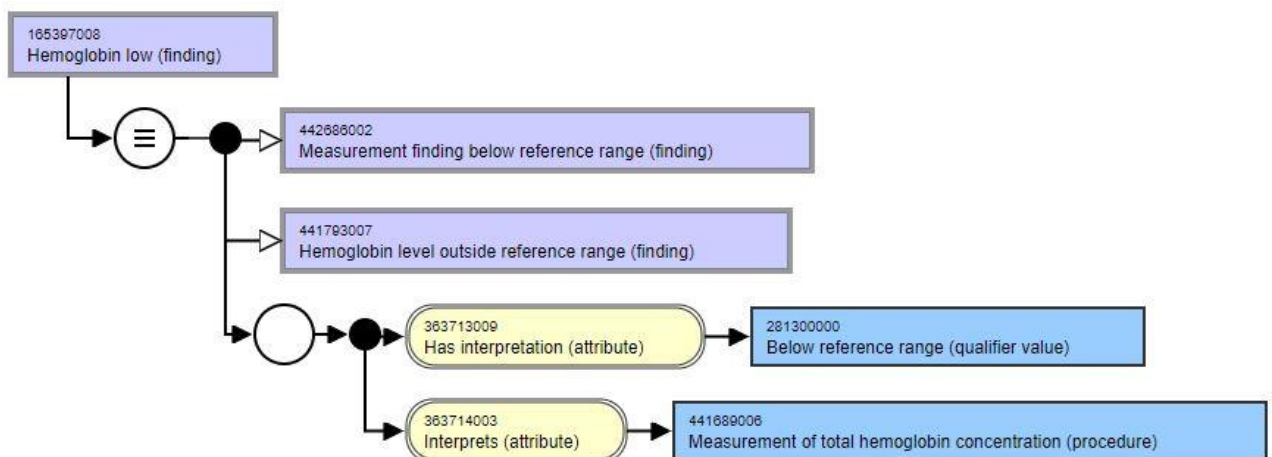

Figure 4. SNOMED CT Hemoglobin low. Source: SNOMED CT Browser [38]

4.1.1.2   Structuring "hemoglobin" sentence with GF

The GF combinatorics works in the same way as in SNOMED CT, where the only variable that changes is the same value as in SNOMED CT. Hemoglobin is a statement and high (*kõrge*), low (*madal*), normal (*normaalne*) and very low (*väga madal*) are variables that can be selected to form a complete sentence, as seen in Figure 5. When the sentence is formed and understood by the computer, in other words the sentence is computer-readable, the sentence turns blue, as it is seen on the Figure 6.
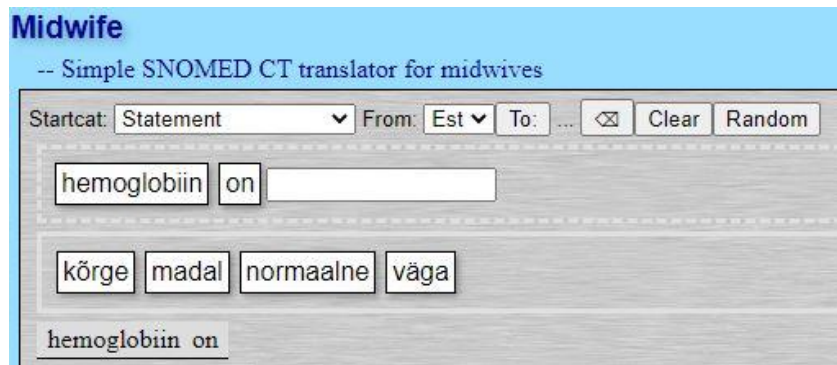
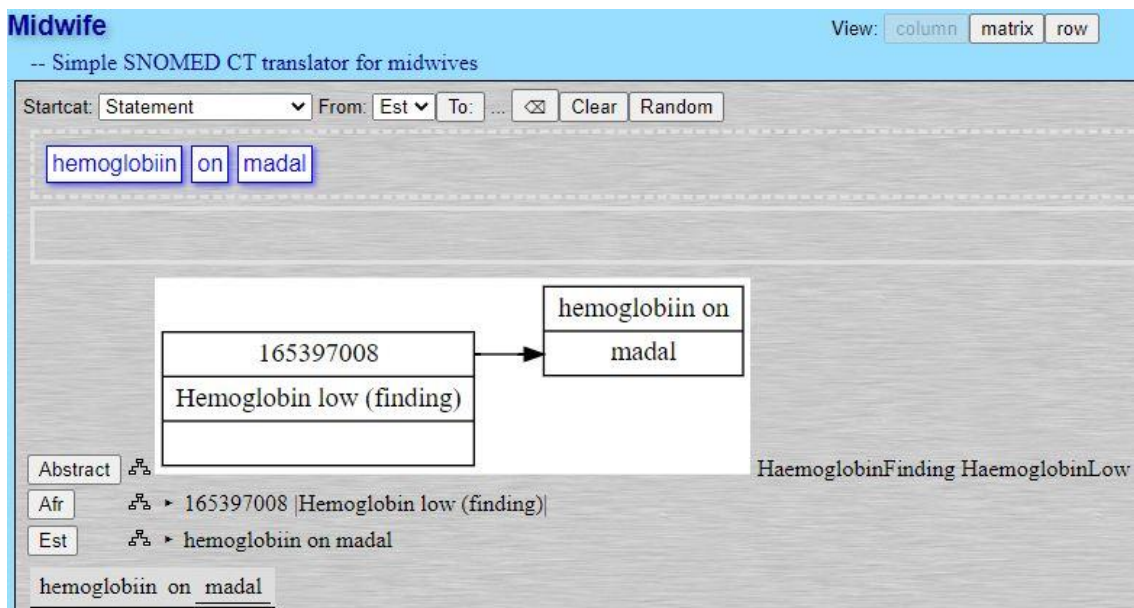Figure 5. GF "hemoblogin" sentence variables. Source: GF Online editor [37]

Figure 6. GF "hemoblogin low" sentence explanation. Source: GF Online editor [37]

Table 1 shows the correspondence between the meaning of statements, SNOMED CT codes and the GF sentences reflecting the hemoglobin levels. In the prototype, one specific SNOMED CT code expresses one sentence:

Meaning of statement	SNOMED CT code	Sentence
Hemoglobin very low (finding)	165396004	*Hemoglobiin on väga madal*
Hemoglobin low (finding)	165397008	*Hemoglobiin on madal*
Hemoglobin normal (finding)	165399006	*Hemoglobiin on normaalne*
Increased hemoglobin (finding)	131141003	*Hemoglobiin on kõrge*

Table 1. Hemoglobin levels meaning of statements, SNOMED CT codes and GF sentences. Source: author and SNOMED CT [37]

4.1.2 Structured sentences for fetal movements

The second sentence chosen is about fetal movements and variables expressing fetal movements felt are selected. The Pregnancy Monitoring guideline advises, that from the 20th week of pregnancy, the pregnant woman should be asked for the presence of fetal movements [25]. A limitation on the structuring of this sentence may be the fact that women feel the movements differently and the setting of variables to some extent may not be sufficient within the experiment and prototype.

4.1.2.1   Structuring "fetal movements" in SNOMED CT

In SNOMED CT, the fetal movements values are expressed with single precoordinated terms and the following three meanings were chosen for the midwife's sentences: 276368003 |Baby kicks a lot (finding)|, 276371006 |Strong fetal movements (finding)|, 276372004 |Weak fetal movements (finding)| [38]. As such, they have not been modelled the same way as hemoglobin findings in SNOMED CT, as seen in Figure 7.
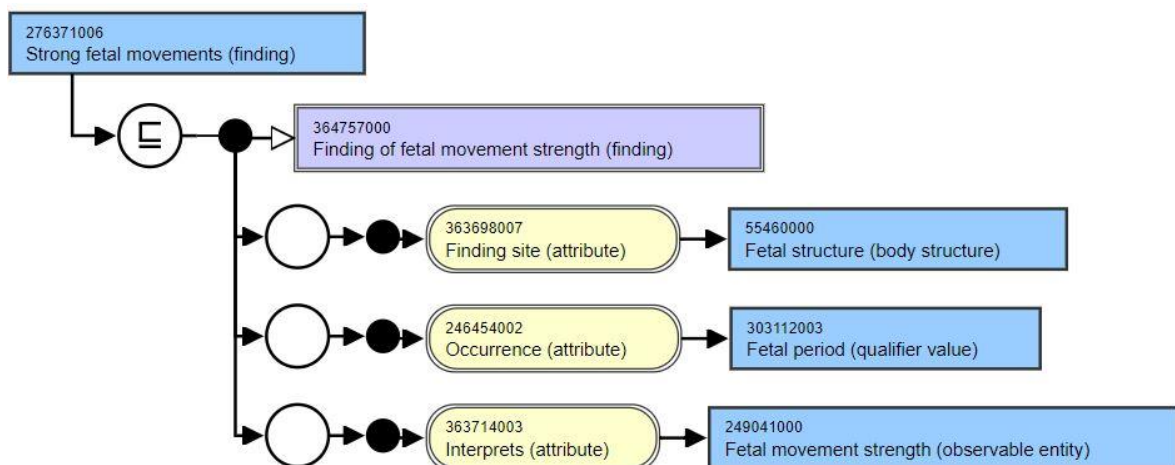

