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SUCCESS FACTORS AND BARRIERS OF CLINICAL INFORMATION SYSTEM CHANGE IN INTENSIVE CARE UNIT

A narrative literature review

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THESIS
Abstract

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Abstract

Intensive Care Unit is a working environment where lots of health data is collected widely. Often collected data has visual presentation and it is used to support decision-making. Many Intensive Care Units have a Clinical Information System (CIS) for this purpose. It is usually a complex patient data management system. Changing a CIS is a multiphase project which needs efforts of participants. The purpose of this thesis was to find out the main success factors and barriers of this change process in the Intensive Care Unit and how to prepare for the successful implementation of a CIS.

The method used in this thesis were a scoping review and a narrative literature review. Seven studies were chosen as a result of a literature search from reference databases. In addition to these search results, a few additional research papers were selected for this review. A total of ten studies were reviewed. These studies were analyzed by using thematic analyses with a deductive approach.

Based on the results of this review, it was important for the success of the implementation that the project had a committed leader. Open and clear communication was highlighted as a way to remove barriers. The change and implementation of a CIS would require lots of resources. It was stated that the leader should guarantee sufficient budget, time and personnel resources. Healthcare professionals' training needs and capabilities to adopt a new CIS were noticed to vary a lot. It was recommended to train superusers of the new CIS who could help to provide training and local user support for the personnel during implementation rollout and after that. It was noted that usability of a new CIS should be at a good level before implementation. Otherwise it can decrease acceptance of a new system. The implementation of a CIS was described as a huge and demanding project which needs proper planning and the execution requires a lot of time and resources.

Keywords

data systems, implementation, intensive care

SAVONIA-AMMATTIKORKEAKOULU

OPINNÄYTETYÖ
Tiivistelmä

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Tiivistelmä

Teho-osasto on työympäristö, jossa kerätään laajasti terveystietoja eri elintoiminnoista. Kerätyt tiedot esitetään monesti visuaalisesti ja niitä käytetään päätöksen teon tukena. Monet teho-osastot käyttävät erityisesti tätä tarkoitusta varten rakennettuja monimutkaisia potilastietojärjestelmiä, joilla kerättyä tietoa käsitellään, hallinnoidaan ja esitellään. Potilastietojärjestelmän vaihtaminen on monivaiheinen projekti, joka vaatii paljon kaikilta osallisilta. Tämän opinnäytetyön tarkoituksena oli löytää onnistumisen edellytykset ja esteet potilastietojärjestelmän vaihtamisessa teho-osastolla, ja kuinka teho-osaston tulisi valmistautua, jotta potilastietojärjestelmän vaihto onnistuisi.

Tähän kartoittavaan, kuvailevaan kirjallisuuskatsaukseen sisällytettiin seitsemän tutkimusta lähdetietokantoihin tehtyjen kirjallisuushakujen perusteella. Hakutuloksia täydennettiin soveltuvilla lisäyksillä hakujen ulkopuolelta. Kaikkiaan kymmenen tutkimusta otettiin katsaukseen mukaan. Tutkimukset analysoitiin käyttämällä temaattista deduktiivista analyysiä.

Katsauksen tulosten perusteella onnistuneelle käyttöönottoprojektille oli tärkeää, että projektilla on sitoutunut johtaja. Avoimella ja selkeällä kommunikaatiolla voitiin vähentää onnistumisen esteitä. Muutos ja uuden potilastietojärjestelmän käyttöönotto vaativat paljon resursseja. Tuloksissa todettiin, että johtajan pitää taata projektiin riittävä rahoitus sekä ajalliset että henkilöstöresurssit. Terveydenhuoltoammattilaisten koulutustarve ja kyky omaksua uusi potilastietojärjestelmä vaihtelivat paljon. Uudelle tietojärjestelmälle suositeltiin koulutettavan niin kutsuttuja superkäyttäjiä, jotka voisivat tarjota lisäkoulutusta ja tukea paikallisesti työtovereilleen käyttöönoton aikana ja sen jälkeen. Potilastietojärjestelmän käytettävyys pitäisi olla hyvällä tasolla ennen käyttöönottoa. Muuten se voi laskea uuden tietojärjestelmän hyväksyntää. Potilastietojärjestelmän käyttöönotto kuvattiin valtavaksi projektiksi, joka tarvitsee asianmukaisen suunnittelun, ja jonka toteutus vaatii paljon aikaa ja resursseja.

Avainsanat

tietojärjestelmät, käyttöönotto, tehohoito

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

Clinical Information Systems (CIS) are widely use in Western countries. Many Intensive Care Units (ICU) have an ICU specific patient data management system (PDMS) or CIS in use. (Kyprianou 2019.) In Finland all ICUs are using CISs and most of them are using the same product (Kenkimäki, Keränen, Haverinen & Reponen 2021).

Usability of ICU CIS affects to user experience. Problems with interface design or integrations, malfunctions and lack of customizability or information management make user's satisfaction of CIS lower. Inefficiency of CIS cause unhappiness against CIS and set barriers to fluent workflow. It is shown that there is difference in overall user experience gradings depending on which CIS brand users have used. (Jansson, Liisanantti, Ala-Kokko & Reponen 2022.)

In Finland there have been some public discussions of CIS implementation project called Apotti in recent years. Apotti is CIS which has implemented widely to public healthcare and social services in Helsinki and Uusimaa region (Apotti 2023). In public Apotti has got criticism its complexity and poor usability. Nisula (2019) reported lower efficiency after two months of implementation. In Finnish Medical Journal physicians Minna Halinen and Tiina Laine demanded further development of usabilitiy after three to four years of implementation (Ekholm 2022). Although public impression of Apotti is mostly negative, Ekholm (2022) reported also some good experiences too. Structural notes of electronic health record can provide more information of efficacy of healthcare and provided treatments.

The vendor of the most used ICU CIS has announced that product development will be terminated in 2027. This announcement has forced Finnish ICUs to explore which alternatives are available after 2027. Most likely many of ICUs will change CIS product to another available on the markets. The change has significant impact for daily routines (Mason & Leong 2016). It can be expected that personnel take time to get familiar with new CIS and this may cause extra workload for professionals. Nisula (2019) mentioned as a one reason of lower efficiency with Apotti is that personnel is not get familiar with new CIS yet after two months of implementation.

Is there something to learn from Apotti implementation project? Are some of barriers avoidable in future? Purpose of this narrative literature review is to find out which are main success factors and barriers of CIS change process from ICU point of view. If Finnish ICUs decide to take another CIS in use what should take noticed before implementation? In theoretic frame there is explained Finnish ICU and it's specialties, phases of CIS's life cycle and success factors of implementation process. There is also described ICU environment and what kind of requirements it set for CIS. In results part there is presented previously published scientific studies and case reports of CIS change projects. The results of this review can be used for preparation of CIS change.

2 INTENSIVE CARE AS PART OF FINNISH HEALTHCARE SYSTEM

Public health service is available for all who lives in Finland. It is financed by tax payments and well-being service counties have had organizing responsibility since the beginning of 2023. There are two levels of services which are primary healthcare and specialized healthcare. Health centers are providing primary healthcare services and specialized healthcare is mostly centralized to hospitals. In addition, private sector provides supplement for both levels of public services. (STM 2023.)

