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Abstract

This thesis addresses the development of a personal electronic logbook for trauma surgeons. A comprehensive literature review and interviews with surgeons were applied to determine residents' basic requirements to a logbook for educational documentation. These identified requirements were implemented in an application prototype for Android smartphones. A subsequent prototyping phase allowed participants to test the application over a period of approximately eight weeks. During this period I collected feedback and applied according changes to the application. The result of this prototyping phase is a final version of the prototype that meets the majority of the identified requirements. Although there were differing individual preferences, all residents appreciated the idea of maintaining their personal case logs in electronic form on the smartphone.

Kurzfassung

Diese Arbeit behandelt die Entwicklung eines persönlichen, elektronischen Logbuches für Unfallchirurgen. Es wurden eine umfassedne Literaturrecherche, sowie Interviews mit Chirurgen durchgeführt und daraus grundsätzliche Anforderungen an ein Logbuch zur persönlichen Dokumentation abgeleitet. Diese Anforderungen wurden in einem Applikationsprototyp für Android Smartphones umgesetzt. Ein anschließendes Prototyping ermöglichte es teilnehmenden Assistenzärzten die Applikation über einen Zeitraum von ca. acht Wochen zu testen. Während dieser Phase wurde Feedback von den Testpersonen gesammelt und entsprechende Änderungen an dem Prototyp durchgeführt. Das Ergebnis des Prototypings ist eine finale Version des Prototyps, der dem Großteil der identifizierten Anforderungen gerecht wird. Trotz unterschiedlicher persönlicher Vorlieben befürworteten alle beteiligten Assistenzärzte die Idee eines persönlichen elektronischen Logbuchs auf dem Smartphone.

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CHAPTER 1

Introduction

Over the last years, the majority of hospitals in America and Europe have introduced electronic medical record (EMR) systems [8]. An EMR system is defined as an ”information system that creates, gathers, manages and stores digital versions of patients’ paper charts within one healthcare organization system” [14]. In the sense of using the advantages of ICT and in order to increase efficiency in hospital work, it is obviously useful to manage and maintain these records in electronic form, as EMR systems have the potential to improve efficiency, safety and health aspects [31].

Despite all those obvious benefits of EMR system, the actual transition process towards paperless, computer based systems turns out to be more challenging than expected [59]. Frequently, the result is a mixture of paper based notices and charts on the one hand, and electronic records on the other. This often causes inconsistencies making work not only inefficient and redundant, but may also result in negative effects on patient care, which is the opposite of what originally wanted to be achieved. Causes for this problematic situation are diverse, but mostly it is just easier and more practical for hospital staff, to simply jot down relevant notes on a piece of paper and enter the information later into the electronic system. [14, 18].

Similar problems can be observed in personal documentation matters. Besides official operative reports, surgery residents have to keep track of a personal operation case log. The same applies to medical students, who have to record the operations they already attended in the course of their medical education, or to already certified surgeons, who aim for achieving additional medical qualifications. In the United States of America there are some attempts to gather this information via a centralized web service in order to promote life long learning and self assessment [46]. This form of efficient clinical documentation is crucial for busy surgeons [57]. Despite those modern approaches to maintain surgeons’ case volumes, many surgeons use pen and paper to keep track of their operations. The reason therefore is that the efficient integration of such new systems into existing hospital systems is a costly and complex task [59]. However, only half of the benefits of such systems lies in the integration into the hospital EMR system. The other half consists of the flexible and yet exact way that ICTs offer to support collection and review of data. Compared to paper-based solutions, the use of technology can help to gain insights, by illustrating a surgeons operative volume in an adapted and more detailed way.

While the potential of ICT in health-care is without a doubt, the choice of an adequate device must not be disregarded. For personal operation documentation, the use of smartphones might be a suitable solution. Over the last years, smartphones have increasingly influenced not only peoples' private lives, but also work-related matters. This development can be also observed in medicine. The majority of physicians and nurses already own a smartphone and moreover use it as an auxiliary tool for diverse medical tasks, such as dosage of drugs or look-up of medical references. Therefore, it is only consequent to use smartphones to support physicians in other daily work tasks, such as personal operation documentation.

Based on this idea, this thesis is devoted to the development of a smartphone application, which aims to support surgeons in personal operation documentation. With respect to the variety of features that is provided by current smartphones, the goal is further not to create a mere electronic version of currently used paper-based solutions, but to use the potential of technology to create an enhanced logbook solution. In order to efficiently support documentation, the thesis focuses on the needs of trauma surgery residents, as a specific target group. Different qualitative methods are used to explore the requirements of this target group and subsequently create a tailored mobile solution using an iterative user centred design approach.

The rest of this work is structured as follows. The first main part is devoted to an exhaustive exploration of the context the application shall be placed in. This is acquired by comprehensive literature research covering related subjects, such as electronic documentation in general, the role of logging in health-care and the impact of smartphones in hospitals.

The second main part of the thesis treats the development of the application in a more practical way. Interviews with residents and surgeons are used to clarify and to extend the findings from literature research. This is followed by the creation of a prototype application that is gradually refined based on feedback from testing residents. The methods section describes how these methods are interconnected, to create increasingly specialised insights of the context.