Figure 7. SNOMED CT Strong fetal movements. Source: SNOMED CT Browser [38]

4.1.2.2 Structuring "fetal movements" in GF

In GF, the fetal movements sentence is modelled as the function, where the single input variable specifies the level. The level can be one of three in the experiment: weak, strong, active. Each level is in straight correlation to their corresponding SNOMED CT code. The levels' Estonian language sentences have been modelled in a simple way:

"patsient tunneb "*level*" looteliigutusi"

The variable "level" corresponds to the Estonian words for weak (*vähe*), strong (*hästi*) and active (*aktiivselt*) as seen in the Figure 8.
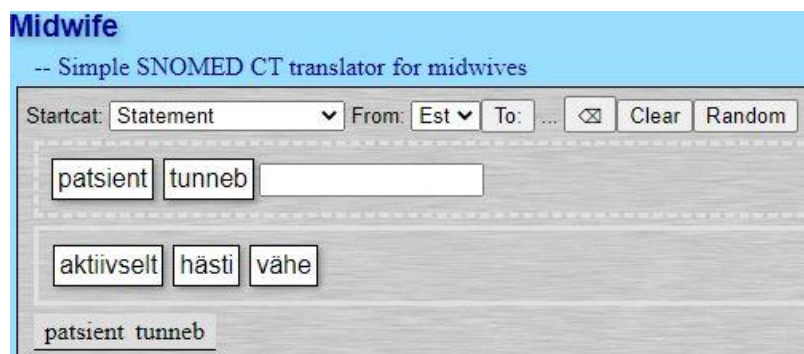
Figure 8. GF "fetal movement" sentence variables. Source: GF Online editor [37]

When the sentence is formed and understood by the computer, in particular the sentence is computer-readable, the sentence turns blue, as it is seen on the Figure 9. In GF, there are summarized variables of the formed sentences and their SNOMED CT equivalents and it can be seen from the Figure 9 that one SNOMED CT code applies to the whole sentence "*patsient tunneb hästi looteliigutusi*".
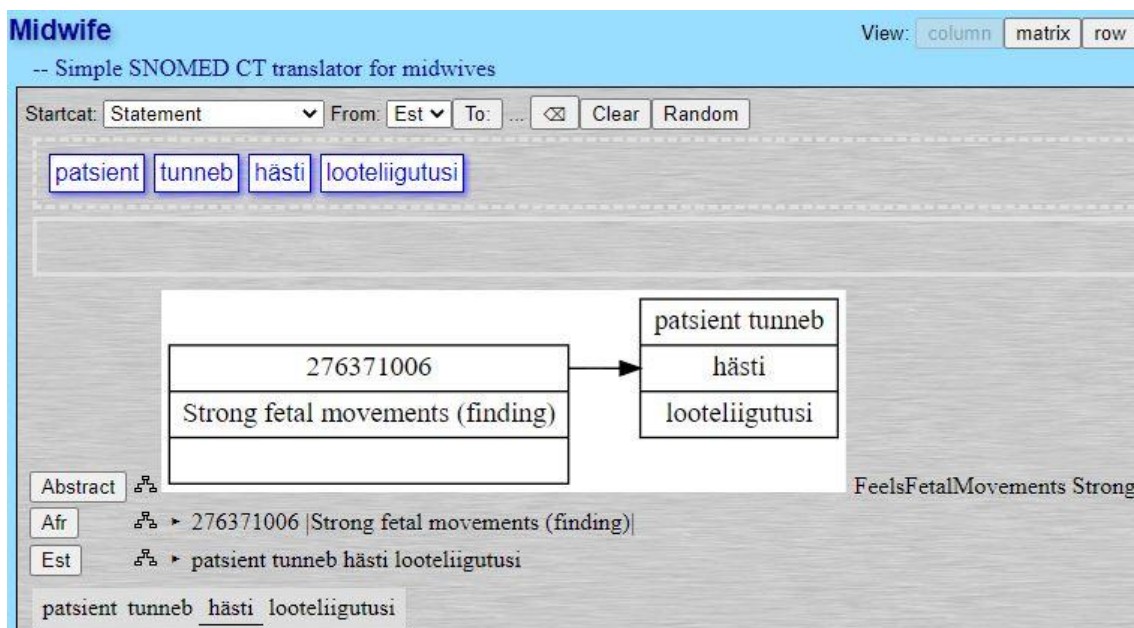
Figure 9. GF "strong fetal movements" sentence explanation. Source: GF Online editor [37]

Table 2 shows the correspondence between the statements, SNOMED CT codes and the GF sentences reflecting the fetal movements. In the prototype, one specific SNOMED CT code expresses one sentence:

Meaning of statement	SNOMED CT code	Sentence
Baby kicks a lot (finding)	276368003	*Patsient tunneb aktiivselt looteliigutusi*
Strong fetal movements (finding)	276371006	*Patsient tunneb hästi looteliigutusi*
Weak fetal movements (finding)	276372004	*Patsient tunneb vähe looteliigutusi*

Table 2. Fetal movements meaning of statements, SNOMED CT codes and GF sentences. Source: author and SNOMED CT [38]

4.1.3 Structured sentences for complaints

The third sentence chosen is about complaints and variables expressing complaints (nausea, dizziness, heartburn, constipation, foot/hand swelling) are selected. The Pregnancy Monitoring guideline advises, that at each appointment during pregnancy, the pregnant woman should be asked about complaints and counselled accordingly [25]. In the experiment, three different complaints can be expressed in one sentence. The limitation of structuring the sentence may be that pregnant women have many different complaints during pregnancy, but five different complaints were used in the experiment, which according to the Pregnancy Monitoring Guideline are one of the most common during pregnancy.

4.1.3.1   Structuring "complaints" in SNOMED CT

In SNOMED CT, the complaint sentence is modelled in a way, that each type of complaint has corresponding SNOMED CT code, an example is shown in Figure 10 and it sums up the whole meaning "the patient has nausea". In SNOMED CT it is also possible to express the absence of any complaints. This has the meaning that the patient has no complaints and this is semantically negative, meaning that the patient had "no complaints", not that the patient was not asked the occurrence of complaints, as seen in Figure 11. The following meanings were chosen for the midwife's sentences: 248264000 |No complaints (finding)|, 162057007 |Nausea present (situation)|, 162260006 |Dizziness present (situation)|, 16331000 |Heartburn (finding)|, 14760008 |Constipation (finding)|, 297142003 |Foot swelling (finding)|, 299037003 |Swelling of hand (finding)| [38].
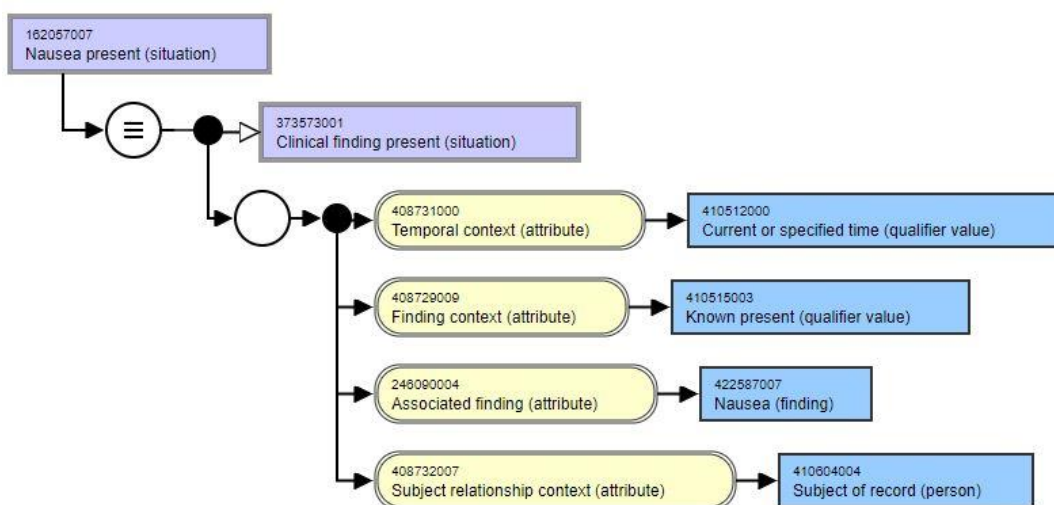

Figure 10. SNOMED CT Nausea present. Source: SNOMED CT Browser [38]
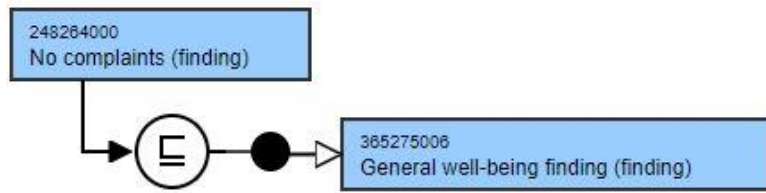
Figure 11. SNOMED CT No complaints. Source: SNOMED CT Browser [38]

4.1.3.2 Structuring "complaints" in GF

The peculiarity of complaint sentence modelling in GF is coordination. Coordination enables the expression of several complaints simultaneously. There may also be a situation where the patient has no complaints "*patsiendil ei ole kaebusi*" as can be seen in Figure 12.