In Finland there are total of 30 specialized healthcare departments which can provide at least basic level intensive care or intermediate care. All of these are public healthcare departments. Determinations of intensive or intermediate care can be variable in different countries and may have local differences. In Finland, Intensive Care Unit (ICU) is a department where patients are treated in case of serious acute illnesses or trauma or post-treated after major surgical operation. Typically, these patients have serious disorder of vital processes or threat of that. (Bendel et al. 2023, 11-13.) Intermediate care patients have continuous demand of monitoring. Indications for intermediate care are mostly same than intensive care has but patients' symptoms are milder. (Bendel et al. 2023, 11-12; HUS 2023.) Average treatment period takes three days and there are around 20 000 treatment periods yearly in Finnish intensive or intermediate care units (Kari et al. 2019).

ICUs are multi professional communities (Brewster, Butt, Gordon & Rees 2020; Bendel et al. 2023, 11-12). Usually, ICUs require high numerous staff and lot of medical devices. One ICU bed requires total resources of six nurses' contribution to be available 24/7. Requirements of personnel numbers are higher at the beginning of treatment but decrease usually during treatment period. Typically, patient in heavy intensive care requires at least one nurse all time. For intermediate care level patients, is one experienced intensive care nurse able to deliver care for two to three. Physician acquainted with intensive care should be all time long available at intensive care unit or intermediate care unit. Usually, intensive and intermediate care are both provided by same personnel with same devices. (Bendel et al. 2023, 11-13.)

ICUs are technical working environments where patients are monitored and treated by several different medical devices. For example ventilator, patient monitor and perfusores are used bed side and these are connected to patient. (Mason & Leong 2016; Bendel et al. 2023, 11, 54.) Data can be collected manually but nowadays it is widely automatized with digital devices and tools. Intensive care units generate large amounts of data because of continuous monitoring by medical devices. There is developed specialized Clinical Information Systems (CIS) for intensive care purposes to process this data. (Mason & Leong 2016; Kyprianou 2019.) In Finland, all intensive care departments are using specialized CISs and 76% are using same product for data management and processing (Kenkimäki et al. 2021).

3 CLINICAL INFORMATION SYSTEM

In developed countries patient's health information is gathered, presented and stored mostly in digital way. Quantity of digital health information can be huge. Results of blood examples, x-ray imagines and medical history are presented and managed with computers. (Payne 2015, 3; Mason & Leong 2016). There are also healthcare units where need for data acquiring is ongoing all the time. This sets challenges for healthcare professionals to collect information with sufficient accuracy as well to manage all gathered data. (Plenderleith 2013; Islam, Poly & Li 2018.) Clinical information systems are developed to comply all these requirements. An idea of Clinical information system is that it can display all necessary information from different sources in rapid way to make healthcare professionals' work more effective. Automation can also acquire and store more information with better accuracy than human so information quality should be better. (Plenderleith 2013; Payne 2015 3; Islam et al. 2018.)

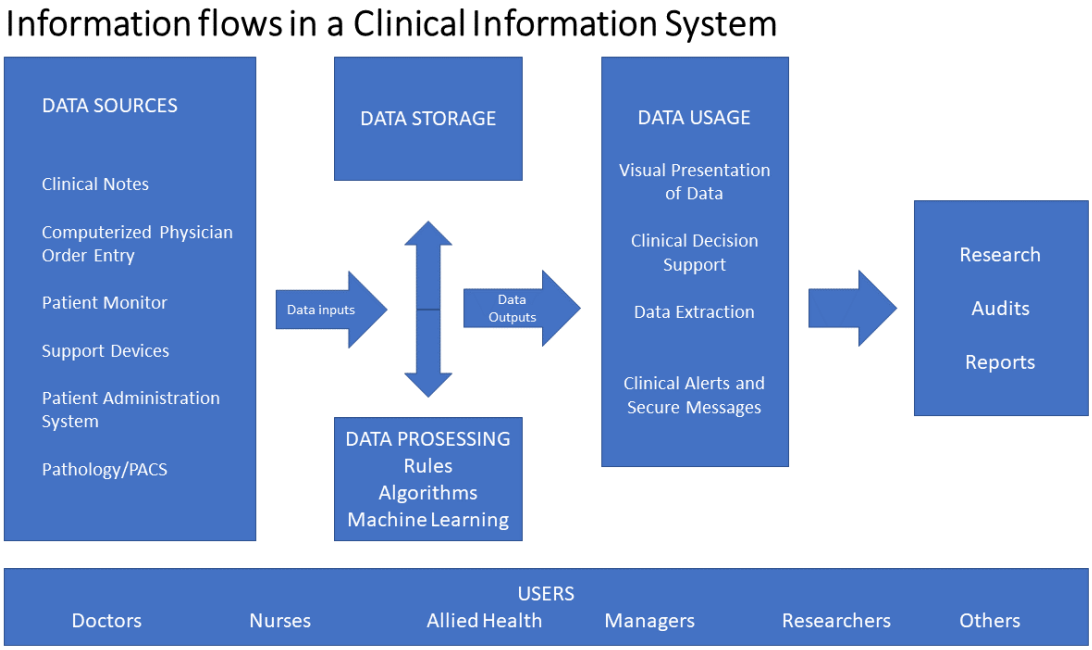

Figure 1: Information flow in a clinical information system adapted from Mason & Leong (2016).

There are several Clinical Information Systems available on the market and these can be classified by functions and properties. Islam et al. (2018) found in their review of Clinical Information Systems that the most common types of systems are ambulatory and impatient information systems, specialty information systems and ancillary information systems. There are also several ways how to call these data systems and some of these names may be used side by side. Data systems of Intensive Care Units are called like Clinical Information System CIS, Patient Data Management System PDMS or Intensive Care Unit Information System ICUIS. These data systems are specialized to collect, manage and display complexity health data from various sources. (Islam et al. 2018.)

3.1 Life cycle of Clinical Information System

All hardware and software have their own period for usage. Advancing technology causes that in some point old technology has more disadvantages and it is better option to change current version

to up to date products. This is called as a life cycle of IT technology or products. Life cycle thinking may help organizations to prepare replacements on time and receive required financial and human resources. (Payne 2015, 55.)