Figure 12. GF "no complaints" sentence. Source: GF Online editor [37]

In the presence of complaints, the patient may experience one or more different complaints at the same time as is illustrated in Figure 13.

Figure 13. GF "complaint" sentence variables. Source: GF Online editor [37]

Expressing in GF that one patient has several different complaints, as nausea (*iiveldus*), heartburn (*kõrvetised*) and foot swelling (*tursed jalgadel*), in SNOMED CT is defined as code + code + 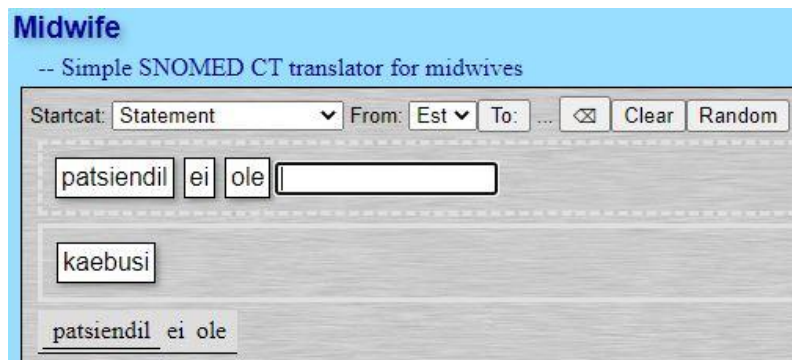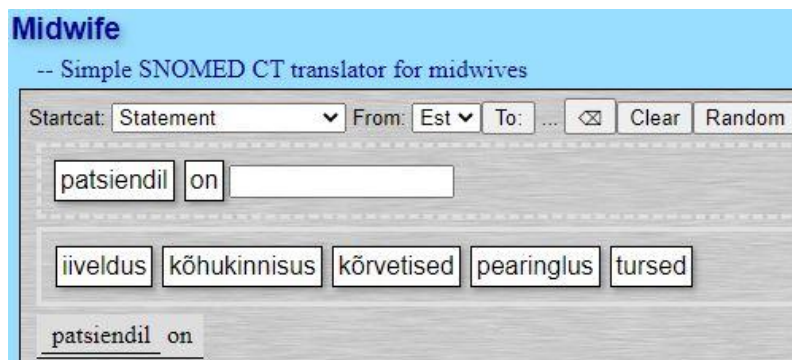code, where "+" stands for and/or, as it can be seen in Figure 14. When the sentence is formed and understood by the computer, in particular the sentence is computer-readable, the sentence turns blue.
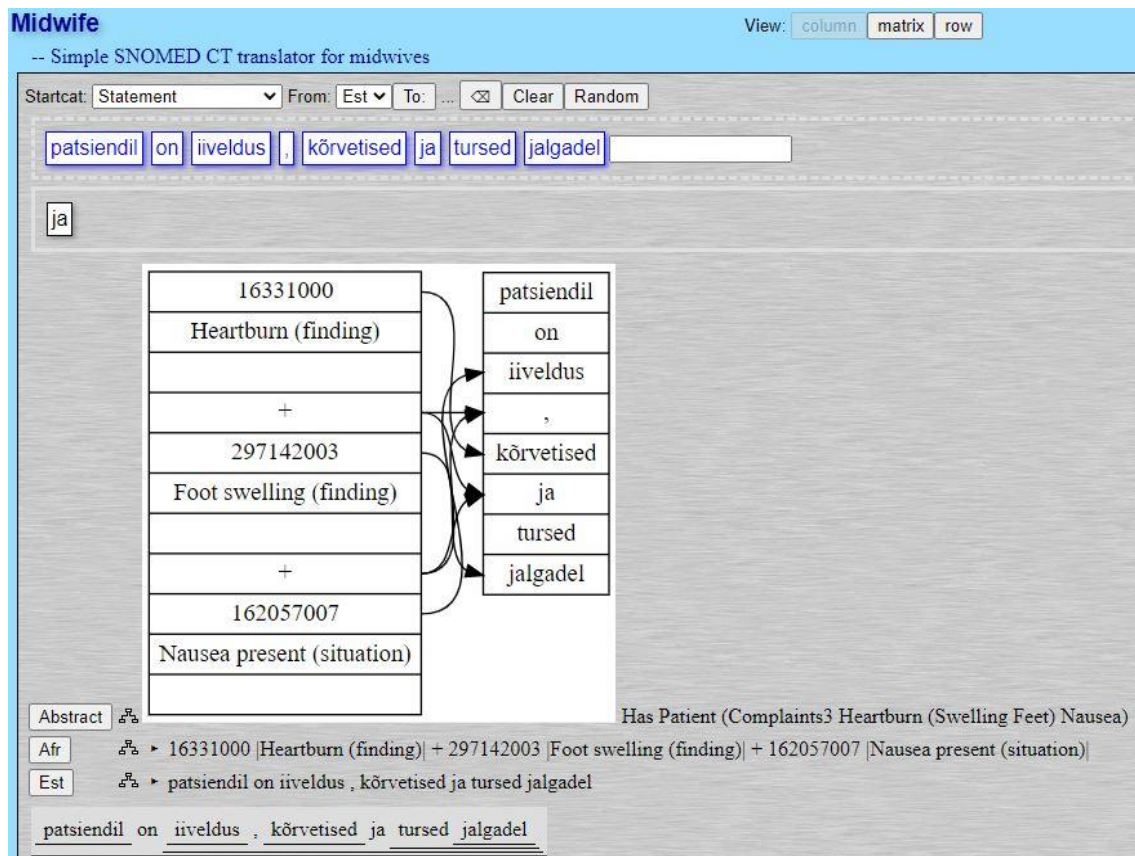
Figure 14. GF sentence "Patient has nausea, heartburn and foot swelling" explanation. Source: GF Online editor [37]

In the GF prototype, it is possible to create 399 combinations for complaints and one for "no complaints". Table 3 shows the correspondence between the statements, SNOMED CT codes and the sentences reflecting complaints:

Meaning of statement	SNOMED CT code	Sentence
No complaints (finding)	248264000	*Patsiendil ei ole kaebusi*
Dizziness present (situation)	162260006	*Patsiendil on pearinglus*
Swelling of hand (finding)	299037003	*Patsiendil on tursed kätel*
Heartburn (finding), Foot swelling (finding), Nausea present (situation)	16331000 + 297142003 + 162057007	*Patsiendil on kõrvetised, tursed jalgadel ja iiveldus*

Table 3. Complaints meaning of statements, SNOMED CT codes and GF sentences. Source: author and SNOMED CT [38]

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4.2 Results of the questionnaire

The questionnaire was sent to West-Tallinn Central Hospital's head midwife, who forwarded the e-mail and questionnaire link to Pregnancy Centre midwives. Based on the website of West-Tallinn Central Hospital, 20 midwives are working in the Pregnancy Centre. 12 midwives out of 20 answered to the questionnaire (response rate 60%) and all of them are analyzed below.

The midwives were asked "*1. How do you document prenatal visits*?". All the twelve respondents answered that they document to the PMR as well as to EMaR in HIS. None of the respondents chose "Other" option.