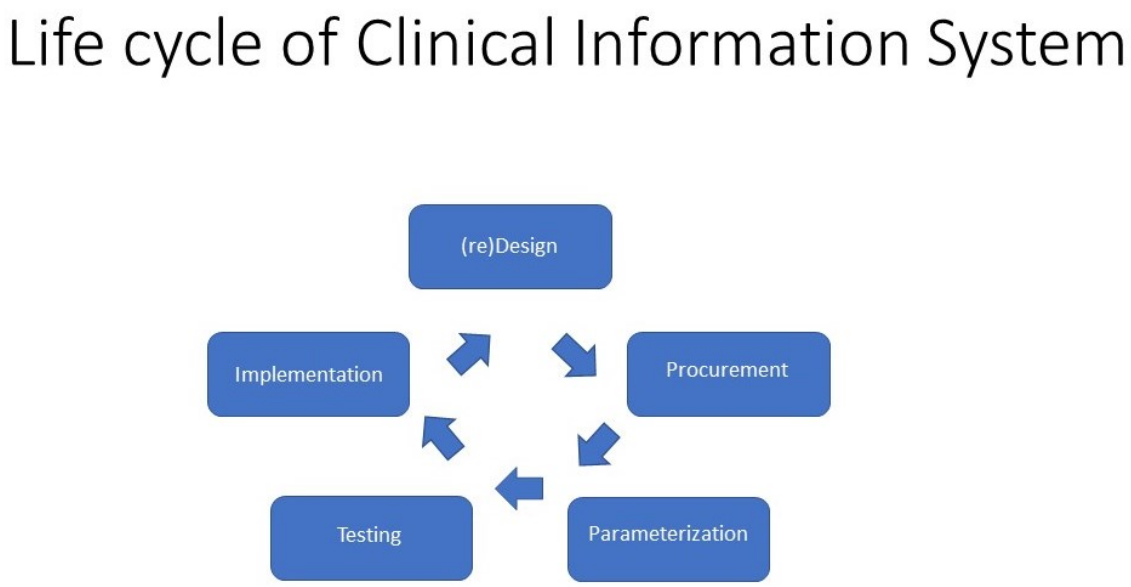

Figure 2: Life cycle of Clinical Information System adapted from Kyprianou (2019).

The key issue of software or application design is to pay attention to product's purpose of use. It is important to focus on good usability, well working interfaces and functionalities (Payne 2015, 4-5; Jansson et al. 2022). CISs are expected to improve workflow and efficiency in healthcare departments while patient numbers are growing constantly. CISs in healthcare need to have a good interoperability with other data systems. Information technology architecture in hospital may be complicated and health information must be transferred between programs. That's why capabilities of integrations and standards for information transfer like HL7 are required features for advanced CIS. (Payne 2015, 3-15.) Health information includes a lot of sensitive and personal information so security and safety of CIS is obligatory. Information security is one concern to deal but also technical malfunctions or service breaks may cause serious safety issues and these are potential threats for patient safety. (Lee et al. 2018.) Risk assessment should be done at design phase in all organizations (Payne 2015, 79-81).

Before procurement process of new CIS is completed there are few steps to take. In early stage it may be good to perform a request for proposal. This process provides information of available products and vendors in the market. (Payne 2015, 86-87.) There will be advantage if determinations of functional and technical requirements are made in early phase of procurement process. At least these specific requirements need to be done before tendering. (Payne 2015, 86-87; Kyprianou 2019.)

Building of CIS to meet local requirements is multiphase process. Complex CISs is like a puzzle of functionalities and features which can be chosen for custom made version of CIS. (Nisula 2019.) It is necessary to know system's functionalities and understand capabilities already in design phase.

Otherwise, there may be difficulties to discover and create relevant configuration solutions for daily use. It is also important that healthcare professionals take part of this local CIS building process. (Payne 2015, 92-94; Nisula 2019.) Parametrization takes time and specific task lists make it easier to follow the progress. It is possible that configuration phase reveals change or development needs which weren't noticed in design phase. Test environment or "sandbox" helps to get familiar with functionalities. (Payne 2015, 93-94.)

Testing of Clinical information system must be done from many points of views. Functions need to be tested standalone and as a part of data system. Integration and information transfer to other programs have to work properly. Testing of medical devices connections includes interoperability and functional observations. Clinical information system's performances should be tested also in situation of high workload. User experience is one part of testing process which has a huge role in reaching acceptance for new clinical information system. Users' feedback must lead to changes towards better usability. (Payne 2015, 94-96.)

Training planning of personnel should start in early stage. In the training stategy it is necessary to define who will be trainer, what and when will be trained. Creating training program is collaboration between system design or configuration specialists and testing personnel. All has own specialties which supply additional understanding for training. There should be participants from both vendor and local personnel. In testing phase it is possible to notice if there is a special need for focusing on something in training part. (Payne 2015, 96-97.) Staff training should be the final phase before CIS implementation goes live (Payne 2015, 97; Nisula 2019).

To ensure successful rollout of new CIS, there are recommendations to train enough super users who are IT skilled healthcare professionals. They can give a support for practice when implementation has moved to activation phase. Success requires that couple of advanced users of CIS are available in all shifts. Technical support should be 24/7 available when activation happens and even after that enough long period. (Payne 2015, 103-104; Kyprianou 2019.)

3.2 Success factors of Clinical Information System implementation

Implementation of CIS is a huge project which has effects to daily workflows. It demands lots of resources and efforts from all involved groups like project leaders, vendor, IT staff and healthcare professionals who are end users of the CIS. (Mason & Leong 2016; Nisula 2019.) It may take years to complete the whole implementation project (Detwiller & Petillion 2014; Nisula 2019). Successful implementation is an objective of the project which usually progress phase by phase although there may be some parallel actions. Execution part of implementation is like own project inside the CIS life cycle. It requires leaders, planning, resourcing, execution and assessments after rollout. This is the phase where plans are going live and the rollout happens. After this it is necessary to monitor and control the change and follow workflows to assess if objectives of implementation are met and is the implementation completed successfully before end of project. (Mason & Leong 2016.)

One critical success factor of implementation project is to name a project team with project leader. The team should be multidisciplinary so that it consists of managers, technical staff from vendor's site and IT department and end users like nurses and physicians. It is important that end users are

involved as team members and testers from the beginning of the project. It may be needed to change workflows with new CIS so those need to be assessed with sufficient understanding of current workflows and healthcare specific requirements. If workflows are designed effectively and these are enough simple, it minimizes needs of training and makes implementation easier. (Mason & Leong 2016.) Objectives, methods to reach goals and available resources need to be determinated before implementation. After implementation it is necessary to have continuous assessment of results and the implementation team should be prepared to react fast if some changes are not working properly. (Detwiller & Petillion 2014; Mason & Leong 2016; Nisula 2019.)

Lack of superusers or project champions can be major risk or barrier for successful implementation. Project champions works between project team and end users and they provide clinical knowledge to the project team and on the other hand they can promote the new CIS for their peers who are other end-users. Champions or superusers have impact to success of CIS implementation as they can remove or report exiting barriers to project team so these can be solved as soon as possible. (Detwiller & Petillion 2014; Mason & Leong 2016). In addition, project leader's commitment has great impact of success. Leader has to provide sufficient resources for budget, time and personnel and s/he has to be engaged to the project to ensure proper completion of implementation within frames. (Mason & Leong 2016.)

CIS has to be suitable for its purpose of use. If the CIS is a part of larger EHR procurement, there is a risk that selected CIS is not perfectly fit for requirements of specific department like ICU. Operational usage of CIS must be at good level when implementation rollout happens so that it will not decrease CIS's acceptance. (Mason & Leong 2016.) If the implemented CIS is complex system, it is good idea to focus on main functionalities and stability of CIS at the beginning of implementation project. There is higher chance of success if the new CIS has less functions which are working correctly than if there are plenty of impractical features which have poor usability or there are stability problems. (Mason & Leong 2016; Nisula 2019.) Ekholm (2022) wrote that her interviewed physician told about same experiences concerning usability of Apotti.