For the question of "*2. How do you rate the convenience of entering data into the current PMR?*" respondents were asked to rate their opinion as "very convenient", "convenient", "neutral", "rather inconvenient", "very inconvenient". The results for this question can be seen in the Figure 15:
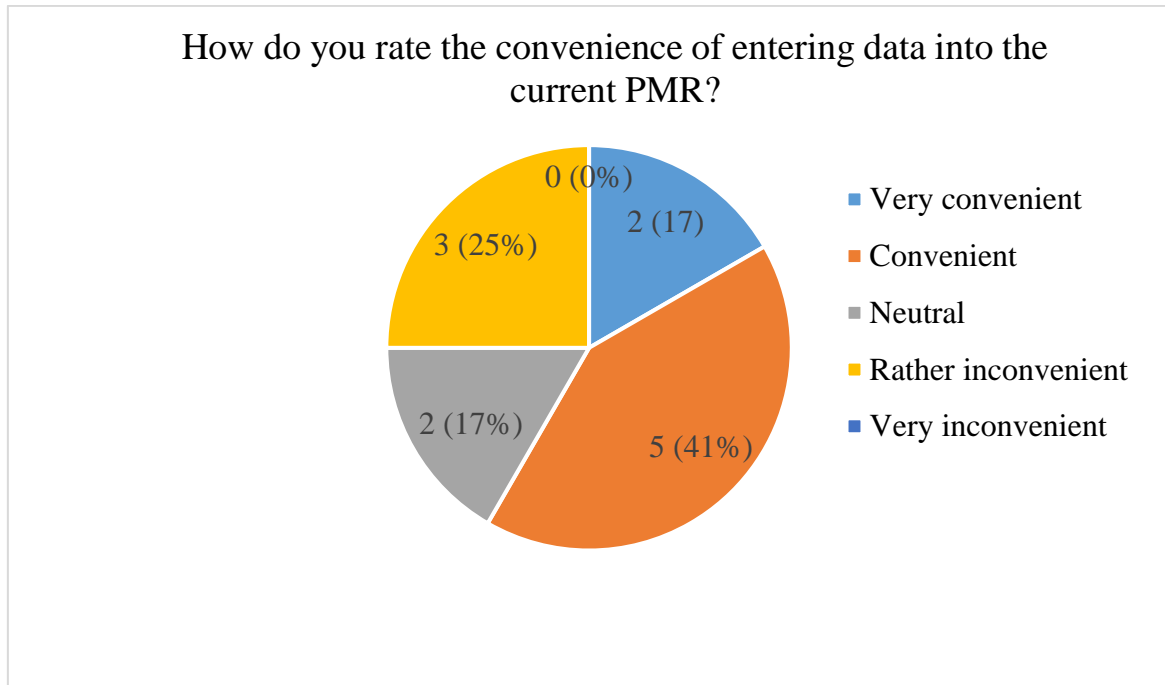
Figure 15. PMR data entry convenience. Source: author

To the question "*3. How do you rate the convenience of entering the data into EMaR in HIS?*" respondents were asked to rate their opinion as "very convenient", "convenient", "neutral", "rather inconvenient", "very inconvenient". The results for this question were as following in the Figure 16:
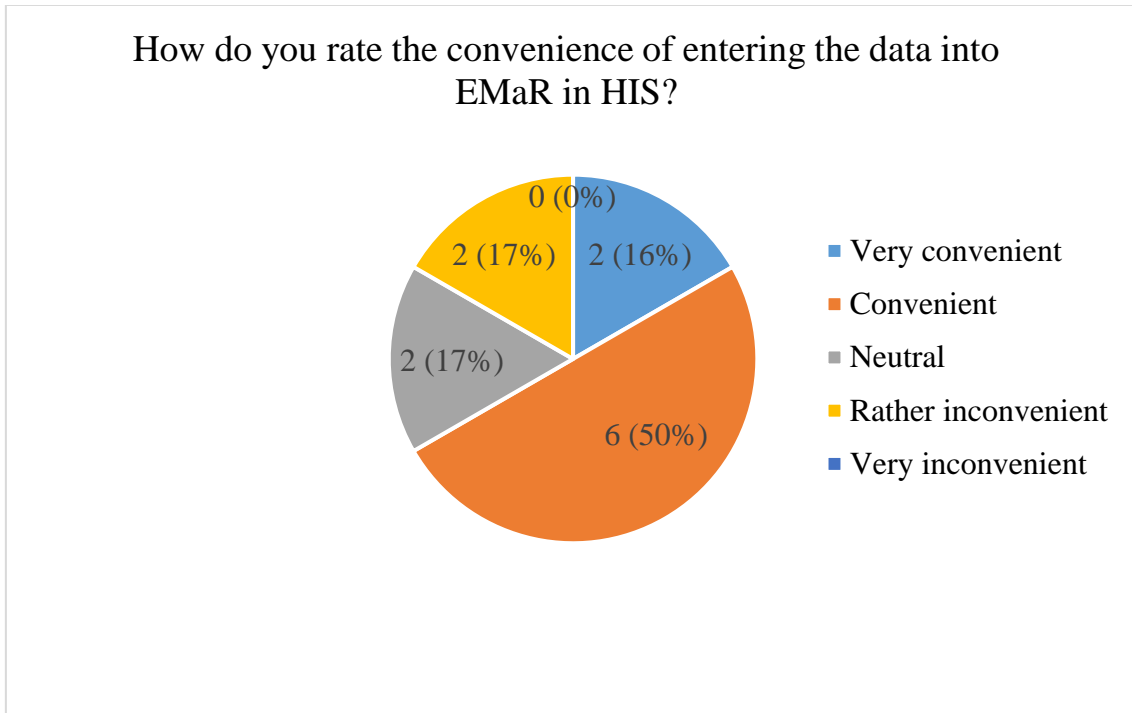
Figure 16. EMaR data entry convenience. Source: author

If the respondents were to choose the "Other" option in question 1, the following question was also intended to answer by the respondents "*4. If you chose "Other" in question 1, how would you rate the convenience of data entry into chosen option?*" as none of the respondents chose "Other" in question 1, none of the participants answered this question either.

The fifth question assessed the appropriateness of the current solution of writing entries in EMaR in free text and the answers can be seen in the following Figure 17:

Are you satisfied with the current solution of writing
entries in EMaR in free text form?

5 (42%)   7 (58%)

■ Yes ■ No
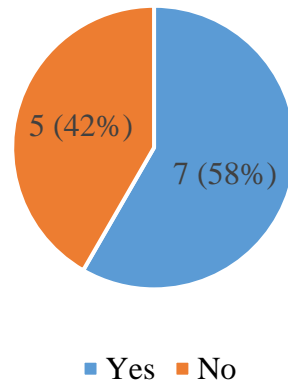
Figure 17. Appropriateness of the current solution of writing entries in EMaR. Source: author

On the question "*6. How important do you consider it to share documentation and important information with the patient and other health care professionals in real time? (Midwives, gynecologists, other relevant parties)*" respondents were asked to rate their opinion as "very important", "somewhat important", "neutral", "rather irrelevant", "completely irrelevant". The results for this question are reflected in the Figure 18:

How important do you consider it to share documentation and
important information with the patient and other health care
professionals in real time? (Midwives, gynecologists, other relevant
parties)

0 (0%)   0 (0%)   0 (0%)

1 (8%)

11 (92%)

■ Very important

■ Somewhat important

■ Neutral

■ Rather irrelevant

■ Completely irrelevant
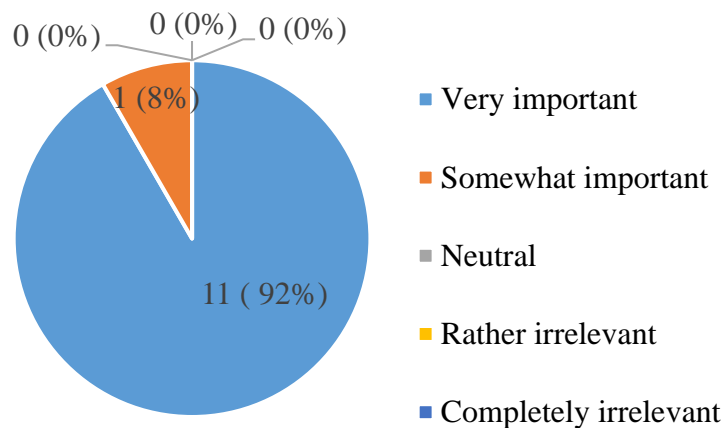
Figure 18. Importance of information sharing. Source: author

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When midwives were asked "*7. How important do you consider making documentation machine-readable? (Making machine-readable means structuring important sentences or phrases in such a way that the information entered reaches the ENHIS in a structured or factual form and is visible in real time to other health care professionals)*" there were five possible answers as in the previous question, "very important", "somewhat important", "neutral", "rather irrelevant", "completely irrelevant" and the answers can be seen in Figure 19:
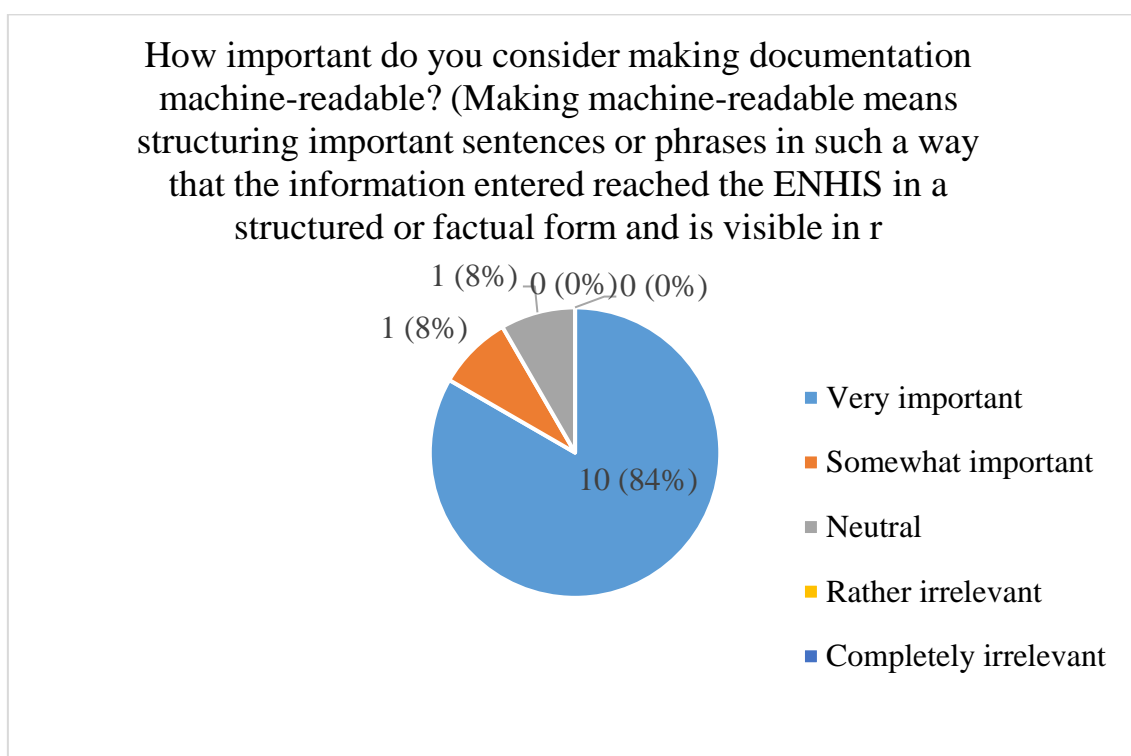
Figure 19. Making documentation machine-readable. Source: author

Midwives were then asked to test the prototype in GF: "*Further on, I would like you to test a prototype of machine-readable sentence entry, where the sentences in the EMaR are structured and changed the way, where you can enter the required sentence as you want it to appear, by clicking on the words to enter the text. The prototype presents combinations of three sentences selected from the midwives EMaR templates (sentences on hemoglobin, fetal movements and complaints). When you have tried the prototype, please answer to the questions below. The prototype can be found at the following address: http://cloud.grammaticalframework.org/gfse/. To reach the prototype from the given address, please click on "Midwife" and then on the top right on "Minibar". In the prototype you can try different combinations of sentences and to form a new sentence,*

you have to press "Clear", by clicking on "Random", the computer itself forms a sentence from the combinations (instructions are given in the pictures below)." The instructions mentioned above are attached to the Appendix 2.

After testing the prototype, the midwives were asked "*8. Would the previously tried machine-readable way of forming sentences help you with documenting and writing entries?*". The majority, such as 9 midwives, answered that the tried method would help them writing entries, as 3 midwives answered *No*, as is shown in the Figure 20.
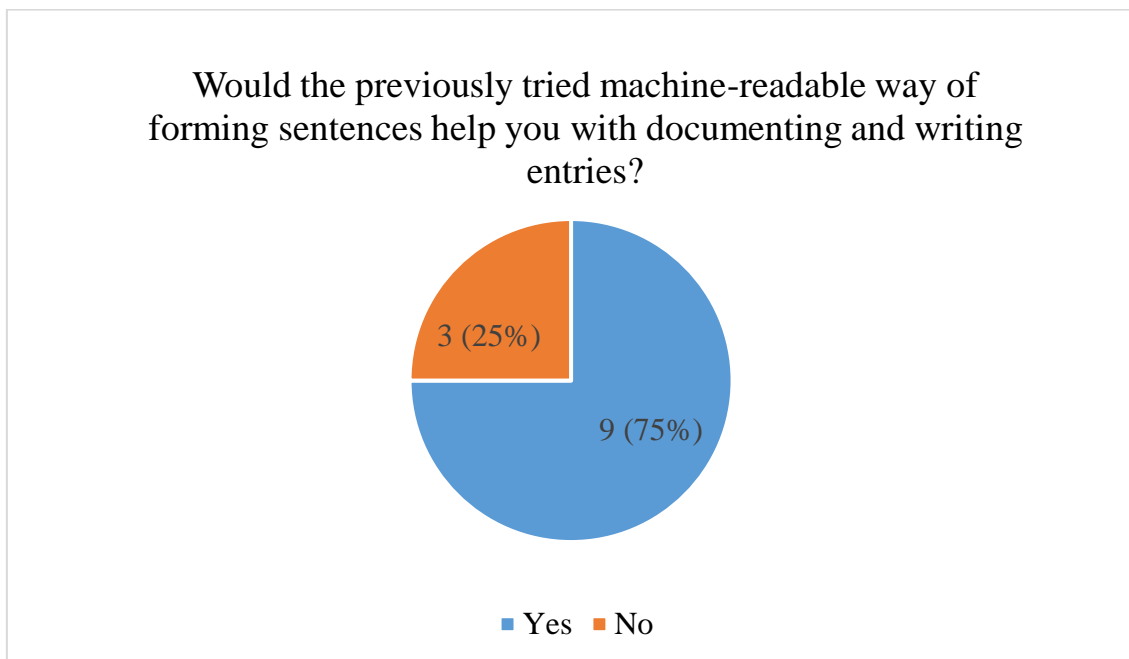
Figure 20. Whether the sentence forming in prototype is helpful. Source: author

Further on, the answers to the question "*9. Do you understand entering sentences in the form of a prototype?*" were divided similarly to the previous question, where 9 midwives noted that the tested method was understandable and for 3 midwives, it was not understandable, as can be seen on the following Figure 21:
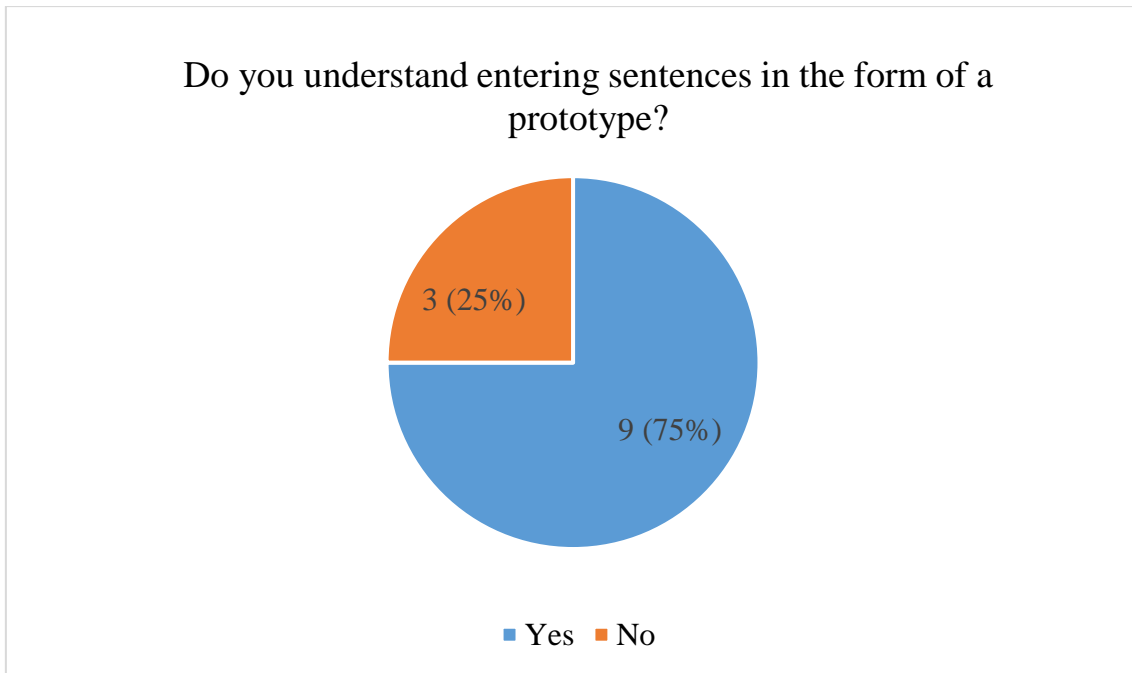
Figure 21. Understandability of entering sentences in the prototype. Source: author

The midwives were asked "*10. What would you like to change?*" and as 5 out of the 12 midwives gave their feedback and the answers were different, the answers in the quoted form are presented as follows: "since I'm a fast writer and I have standard answers on computers, I don't think this option adds anything", "needs practicing, in addition, did not understand whether the sentences still can be changed manually if necessary? Maybe there is a need to add something more specific. As it is not clear at the moment how this is compatible with the hospital system, it would also be important not to have to do any extra button presses or searches, otherwise it will not make the midwife's job of documenting easier", "the system could have base sentences that can be selected immediately and adjusted if necessary", "could be easier to enter and in the case of other EMaRs, previous diagnoses could be carried forward automatically" and "at first, getting to know the prototype was a bit confusing".