It is easier to achieve individuals' commitment of change if all understand objectives. Strong efforts for communication are obligatory and it is one of the most important success factors. The leader has to communicate clearly to all levels of organization. Change management is crucial and leaders should support implementation. (Detwiller & Petillion 2014.) To ensure permanence of change it is suggested to perform pre-assessment and research of department's technical and mental readiness to adapt the new CIS before implementation. It helps to create realistic plans and to assess readiness. In addition, sufficient continuous support is important after implementation and it should last long enough. (Detwiller & Petillion 2014; Tun & Madanian 2023.) Nisula (2019) reported high number of support request in three weeks after CIS implementation in Peijas Hospital and lower efficient of workflows after two months of implementation.

Pre-assessments provide also information of training needs. Personnel may have different level of digital skills which affects to training needs. (Scott, Sullivan & Staib 2019.) Well planned training is one of important success factors (Payne 2015, 104; Scott et al. 2019; Tun & Madanian 2023.) Classroom training and eLearning are the most used methods and usually those are used as a mix (Payne

2015, 104). Still Tun & Madanian (2023) reported that classroom training is not efficient and kept one by one training or shadowing as better way to provide training of new CIS.

3.3 Intensive Care Unit's requirements for Clinical Information System

Many ICUs of the Western countries have some Clinical Information System in use but in poor countries the situation is not same. Requirements of CIS depends on purpose of use. ICU is one of the most demanding working environments where CISs are in use. (Kyprianou 2019.) These circumstances set high requirements of performance capability and functionalities to gather, manage and present several parallel information.

Monitoring vital signs of life functions is continuous and it create huge number of measurements and data. This is done by several medical devices from different vendors. (Payne 2015, 3.) It is a great advantage if clinical information system is capable to receive transferred information automatically via integrations. Gathered data should be available and presented in informative way so it can be used for decision making support. (Mason & Leong 2016.)

In addition, ICUs work together with other departments so integration with other hospital data systems is extremely important. Typical needed integrations are with electronic systems of radiology and laboratory. Well working integrations with important programs improve efficiency of workflows. (Payne 2015, 15-16; Nisula 2019.)

4 STUDY METHODOLOGY

4.1 Narrative literature review

Literature reviews are scientific methods to produce information for different purposes and these reviews have got a stable place in the field of science in last decades. Literature reviews can be divided to three categories which are narrative literature reviews, systematic reviews and meta-analysis. Narrative literature review is a way to produce descriptive information of selected agenda based on earlier scientific information available. (Kangasniemi et al. 2013; Stolt, Axelin & Suhonen 2016, 7-8.) It has been criticized to be unspecific, tendentious and partly insufficient method but still it is widely used to describe theoretical or practical phenomenon defined, analyzed and thoroughly based on previously published literature (Kangasniemi et al. 2013). Depending on a point of interest and study pre-setting narrative literature reviews can be divided to subtypes. Known subtypes of review technics are traditional, critical, mapping, scoping, rapid, overview and state-of-art review. (Stolt et al. 2016, 9.)

Scoping reviews are used to find out previous studies and what is known of the subject already. Scoping review can be also done as a preparation of systematic review to explore if there are enough studies available. The main idea is to find information as much as possible and usually there is less focus on ethical and reliability issues. Analytical results of scoping review provide synthesis of previous studies' observations and conclusions which can be useful support for decision making. (Stolt et al. 2016, 10-11.) This narrative literature review will be scoping review of CIS change process, its phases and success factors.

The purpose of this thesis is to describe known information of electronic CIS change process in healthcare unit. Important findings are phases of the change process and with this literature review it is tried to recognize requirements and main barriers which may affect CIS change project. This may provide necessary information for healthcare units to make planning and resourcing for such projects in the future.

4.2 Research questions

The basis and the first step of narrative literature review is creating research questions successfully. This determinate how deeply and widely the agenda will be studied and which point of views are used. Research questions of narrative literature reviews are usually well suited for evaluation of present practices, development of recommendations or improvement of working habits as well as gathering scattered information for working or educational purposes. (Kangasniemi et al. 2013.)

Research questions of this narrative literature review are:

1. Which are main success factors and barriers of Clinical Information System change process in Intensive Care Unit?

2. How Intensive Care Unit should prepare for Clinical Information System change?

4.3 Search strategy and results

Search strategy base on research questions. Searching and selecting of material for review depends on used method and resources available. (Stolt et al. 2016, 25.) Selecting and analyzing of material are happening partly at same time. During the selection process all material adequacies will be compared to research questions. The selected material usually consists of recently published scientific information which is relevant from study point of views. This information can clarify, classify, criticize or interpret the research question. The materials of literature reviews are searched from selected electronic databases. (Kangasniemi et al. 2013.)

Material selection process is required to describe so that it can be evaluated and redone. The selection process description can be done from selected material only or include the whole systematic process. If the selected material is only described, reporting should focus on adequacy, meaning and reliability of source and the source critic should be included to description and analysis. In systematic selection tabling is useful tool to present how material has selected. In narrative literature review's systematic material selection allows to differ from original search title and manual search may be necessary. The most important thing of material selection is the content. Some material can be accepted from outside of the structured search if the content is meaningful and relevant for research questions. Narrative literature reviews can also use some other material than only scientific publications. (Kangasniemi et al. 2013; Stolt et al. 2016, 25-27, 32.)

For literature search of this review, it was used three reference databases which include publications from the field of healthcare. CINAHL Ultimate is a wide reference database where can find publications of health and nursing sciences. PubMed is one of the most important reference database in medical and nursing sciences including also the nearest fields of sciences. ScienceDirect includes publications from medical and technological sciences. In addition, the Finnish healthcare reference database MEDIC was used as a tool to identify adequate keywords for search title.

Keywords were selected from commonly used determinations of Clinical Information Systems, Critical Care, Implementation and Success. Medical Subject Headings (MeSH) were used in addition to increase accuracy of search. Search title was created with keywords and Boolean operators. The searches were limited to publications which were published in 2010 or later and were written in English or Finnish and available abstract was required. At first, search results were evaluated by relevancy of title. If the title refers to implementation of Clinical information system or Electronic Health Record or CIS use in Critical Care the relevancy of publication was checked from abstract which after decision was made if it can be included or not to this review as literature material. Inclusion criteria were evaluated as presented in table 1 and decision to include or exclude based on that inspection.

INCLUSION CRITERIA	EXCLUSION CRITERIA
Published 2010 or later	Published before 2010
Written in English or Finnish	Written in any other language
Material has published in scientific journal	Not published in scientific journal
Available in digital form	Not available in digital form
Free access or available via Savonia's access	Not available without payments
Abstract available	Abstract not available
related in electronic health record or clinical information system, implementation or adoption	not related in electronic health record or clinical information system, implementation or adoption

Table 1: Inclusion and Exclusion criteria

The Medic reference database was used as a tool to find relevant keywords of Medical Subject Headings. The search was completed with MeSH keywords "Critical Care" AND "Medical Record Systems, Computerized". This resulted three hits but none of these were scientific studies and these were excluded.

In CINAHL Ultimate reference database the search was completed on 22nd of February 2023. Search title was following: ("Hospital Information System*" OR "Clinical Information System*" OR "Electronic Health Record*") AND ("Critical care" OR "intensive care" OR ICU OR "Critic*") AND ("Implementation*" OR "adopt*") AND ("Success*"). It resulted 135 hits which led to more accurate inspection of abstract in 18 publications. Finally total of three subjects were included to this review.