In addition, the midwives were asked *"11. Would entering sentences in the form of a prototype make documentation easier?"* and the answers were as following as illustrated in Figure 22:

Would entering sentences in the form of a prototype make documentation easier?

3 (25%)

9 (75%)

■ Yes ■ No
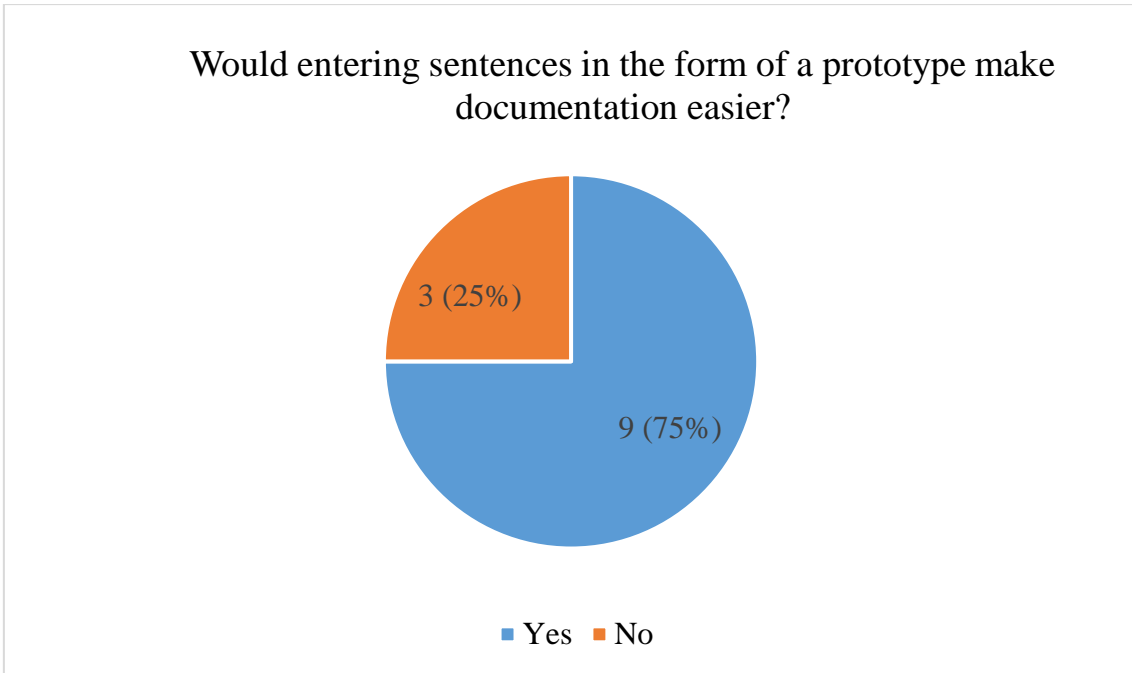
Figure 22. Whether entering sentences in prototype would make documentation easier. Source: author

Lastly, on the question "*12. What do you think are the most useful and important phrases or facts that need to be documented, would be machine-readable and visible in real time to other midwives and doctors?*" The most popular response (n=6) was the results of the analyses/examinations. In addition, fetal movements, problems during pregnancy and the size of the pregnancy were also highlighted multiple times (n=4). Analyses and tests prior to the next visit, medications and complaints were also highlighted on several occasions (n=3). Furthermore, the following points were emphasised and considered important: medical history, swellings, fetal heart rate, uterine contractions, vital signs, pregnant woman's emotional state and mental health information, signs of pregnancy pathology, previous births, hereditary diseases, pregnancy-related diagnoses, presumed fetal weight, comorbidities, allergies, blood group and information on next visit (n=1).

5 DISCUSSION

This section explains the analysis of the midwives' free text entry templates, interpretation of the practical experiment, questionnaire answers and prototype testing. Likewise, study limitations and recommendations are discussed at the end of the chapter.

Adoption of EHRs and usage of e-health is a fundamental foundation of how healthcare is delivered today. Standardization of processes, encouragement of evidence-based practice, safety and security, usability and reduction of workload have been important key components in implementation processes. The PMR has been an effective and fundamental tool and remains the primary source of information in maternity shared-care environment. However, having many beneficial features, PMR still has several disadvantages, in particular poor readability, and unavailability to several healthcare professionals concurrently and in emergency situations. The implementation of EMaRs has increased the possibility of data exchange and availability between various healthcare professionals [2], [13], [14]. Standard data descriptions and structures are essential for producing and exchanging data in maternity care. Standardization enhances interoperability between different healthcare information technology systems and the need for standardization must be acknowledged to obtain consistent data integration. Using standard data elements and validated definitions enables common language and facilitates data exchange [15]. The EMaRs are implemented and in use in many different countries, for instance in Finland, England, and Australia. The Finnish EMaR, IPana Maternity, has been implemented and is in use however it remains unclear if and how the documentation of midwives is standardized. Although "The Women's Digital Care Records" plans to offer all pregnant women in England the access to their digital care records by the year of 2023/24, it is not clear how and by which methods it will be implemented [4], [5], [6].

The thesis explored the feasibility of standardizing maternity record on the example of midwives' free text entries, using GF and SNOMED. In order to achieve the aim, the work included three main parts – an analysis of the free text entry templates followed by practical experiment with standardisation of those three sentences using GF and

SNOMED CT, including the creation of the prototype and lastly, a questionnaire was conducted to receive feedback on the prototype and receive opinions on documentation among West-Tallinn Central Hospital's Pregnancy Centre midwives.

In order to reach the aim of the master's thesis, at first the free text entry templates were analyzed. As a first step of the analysis, samples were collected of one midwife's free text entry templates at West-Tallinn Central Hospital's Pregnancy Centre. As a results of the analysis, three sentences were selected that correspond to the importance according to the "Pregnancy Monitoring Guideline" [25] and whether the sentences would be easy to use and structure for the experiment. The sentences chosen were about hemoglobin, fetal movements and complaints, which are greatly important areas, but midwives use significantly more sentences and expressions in their daily work that were not reflected or standardized in this master's thesis due to workload limitations. The sentences reflected in the master's thesis are not sufficient to carry out the complete standardization process and for this it would be important to select all the sentences and their variables that midwives use in free text entries for documentation. Only the main variables were selected for structuring sentences, like the level of hemoglobin or fetal movements felt. Although the variables chosen were sufficient for the practical experiment, there are significantly more nuances in the work of midwives. Four variables were chosen to form the hemoglobin sentence, which gives an overview of the hemoglobin value when forming the sentence, but in common practice, the hemoglobin value is written not only with the variables used in the work but also with a numerical value. As it was not possible to structure the numerical values in the master's thesis, four written variables were chosen. The same need for expressivity of nuances is for fetal movements and complaint sentences. Three variables were chosen for fetal movements, but women may feel fetal movements psychologically differently and the three variables chosen may not define all possible expressions of how fetal movements are felt. Five different variables and "no complaints" options were chosen to structure the complaint sentence. The complaints were selected from the "Pregnancy Monitoring Guideline" [25] and are the most common complaints during pregnancy. The disadvantage of the selected variables is that they do not cover all the possible complaints that women may experience during pregnancy, but the five selected variables met their purpose for the practical experiment.

EMaRs are commonly hospital-based and the structure of documentation varies according to the hospital's regulations. For the master's thesis, the free text entry templates of only

one hospital and only one midwife were selected, which fulfilled the purpose and enabled the experiment to be carried out, but in order to standardize the maternity record, it is definitely necessary to involve more midwives and free text entry templates from different hospitals.