In PubMed reference database the search was completed on 24th of February 2023. Search title was following: ("Hospital Information System*" OR "Clinical Information System*" OR "Electronic Health Record*") AND ("Critical care" OR "intensive care" OR ICU OR "Critic*") AND ("Implementation*" OR "adopt*") AND ("Success*"). It resulted 254 hits which led to more accurate inspection of abstract in 13 publications. Finally total of three subjects were included to this review.

In ScienceDirect reference database the search was completed on 26th of February 2023. Search title was reduced from previous data searches due to limitation of Boolean operators in ScienceDirect and requirement of remove *-marking. The search title was following: ("Hospital Information System" OR "Clinical Information System" OR "Electronic Health Record") AND ("Critical care" OR "intensive care" OR ICU OR "Critic") AND ("Implementation" OR "adopt"). It resulted 87 hits which led to more accurate inspection of abstract in 6 publications. Finally total of one subject was included to this review.

In addition, it was found three relevant studies out of the searches which were evaluated with criteria like presented on table 1. The inclusion criteria were met by all three articles and these were included to review. In table 2 all selected studies are listed and it is available in Appendix 1.

The search results are presented on table 3. Total of 41 research were performed more accurate evaluation and 10 of these were included to review. All selected literature were related to implementation process of EHR or CIS but the point of view varied a little. One of ten was focused on factors of successful implementation of EHR. Six studies of ten had focused more on factors of EHR adoption and one study of ten had a point of view in implementations in ICU. One article of ten had focused on leadership perception and one was describing human resourcing in cost-effective way.

	HITS OF PRIMARY SEARCH	SELECTED FURTHER INSPECTION BASED ON TITLE	INCLUDED TO REVIEW
CINAHL Ultimate	135	18	3
PubMed	254	13	3
ScienceDirect	87	6	1
Medic	3	1	0
manual	3	3	3

Table 3: Summary of search results

4.4 Thematic analysis

In analysis part of study, it is tried to find out answer to research questions and make further conclusions. While doing analysis of selected material, it is compared similarities and differences of material and perform critical evaluation of information and sources. In synthesis gathered information will be put together and create an overall view of study subject. If the findings include incoherencies, those are presented also in synthesis. The aim of analysis and synthesis is to make internal comparison of material, discover strength and weakness of information and to create conclusions. Observation point of views and classifications of results can be selected depending on research questions. One useful way to perform analysis is to have one or few main sources and compare other literature with it. (Kangasniemi et al. 2013; Stolt et al. 2016, 30-31.)

The content of studies which were included to this review were analyzed by using thematic analysis method. In this method it is discovered main subjects of the included data and big picture of the themes is created around of main subject by using mind mapping. In thematic analysis it is possible to use inductive or deductive approach. (Tuomi & Sarajärvi 2018.) Inductive approach bases on findings of data and those are leading analysis forward. In deductive approach there is a framework which bases on previous knowledge or theory. Facts and phenomenon are discovered from data according to created framework. Deductive analysis framework can be wide, and it can be completed with inductive approach during analysis process. (Kyngäs, Elo, Pölkki, Kääriäinen & Kanste 2011.)

With thematic analysis it was tried to find out answers to research questions. In this review studies were analyzed by following deductive thematic analysis. From theory framework there were selected the most relevant main subjects of research questions which created framework of deductive analysis. Based on previous literature, training, resourcing, leadership, human factors and technical factors are critical success factors of CIS implementation. The included data was carefully analyzed, and it was discovered findings related to selected themes. Figure 3 presents an example of completed thematic analysis around one theme. It was created a mind map according to findings. The figure 3 is available as Appendix 2.

5 RESULTS

Results reporting includes discussion of content and used methods as well as evaluation of ethical issues and reliability. Results reporting gather and summarize main observations and compare how these or conclusions affect present practices or environments. Results can be estimated in the future's point of view and many times reports have predictions for further study subjects. (Kangasniemi et al. 2013.)

5.1 Training

Importance of training comes clear from several studies, and it has seen as one of the critical success factors. Focus of training is needed and organizations have to commit to do it properly. Studies highlight that training should be effective and it need to be available enough. (McAlearney et al. 2012; Safdari et al. 2015; Vadillo et al. 2016; Sidek & Martins 2017; Luyten et al. 2021.) Success of training depends on timing, targeting, quantity and executing ways. If training is not relevant, is too early or is insufficient, it may be significant barrier for successful implementation. (Saleem et al. 2015; Vadillo et al. 2016; Sidek & Martins 2017.) Well performed training may increase efficiency and affect chance of successful implementation of CIS (Vadillo et al. 2016).

In the planning stage of training, it is good to realize that healthcare professionals' basic IT or digital skills and capability of learning new technologies may be variable. In studies were noticed needs of basic computer skill learning and IT vocabulary. (McAlearney et al. 2012; Vadillo et al. 2016.) Digital skills were identified as important element for adoption of new technology and if staff do not have sufficient skills and knowledge, it may decrease the chance of CIS implementation successfully (Vadillo et al. 2016; Sidek & Martins 2017). Pre-assessment can be considered to find out demand and needs of training. Assessments can be used also for assessing of retraining after CIS implementation has gone live. (McAlearney et al. 2012.)

It is also good to notice features of training group and targeting training to meet their training needs. All healthcare professionals do not need to teach all same features but training should be concentrate to necessary functions only. (McAlearney et al. 2012; Dziadzko et al. 2016.) Targeting may be necessary also considering digital skills as lower skills may cause slower learning. If the skills are noticed, it is possible to forward slowly with some groups. (Vadillo et al. 2016.) Mostly in studies it was discovered that traditional classroom training was the most effective way to learn for staff (McAlearney et al. 2012; Luyten et al. 2021). Web courses and one-by-one training were not so efficient or requested training method (Luyten et al. 2021). On the other hand, those training methods were good addition for training. The selected training method impacts the structure of training and it need to be considered at planning stage. (McAlearney et al. 2012.) For proper training environment it is necessary to have trainers and computers available enough for efficient training. Trainers need to be available for all groups of professionals. (Vadillo et al. 2016; Arabi et al. 2022.)

It is common startegy to recruit and train some "superusers" of CIS. Their duty is to provide support for staff locally when implementation goes live and after that. There are different variations of using superuser but common is the role of superusers which is highlighted in studies (McAlearney et al. 2012; Saleem et al. 2015; Standing et al. 2015; Vadillo et al. 2016; Bullard 2016; Arabi et al. 2022).

Training of superusers need to be started earlier that other staff so that they get familiar with CIS. It is necessary to allocate time enough for superuser training. This time resource has great variation from 8 weeks to 8 hours in studies. (Saleem et al. 2015; Bullard 2016.)

5.2 Resourcing

Implementation process of CIS demands high recourses. Training of new CIS has to be done along with daily action and this increase the need of staffing. With insufficient staffing it can be hard to complete effective training. (Bullard 2016.) McAlearney et al. (2012) also mention that it is important to have recruited healthcare professionals as trainers as it was more effective to teach them to use and teach CIS than IT professionals to talk and understand about terminology of healthcare. This affects to efficient of training but also requirements of staffing. In addition, it is good to prepare that when the new CIS goes live and few weeks after that, daily actions may need some extra staffing. Implementation of new CIS decreases efficiency of working and causes slower actions than normal so extra workforce may be needed to comply daily routines. (Vadillo et al. 2016; Sidek & Martins 2017.) These need to be considered when personnel staffing is in agenda and organization has to commit to provide sufficient personnel resources to make successful implementation possible (McAlearney et al. 2012). Investments at the beginning affected positively to learning performances and acceptance of CIS which advances success of implementation (Luyten et al. 2021).