The selected sentences were aligned with their SNOMED CT counterparts expressing the same semantics using the Grammatical Framework. GF is a functional programming language for developing multilingual applications and controlled natural languages and the typical applications are in natural language generations, dialogue systems, machine translation or the question-answering systems [11]. The novelty of the master's thesis is the fact that GF was used in the field of healthcare standardization process. The technical issue with GF is that it is not known how to integrate or apply it to the hospital information systems, as hospitals have different information systems and programs. One good feature of GF is that it is free text based and the text window in the hospital information system is the same and midwives do not have to change anything other, than the text or entries in the text window. In this way, it seems to simplify it, the hospital information system does not have to bring in additional features, the midwives have the working desk as they are used to and only the free text entry window gets more functionality.

Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) is a tool for translating patient clinical data into a computer-readable form, which has the largest list of clinical terms in the world, containing 350,000 terms. SNOMED CT has very detailed multilingual health terminology, which supports the electronic exchange of information about clinical health [12]. The great advantage of SNOMED CT is that it allows the meaning of each sentence to be expressed very precisely. For the three sentences selected for the experiment on hemoglobin, fetal movements and complaints, SNOMED CT counterparts expressing correct semantics were selected. The disadvantage of SNOMED CT is that only certain terms can be selected to express sentences and numeral values are not expressable. Therefore, written values were chosen for the master's thesis to express sentences about hemoglobin.

A questionnaire was compiled to receive feedback from midwives on the documentation and the practical experiment. Although it can be said that the feedback from the questionnaire was positive and there were enough questions to obtain initial feedback on documentation and the prototype testing, some questions were missing, which became

clear after the questionnaire was conducted. A lot of important information and overview would have been provided if the questionnaire had included questions about the age and working experience of the midwives. Therefrom, it could have been analyzed how midwives of different ages and experiences evaluate the documentation in the existing solution and the satisfaction and readiness to use the prototype. A cover letter was also attached to the questionnaire, which introduced the author of the work, the aim of the master's thesis and the prototype. The part on the prototype stated that the prototype is the initial version for writing free text entries and it is not a final solution, but a test of whether such an option could be implemented in the future. The brief introduction of the prototype gave midwives an overview, but in order to get a more detailed description, there could have been a more thorough explanation of the prototype, that sentences can be formed by either writing or clicking on words. As part of the questionnaire explained the use of the prototype, it would have been better for midwives to read a thorough explanation. On the other hand, reading a long introduction and in addition filling the questionnaire could have caused a quick loss of interest. An explanation of the use of the prototype and a link were attached to the questionnaire, which can be seen in Appendix 2. Unfortunately, it was not possible to add a direct link to the prototype and the midwives first had to click two buttons according to the instructions and then reached the prototype. Furthermore, the prototype was not similar to the hospital information system used by midwives on a daily basis, which may initially be confusing, but the questionnaire also provided instructions on how to use the prototype and explained that the prototype was not the final version.

In order to receive feedback on the prototype and to assess the feasibility of standardizing the maternity record, a questionnaire was conducted among midwives. The questionnaire confirmed that midwives document prenatal visits both into the PMR and EMaR in HIS. The convenience of documentation to the PMR and existing EMaR varied by midwives, but in general it could be said that it was rated rather convenient and rather inconvenient. Most midwives stated that writing free text entries in EMaR was convenient for them, but there were also those who found that free text entries was no convenient. Documentation and information exchange in real-time and documentation being machine-readable was important for majority of midwives. It can be assumed that it is important for midwifes if the information about the patient is available and visible at all times, so that they can make appropriate decisions or plan further care if necessary. Information gathered during

pregnancy should also be visible if the pregnant woman has visited another hospital or turned to another specialist.

The midwives had the opportunity to comment on what they would like to change about the prototype. It is worthy to use the comments as a basis and further guidance if there should be an opportunity to develop the prototype into a user interface for midwives. The midwives pointed out, that the method needs practice, and it must be ensured that the use of the method does not require additional work for midwives. It can be considered from this comment, it is important that the updated documentation method does not generate additional programs or require midwives to make additional clicks to reach the documentation text window. Since midwives had to click two buttons to reach the prototype, this comment may be due to that. It was also pointed out that there should be more sentences in the prototype that can be modified if necessary and information about previous pregnancies and diagnoses could be transferred to the user interface automatically. The author of the work came to this conclusion also, that to create the final user interface, it is important to work through more free text entry templates and add significantly more sentences. Regarding the necessity of the tested prototype, most midwives replied that the method would be useful for writing entries. Based on the answers, it can be stated that midwives like to write free text entries and for the author of the work, it is greatly positive feedback and it allows to plan for further research. Likewise, midwives are willing to use a method that would allow data to be entered in a structured way and enable data to be transferred to the ENHIS. Most midwives stated that the use of prototype was understandable. According to this, it can be expressed that midwives have an interest with modernizing the system, prefer writing free text entries and it is certainly important to involve midwives in further developments in order to take into account their suggestions, views and needs. The "Quality of Independent Prenatal Midwifery Care" summary [29] and the document of the Estonian Nursing and Midwifery Development Strategy 2021-2030 [30] have stated, that a unified system in all institutions providing prenatal monitoring services must be introduced and digital solution for evidence-based documentation must be created.

From this thesis it is revealed that although midwives are somewhat satisfied with the existing maternity record solution but real-time data transfer and accessibility are important to them and the prototype in the form of a practical experiment would help them to document the entries and achieve real-time data transfer. Midwives are ready to

use modern systems and it can be concluded that the standardisation of the maternity record with GF and SNOMED is feasible but needs further research and development on a national level.

5.1 Limitations

As a practical experiment was carried out based on the entries of one midwife, it is not sufficient to understand the content of the whole system of maternity record and the entries of the midwives. For further research, more entries of midwives from different hospitals should be considered, to have a broader representation and to allow a more comprehensive system to be implemented. The experiment was carried out in GF, where a prototype was tested and whereas the aim was to understand the feasibility of standardizing maternity record, it did not correspond to the user interface of the HIS, hence midwives could not get a real impression of the possible functioning of the system in the HIS.

The sentences chosen were about hemoglobin, fetal movements and complaints, which are greatly important areas, but midwives use significantly more sentences and expressions in their daily work that were not reflected or standardized in this master's thesis due to workload limitations. The sentences reflected in the master's thesis are not sufficient to carry out the complete standardization process and it would be important to select all the sentences and their variables that midwives use in free text entries for documentation. The main variables were selected for structuring sentences. Although the variables chosen were sufficient for the practical experiment, there are significantly more variables in the work of midwives. Twelve midwives answered the questionnaire conducted within the master's thesis, which is not completely sufficient to introduce changes, which is why it is important to involve more midwives from different hospitals for further research.

Finally, the questionnaire was not based on previous questionnaires, but on the author's personal experience, practical experiment and "The Handbook of Midwifery Research" principles, because there were no studies based on a similar questionnaire. The questions prepared by the author were largely based on the prototype, therefore the questions were topic specific.

5.2 Suggestions for further studies and developments

The methodology used in this thesis can be used as a basis for further research, as action research is a continuous method, where the findings and conclusions can be used as a basis for further research. As the digitalization of the maternity record is an ongoing and important issue, it should be further researched more thoroughly, involving more parties at national level.

In further research, it is important to involve different doctors and midwives from different hospitals and form working groups to map the needs and expectations of different parties. Likewise, it is also essential to create a more comprehensive user interface that corresponds to the real existing user interfaces and gives a more realistic overview of the existence of the system. In addition, it is necessary to analyse the entries of more midwives in order to map the data fields, which would correspond to the evidence-based practice and guidelines, to be implemented in the user interface. Moreover, it is important to analyse the compatibility of the user interface with the information systems of different hospitals and to create a user interface or EMaR that would be usable in hospitals nationwide and that would automatically transmit data to the ENHIS. Further research should also consider one party as a patient, who should also be able to enter their own data, which should be accessible to healthcare professionals.

Conclusion

Increasing usage of e-health, adoption of modern Electronic Health Records (EHRs), including Electronic Maternity Records (EMaRs), requires modernization processes, in particular creation of standards and the introduction of common and evidence-based midwifery documentation language and real-time communications compatibility with various information technology systems.

In this study, feasibility of standardizing the maternity record in the form of structuring midwives free text entries was evaluated. Firstly, as a result of the analysis, sentences of hemoglobin, fetal movements and complaints were chosen from one midwife's free text entry templates. Furthermore, a practical experiment was performed, where chosen sentences were structured using GF and SNOMED CT for the purpose of simplifying midwives everyday work and to enable the automatic transmission of data to the ENHIS. The practical experiment involved creating a prototype in GF, where selected sentences could be formed by either writing or clicking on words. And lastly, to assess the feasibility of standardizing maternity record and the necessity of the tested prototype, a questionnaire was conducted among midwives.