User support during and after implementation is necessary taken account in resource planning. It should be available easily long time enough. (McAlearney et al. 2012; Bullard. 2016; Arabi et al. 2022.) Agreements and responsibilities of user support and co-operation need to be determinate with local IT department and vendor (Safdari et al. 2015; Arabi et al. 2022). User feedback requires fast reaction so that satisfaction can be ensured. From number of feedbacks, it can be estimated how successfully the implementation has proceeded and what is the level of support need. (Arabi et al. 2022.) Successful solution of managing feedbacks and technical requests was recruit a full time CIS coordinator or start a command center which reacts and coordinates support and all requests (Saleem et al. 2015; Arabi et al. 2022). Continuous need of support lasted 2 to 4 weeks after implementation in these studies (Bullard 2016; Arabi et al. 2022).

Bullard (2016) wrote that experienced professionals are usually recommended to be superusers which affects to staffing. Superusers are out of normal duty for variable time and this may cause lack of knowledge in daily actions. As a solution for this challenge she reported good experiences of hiring newly graduated nurses as superusers. Some of requested superuser group were experienced and some novices. Novel nurses were well capable to learn new CIS and they were able provide local support for experienced colleagues during implementation as well. Bullard also reported good effects of recruitment as many of newly graduated and hired as superusers got their introduction at same time when they provided user support of CIS and they were able to join staff permanently after need of superusers ended.

Financial requirements are high in implementation process and it is mandatory to have sufficient financial resources available (Standing et al. 2015; Bullard. 2016; Vadillo et al. 2016). Financial is-

sues may halt the implementation totally (Vadillo et al. 2016). The investment is significant and resource needs are huge (Arabi et al. 2022). Some financial saves were reported by Bullard (2016) in case of hiring newly graduated superusers instead of experienced superusers.

5.3 Leadership

Leadership of CIS implementation project may be the most critical success factor according to studies (Safdari et al. 2015; Standing et al. 2015). Change management has a great role of CIS change project and adoption of new technology. Open, clear communication and meaning of sufficient information providing is highlighted in studies. (Vadillo et al. 2016; Sidek & Martins 2017; Arabi et al. 2022.) Careful use of communication may be affected to amount of resistance. Communication is another critical success factor of CIS successful implementation. Vadillo et al. (2016) reported that well performed communication is the only way to overcome staff's concerns of implementation. So clear communication really needs special attention (Sidek & Martins 2017; Luyten et al. 2021).

Project manager of CIS change should determinate clear vision and strategy how to reach the goal. Good planning improves chance of success. (Arabi et al. 2022.) Implementation roadmap provides sight of project phases and an assessment tool where all tasks are listed provides information of readiness of phases (Safdari et al. 2015; Arabi et al. 2022). The most used implementation strategy is called as "big bang" which means preannounced date when all go live with new CIS (Bollard 2016; Arabi et al. 2022).

Organizational support for implementation project is crucial from leadership point of view (Standing et al. 2015; Sidek & Martins 2017). Collaboration with partners should be well coordinated and it is important that tasks and roles and expectations are clear for all (Saleem et al. 2015; Standing et al. 2015). Collaboration should be started early so that requirement analysis and preparations can be done together (Saleem et al. 2015; Sidek & Martins 2017). If there are several departments involved to CIS change project, all departments should have their own change managerial group to report and follow local progress (Arabi et al. 2022).

5.4 Human factors

Change may cause resistance among people. Sidek & Martins (2017) reported resistance especially among veteran professionals. Implementation of new technology was felt stressful and hard in study made by Vadillo et al. (2016). They also reported concerns and fears related to implementation and they found that digital skills, age group and experience level affected to acceptance of new technology. Resistance of change may be result of unsatisfaction of changing workflow (Dziadzko et al. 2016). Dziadzko et al. (2016) as well as Luyten et al. (2021) both reported that this was temporary decrease of satisfaction and it started to return at later.

Human factors and behavior are important critical success factors for CIS implementation (Safdari et al. 2015; Sidek & Martins 2017). If personnel has possibility to join implementation planning it may decrease the resistance of change (Safdari et al. 2015; Arabi et al. 2022). Vadillo et al. (2016) reported positive effects of noticing and responding individual's needs. Chance of success increased if needs were met. Human factors engineering was recommended to use before implementation goes

live. Impacts of social, technical and environmental aspects should be assessed. (Saleem et al. 2015.)

5.5 Technical factors

Technical issues may be significant barriers for successful implementation (Standing et al. 2015; Sidek & Martins 2017). Problems of stability decrease reliability. Poor usability of CIS may have effects to efficiency. (Saleem et al. 2015.) Time consuming data search decreases efficiency (Dziadzko et al. 2016). In the worst case the poor usability may cause extra workload for staff like double documentation. Also, if data is presented poorly or information is hard to find it affects to acceptance of CIS. One important feature of CIS is reporting capabilities but if these are missing or are inadequate it causes frustration. (Saleem et al. 2015.)

Good and clear data presentation and visualization may increase acceptance of new CIS. Dziadzko et al. (2016) reported that accuracy and timelines together with visualization increased satisfaction and encouraged to continue use of new set up. On the other hand, if customization chances are insufficient it may be significant barrier for further use CIS (Saleem et al. 2015; Sidek & Martins 2017).

Saleem et al. (2015) found that hardware issues are barriers of CIS implementation if these are experienced. They also reported that lack of integration capability to other systems and devices caused frustration. Dziadzko et al. (2016) made same kind of notice in their results. The connection between devices and CIS was too complicated so it caused lag-time which led to decreased satisfaction. Necessary and sufficient technical support for hardware and software issues is mandatory through whole implementation (Safdari et al. 2015; Saleem et al. 2015).

6 DISCUSSION

This literature review process has proven how huge and complicated project is CIS implementation. It is burden and demanding situation for personnel but also gigantic challenge for leaders of department and project manager. There are several factors affecting to final results. None of these should ignore if the goal is successful CIS adoption.

The results of this review are very much same as previous literature suggested. Detwiller & Petillion (2014) and Mason & Leong (2016) mentioned importance of leadership and communication which were noted from studies of this review too (Safdari et al. 2015; Standing et al. 2015; Vadillo et al. 2016; Sidek & Martins. 2017; Arabi et al. 2022). Leaders should provide sufficient resources of funding, staffing and timing and take care that project team has proper knowledge enough (Detwiller & Petillion 2014; Mason & Leong 2016; Nisula 2019). According to Luyten et al. (2021) and Arabi et al. (2022) study results it is profitable in long term to invest more to implementation as this has positive affects to satisfaction of end users and ensures smoother and efficient workflows.

Payne (2015), Mason & Leong (2016) and Nisula (2019) mentioned technical readiness and good usability as success factors of implementation which were confirmed in reviewed studies. Saleem et al. (2015), Standing et al. (2015), Dziadzko et al. (2016) and Sidek & Martins (2017) were all reporting results of usability and technical readiness which affected to success of CIS implementation. According to their study results, if local configuration and parametrization works well there is better chance to success of implementation. Saleem et al. (2015) and Dziadzko et al. (2016) found that integration capabilities and data transfer are important features like Payne (2015, 94-96) wrote before.

Change management and training are keys to manage human factors of implementation process. Detwiller & Petillion (2014) wrote importance of individuals' commitment as a success factor. Reviewed studies reveals that the change caused reactions like stress and fears which may lead to resistance (Vadillo et al. 2016; Sidek & Martins. 2017). By investing to training of personnel, it is possibility to reduce their burden. Although Tun & Madanian (2023) reported that classroom training is not efficient, in result of this review McAlearney et al. (2012) and Luyten et al. (2021) reported it as an effective training method and the most recommended strategy. Nisula (2019) described intensive staff training on last weeks before implementation. According to results of Saleem et al. (2015) and Vadillo et al. (2016), right timing of training is important and too early provided training may be obstacle for success.

Mason & Leong (2016) mentioned that lack of a project champions may be one of risk factors for unsuccessful CIS implementation. Detwiller & Petillion (2014) reported super users' capability to help overcoming of barriers. McAlearney et al. (2012), Saleem et al. (2015), Standing et al. (2015), Bullard (2016), Vadillo et al. (2016), and Arabi et al. (2022) all reported of benefits of superusers or champions during implementation process. Superusers are recommended way to provide local and effective user support at the time and after the big bang has happened.

Studies which were included this review reveals that training of new CIS may be time consuming but mandatory part of implementation preparation. How much of training is enough depends on selected CIS. Resources for training, all day long available user support and project financing requires guarantee from organization. It may be good idea to start recruiting extra personnel in early stage of implementation project. Leadership reported as the most important success factor. Quality of communication seems to have significant meaning for successful implementation. CIS change in ICU environment is so huge project that the leader should have full concentration on the project. ICU has numerous personnel. All individuals have different capabilities to handle this kind of changes. Human factors can be barriers or facilitator depending on how these are taken into account. In preparation stage it would be a good idea to find out personnels skills and capabilities beforehand, so department is better prepared to overcome barriers if they are faced. Technical facilities and requirements should be investigated together with vendor and local IT department. Collaboration should start early stage of implementation and roles and expectations should be stated clearly. Overall, CIS implementation at ICU is time and resource consuming project which needs good planning and commitment of personnel, leader and organization.

Many of Finnish ICUs are going to change their CIS in next few years. It is also reported that there is huge lack of healthcare professionals through whole country. Challenges of human resources are expected also in CIS implementation point of view. Bullard (2016) reported use of superusers who changed site to the next implementation site after the first implementation was completed. This is not common in Finland that nursing personnel change to another hospital to perform their duties. Physicians do some site exchange during their education. This challenge may need new thinking out of the box. It would save some resources if same CIS will be implemented to several hospital and they could use same superuser for end-user support when CIS implementation goes live. It might need some financial incentives for superusers and solving of some bureaucracy issues, but it could provide solution for intensive need of extra staff during implementation.

Narrative literature review has wide range of possibilities to complete review, so it is important to follow research ethical requirements from beginning. Ethicalness and reliability are results of whole process. Reliability can be improved with transparency of research process and by following presented structure of research process. For reliability it is important that research questions are defined clearly, material selecting process is defined precisely and selected material is analyzed widely. Reliability of conclusions depend on how thoroughly these are argued. In study report all these need to be reported precisely enough. For reader of the review qualified narrative literature review can provide wide view of available information and previous studies of subject. (Kangasniemi et al. 2013; Stolt et al. 2016, 32-33.)

Reliability of this review can be evaluated by assessing quality of selected data and used methods. There are quite few high-quality studies available of CIS implementation in ICU environment. That is the reason why there were included also some other EHR implementation studies from different fields of healthcare to data of this review. Included studies were completed all over the world and this means that all healthcare systems are not similar with Finnish system. Professionals' level of

education or skills may be different as well as facilities of healthcare. All these things can be estimated to decrease reliability of this review partly. A quantity of included studies is limited which may decrease generalization of results. Available resources affected to a quantity of used reference databases and this have affected number of search hits. This literature review has been one man's project with support of lecturer. Writing of review has not been the main job of writer so time resources have been limited and there was no chance to expand review more. On the other hand, there were includes only studies and review articles were excluded after analyzing used references. In that way it was tried to have better view of available literature. To increase reliability, all data collection and selection processes were described exactly how these were done. This is how the reader may assess the used methods and sources.

Thematic analysis is a method where an investigator has a great role in analyzing results. An interpretation which is based on data, is primarily investigators view of results so the same data may be assessed variable interpretations if other investigators assess it later (Tuomi & Sarajärvi 2018). Ethicalness is also depending highly of investigator's actions. In this literature review has followed guidelines of Responsible Conduct of Research published by Finnish National Board on Research Integrity TENK (TENK 2023). Material selection, analyzing and reporting processes has proceeded as described. Results of review were reported without any favored interest or preferred attitude.

The further research is needed. There are quite few studies available of CISs of ICUs. Even less studies have performed of CIS implementation in ICU. Many of Finnish ICUs are forced to change their CIS so there would be wonderful possibility to start some research of implementation science at ICU. It could be before-after setup, training efficiency assessment or maybe success measurement of leadership. Several research setups are possible in next years.

7 CONCLUSION

Based on results of this review implementation project of new CIS is demanding project. Success factors of implementation project are leadership, resourcing, technical usability, training and human factors. Leader's commitment and full concentration to project are recommended and reported as keys of success. Communication skills are highly valuable as successful implementation project needs open communication in all levels and with all different groups involved the project. If the leader does not have proper understanding how project is going forward or the leader is not available to solve faced problems, lack of commitment will be barrier of success. Lack of communication may lead to individuals' decreasing commitment of change which may cause resistance.

Project and organization leaders have also great impact to available resources. CIS change project demand sufficient resources of time, fund and staff. It is multiphase project and the whole project may take years to accomplish. Funding should be secured for the whole project although CIS change is not a cheap at all. Need of staff will rise during the project. It is important that end users can join planning and preparation from the beginning. Training phase requires also extra personnel and some superusers are out of daily work during implementation. At and after implementation it may be expected lower efficient of workflows which is good to know when planning sufficient personnel for daily services. Insufficient resourcing may cause significant obstacles for progress and successful implementation and lack of funding may stop the progress totally.

It is important to follow how personnel react to change. Personal thoughts and reactions may be variable and if these can be solved it is better chance of success. Change management and targeted training are in spotlight when are dealing with human factors. Proper and effective training and sufficient user support with new CIS may decrease burden level of personnel. Superusers are recommended way to provide local peer support and they have positive affect to implementation project. Superusers can clarify new workflows and promote new CIS which decrease level of resistance usually. The change may cause feelings of fear and extra stress. All negative feelings may work as a barrier of change. With lack of proper training, support or change management, obstacles are expected.

CIS should meet requirements and purposes of use. Technical stability and good usability of CIS are critical success factors of CIS implementation. Integration capabilities and reliability of stable data transfer between medical devices and CIS are required. Usability of CIS affects to opinions of end users which have direct impact to success of implementation. Technical challenges like unstable software or connections causes reliability issues. Poor usability may lower efficiency of workflows. All these are mentioned as a barrier of implementation.