Based on the results of the questionnaire, it is revealed that midwives are somewhat satisfied with the existing duplicated maternity record solution but real-time data transfer and accessibility are very important for them and the tested prototype would help them to document the free text entries during pregnancy. Midwives are ready to use modern systems and it can be concluded that the standardization of the free text entries for the maternity record with GF and SNOMED is feasible but needs further research and analysis. Communication implies more than a single participant. In order to reach a solution that benefits more people, the results of this study need to be broadened with research and development on national level, involving more midwives, hospitals and national stakeholders.

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Appendix 2 - Questionnaire

Questionnaire for the midwives about documentation and structuring free text entries.

1. Kuidas dokumenteerite raseduse visiite? (kui valiste muu variandi, palun täpsustage valikut)

- Paberkandjal rasedakaarti

- Haigla infosüsteemis olevasse rasedakaarti

- Muu variant

2. Kuidas hindate praeguse rasedakaardi andmete sisestamise mugavust paberkandjal rasedakaarti?

- Väga mugav

- Mõneti mugav

- Erapooletu

- Pigem ebamugav

- Väga ebamugav

3. Kuidas hindate praeguse rasedakaardi andmete sisestamise mugavust haigla infosüsteemis olevasse rasedakaarti?

- Väga mugav

- Mõneti mugav

- Erapooletu

- Pigem ebamugav

- Väga ebamugav

4. Kui valisite küsimuses number 1 "Muu variant", siis kuidas hindate andmete sisestamise mugavusr Teie poolt välja toodud variant?

- Väga mugav

- Mõneti mugav

- Erapooletu

- Pigem ebamugav

- Väga ebamugav

5. Kas olete rahul praeguse lahendusega sissekannete kirjutamisel vaba teksti kujul?

- Jah

- Ei

6. Kui oluliseks peate dokumenteerimise ja olulise info jagamist reaalajas patsiendi ja teiste tervishoiutöötajatega? (Ämmaemandad, naistearstid ja muud olulised osapooled)

- Väga oluline

- Mõneti oluline

- Erapooletu

- Pigem ebaoluline

- Täiesti ebaoluline

7. Kui oluliseks peate dokumenteerimise masinloetavaks muutmist? (Masinloetavaks muutmine kujutab endast oluliste lausete või väljendite struktureerimist viisil, et sisestatud informatsioon jõuab struktureeritud ehk faktide kujul tervise infosüsteemi ja oleks reaalajas nähtav ka teistele ämmaemandatele ja arstidele)

  - Väga oluline

  - Mõneti oluline

 - Erapooletu

- Pigem ebaoluline

- Täiesti ebaoluline

Järgnevalt palun Teil katsetada masinloetavat lausete sisestamise prototüüpi, kus haiguslugude sissekannetes esinevad laused on struktureeritud ning muudetud selliseks, kus teksti sisestamiseks on võimalik sõnade peale vajutades moodustada vajalik lause sellisena, kuidas seda kajastada soovite. Prototüübis on välja toodud kolme lause kombinatsioonid, mis on valitud ämmaemandate haiguslugude sissekannetest (laused hemoglobiini, looteliigutuste tundmise ja kaebuste kohta). Kui olete prototüüpi proovinud, palun lisaks vastata alljärgnevatele küsimustele. Prototüüp on leitav järgnevalt aadressilt: http://cloud.grammaticalframework.org/gfse/ Prototüübini jõudmiseks antud aadressilt palun vajutada "Midwife" peale ning edasi ülevalt paremalt "Minibar" peale. Prototüübis saate proovida erinevaid lause kombinatsioone ning uue lause moodustamiseks tuleb vajutada "Clear", "Random" peale vajutades moodustab arvuti ise kombinatsioonidest lause (juhised on toodud piltidena allpool).

Kui olete "Midwife" peale vajutanud, vajutage "Minibar" peale, et jõuda prototüübini.
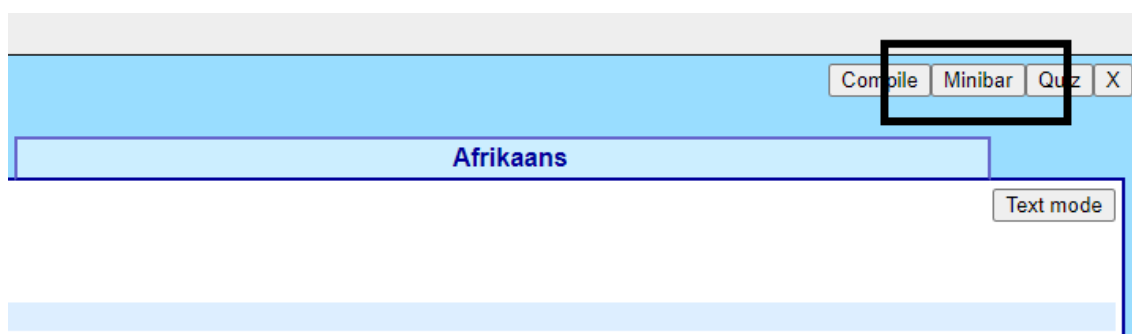
Kui olete jõudnud prototüübini, siis lause moodustamiseks vajutada sõnade peale. Noolega saab kustutada viimast sõna, "Clear" peale vajutades saab alustada uue lause moodustamist ning "Random" peale vajutades moodustab arvuti ise lause kombinatsiooni. Kui sõnad lähevad siniseks, on arvutile arusaadav lause valmis ning saate alustada uue lause moodustamist. Kui pildi peal toodud vasakus mustas kastis on "Afr", siis valida valikust "Est" ning saate hakata lauseid moodustama.
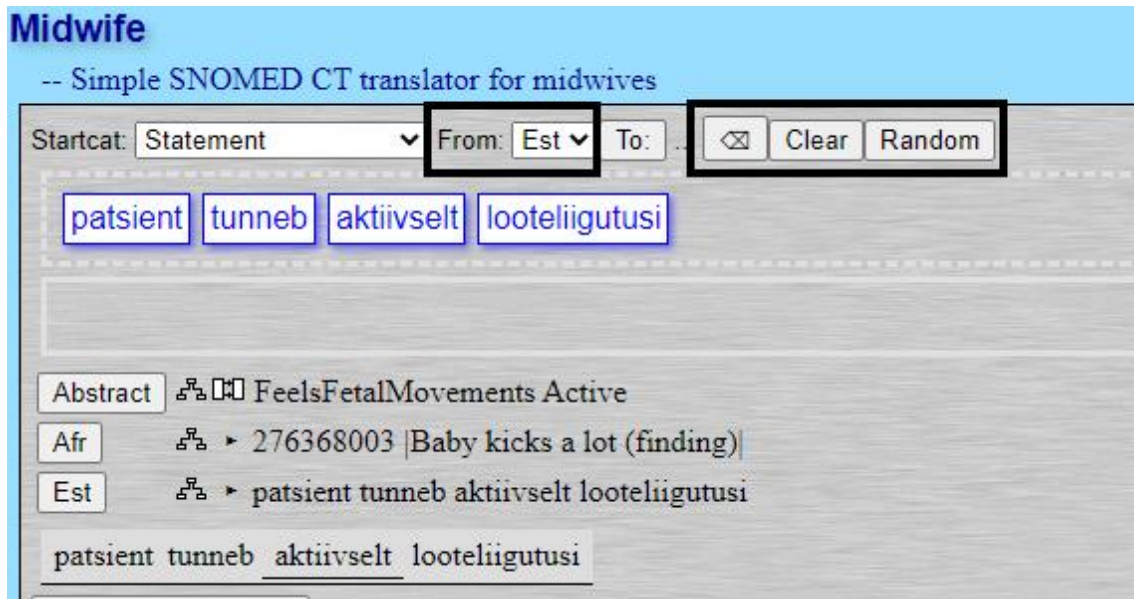
8. Kas eelnevalt proovitud masinloetavavast (arvutile arusaadavast) lausete lisamise viisist oleks Teile abi sissekannete kirjutamisel?

- Jah

- Ei

9. Kas andmete sisestamine prototüübi kujul on Teile arusaadav?

- Jah

- Ei

10. Mida tahaksite muuta?

- ………

-

11. Kas lausete sisestamine prototüübi kujul lihtsustaks dokumenteerimist?

- Jah

- Ei

12. Millised on Teie meelest kõige kasulikumad ja olulisemad laused või faktid, mis on vajalikud dokumenteerida, mis oleksid masinloetavad ja nähtavad reaalajas teistele ämmaemandatele ja arstidele?

- ………