Success factors and barriers for CIS change in Intensive Care Unit are most likely same as mentioned before. The project needs proper planning and resourcing. In planning it should pay attention to success factors and methods how barriers will be overrun. Well prepared team and department have better chance for successful CIS implementation.

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APPENDIX 1:

WRITER, YEAR	TITLE	POINT OF VIEW	RESEARCH METHOD	OBJECTIVE	RESULTS
Vadillo et al. 2016	Maximizing Healthcare Professionals' Use of New Computer Technologies in a Small, Urban Hospital's Critical Care Unit.	factors of EHR adoption	an action research	To find out factors influencing EHR adoption in ICU.	Staff's needs and abilities must be recognized for successful implementation of EHR.
Dziadzko et al. 2016	User perception and experience of the introduction of a novel critical care patient viewer in the ICU setting	EMR implementation in ICU	before–after study	Evaluate implementation experience of new EMR interface in ICU	Task- and role-specific conciderations are needed for successful implementation of EMR.
Luyten et al. 2021	Examining the acceptance of an integrated Electronic Health Records system: Insights from a repeated cross-sectional design	factors of EHR adoption	repeated cross-sectional study	differentiatdiate the enablers and barriers of EHR acceptance prior to EHR implementation	Wide range of factors should be taken account when assessing an acceptance of the EHR.
Saleem et al. 2015	Understanding barriers and facilitators to the use of Clinical Information Systems for	factors of EHR adoption	a rapid ethnographic study	To describe current use of CIS in ICU	Barriers of use may cause worse adoption of CIS.

	intensive care units and Anesthesia Record Keeping: A rapid ethnography				
Safdari et al. 2015	Electronic health records: critical success factors in implementation	successful implementation of EHR	a cross-sectional survey	To find out success factors of EHR implementation.	Roadmap of EHR implementation should be created with special focus on project management and human factors.
Arabi et al. 2022	Electronic medical record implementation in a large healthcare system from a leadership perspective	EHR implementation from a leader's perspective	a case study	To describe EHR implementation experience from leader's perpective	Leadership competencies are critical for the success of complex EHR implementation process.
Bullard 2016	Cost-Effective Staffing for an EHR Implementation	resourcing of EHR implementation	a case study	To describe costs of EHR implementation with the nursing super-user role	Super-users are crucial for success of EHR implementation. Novice nurses can be considered as EHR super-users as well as experienced nurses.

McAlearney et al. 2012	The Role of Cognitive and Learning Theories in Supporting Successful EHR System Implementation Training: A Qualitative Study	factors of EHR adoption	a multiple case study	To discover how sociological and cultural factors affect to training strategies of EHR implementation	Sociological and cultural factors may improve likehood of successful EHR implementation.
Standing et al. 2015	Critical success factors in the implementation of electronic health records: a two-case comparison	factors of EHR adoption	a two-case comparison	To identify CSFs of EHR adoption	Many of common CSFs have contextual factors which were critical in implementation
Sidek & Martins 2017	Perceived critical success factors of electronic health record system implementation in a dental clinic context: An organisational management perspective	factors of EHR adoption	a case study	To identify success factor of CIS implementation in dental care context	Usability, emergent behaviours, requirements analysis, training, change management, and project organization are main success factors

Table 2: Selected literature for review

APPENDIX 2:

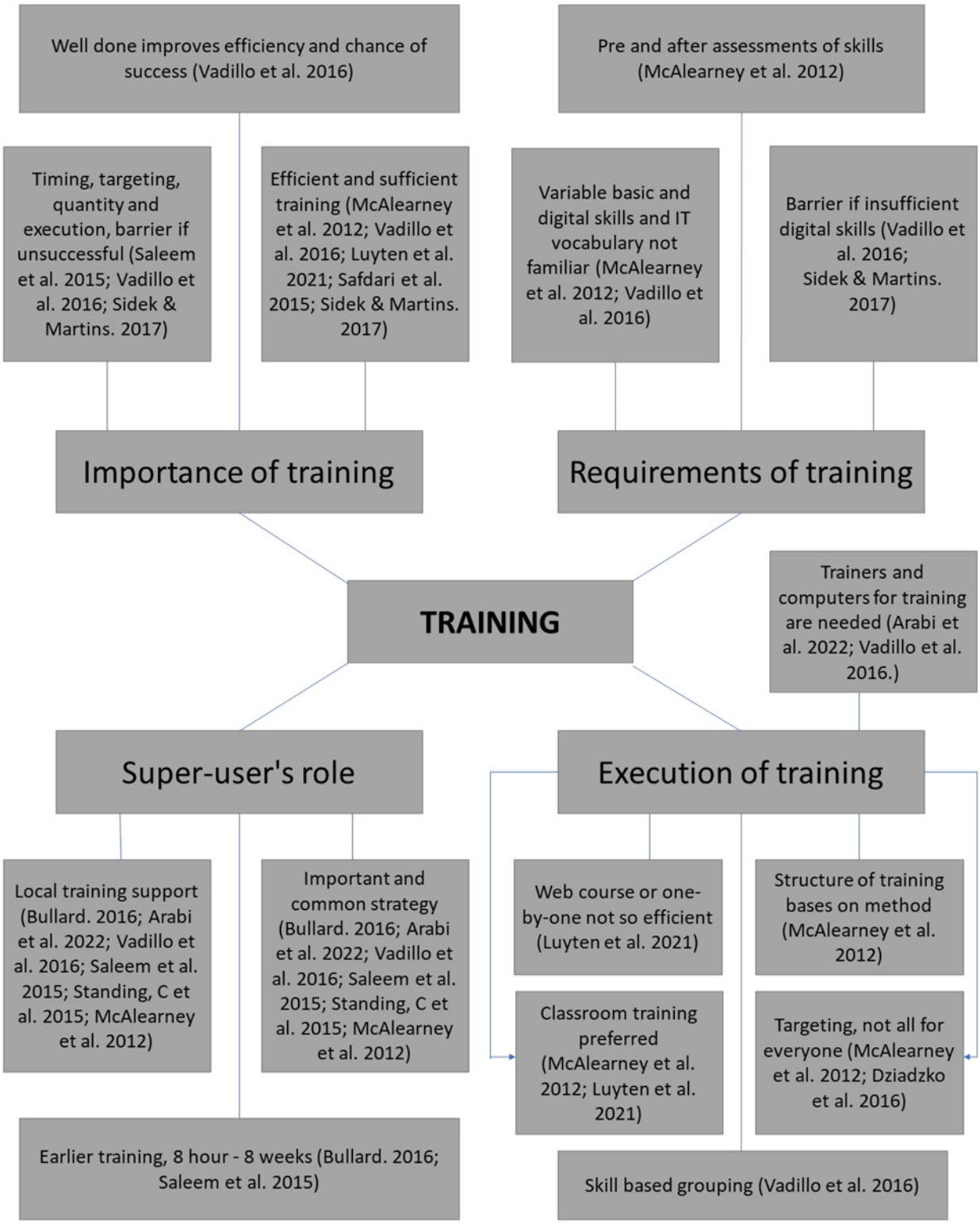

Figure 3: An example of thematic analysis mind mapping