Findings and interpretations from interviews and prototyping are described in the next section. Findings from interviews result in a list of requirements, whereas the result from the prototyping phase is presented in form of a description of the final prototype.

CHAPTER 2

Literature Review

Over the last decades computers and technology have not only significantly influenced society and peoples' daily life, but also and especially more specific fields like health care. The accurateness of modern technologies added completely new possibilities for patient treatment compared to traditional methods. Almost in all fields of medicine there have been technical advances to directly or indirectly improve patient care. Physicians working in internal medicine wards for example are using computers for accessing and managing patient medical histories, for reminders and alerts or to look-up clinical guidelines [42]. In surgery on the other hand, physicians profit from the exactness of computer integrated surgery including for example image-guided surgery, robotic surgical assistants or telesurgery [75]. These examples show that the general possibilities for applications of modern technologies in internal medicine and surgery differ fundamentally. The technical advantages in internal medicine are mainly focused on documentation and information issues, contributing in a indirect way to patient care. Whereas the surgical domain offers completely different forms of applications that have a direct impact on the patient. Still, surgeons and physicians in other procedure-based specialities also have to concern themselves with documentation tasks as well, of course.

2.1 Clarification of Terms

In the context of electronic documentation of patient data there exist a number of different terms that shall be clarified. The most frequent terms referred in literature are electronic medical record (EMR), electronic patient record (EPR), electronic health record (EHR) and personal health record (PHR). The U.S.Department of Health and Human Services describes the electronic medical record as a "digital versions of the paper charts in clinician offices, clinics, and hospitals. EMRs contain notes and information collected by and for the clinicians in that office, clinic, or hospital and are mostly used by providers for diagnosis and treatment. EMRs are more valuable than paper records because they enable providers to track data over time, identify patients for preventive visits and screenings, monitor patients, and improve health care quality" [27]. This way clinical staff can access patient data at any given location. EMRs not only include pure medical data but they also keep track of other relevant information like billing, scheduling or prescriptions [71].

Very similar to the EMR is the EPR. It contains all or most of a patient's clinical information from a particular hospital [26]. Although there are sources that describe the EPR not that closely connected to a single institution [8] the EPR is best compared with the EMR, and terms are often used synonymously. Both of them have in common that they are focussed on managing patient data inside a particular hospital [26, 71].

The idea of electronic health records basically follows the same idea like EMRs but in a more general way. Whereas EMRs are part of a local stand-alone health information system that may differ among organisations, the EHR is a concept to provide patient related information that exceeds organisational restrictions. EHRs "contain information from all the clinicians involved in a patient's care and all authorized clinicians involved in a patient's care can access the information to provide care to that patient. EHRs also share information with other health care providers, such as laboratories and specialists" [27]. The focus lies on a complete collection of the patient's medical history to support physicians in decision-making. The EHR provides all the data that might be relevant for a patient's treatment and not only records from the particular institution the patient is currently located in. The key-characteristic of EHRs is their capability of being shard among various health care settings. Embedding EHRs in network-connected enterprise-wide information systems allows to benefit from its whole potential [8].

Regarding its contents the PHR is very similar to the EHR, as it includes diagnoses, medications, immunizations, family medical histories, provider contact information and so on. They main difference lies in its form of maintenance. The PHR is "designed to be set up, accessed, and managed by patients" [27]. Information sources are - besides clinicians, home monitoring devices or healthcare providers - the patients themselves. It is entirely controlled by the patient, meaning each patient can maintain his or her personal health record in a secure and private environment and individually grant access rights to others [8, 27].

2.2 The Electronic Medical Record

The aim of this work is support clinical staff, surgeons more precisely, in their daily documentation tasks. As explained above the EMR represents a central element in electronic documentation for a single hospital and is therefore an important concept of electronic health documentation for this work. The following section gives a deeper understanding and explanation of the EMR.

In 1999 a report of the Institute of Medicine (IOM) [37] in the United States revealed that approximately 98,000 people die every year because of medical errors, that could have been prevented. Thereby it was on the sixth position of most frequent causes of death in the United States in 2011 [35]. However medical errors are rarely the fault of human failure alone. Physicians make their decision often based on the information systems they work with, consequently they are often not to blame as there might have been an error in the system previously. Yet there is always some space of interpretation between the information of the computer system and the actual decision of the physicians. The health information system does not entirely control human decisions but is has undeniably a great influence. So the goal should be to design systems that make it hard for people to do the wrong thing and easy for people to do the right thing [47].

Concrete concepts of a electronic medical model emerged already more than 20 years ago. In 1988 McDonald et al. described that completely electronic medical records will replace traditional paper documentation in the future, while there will be an intermediate solution in the meantime, meaning hybrid systems that include computers and traditional paper records [49]. Even then researches were absolutely clear that the EMR will be more than just an electronic version of the hitherto existing paper charts. Communication, data interchange, cooperative working, decision support and legal documentation are just a few examples that have been proclaimed as potential benefits [64].

Today there is still research about the potential benefits of EMR systems in hospitals frequently focussing on financial aspects [31, 80]. Results of this type of research are generally optimistic and indicate that hospitals might save up to 300,000 dollars over a five year period with the introduction of a EMR system [80]. Yet the ongoing research and demonstration of positive impacts of EMRs indicates, that persons in charge still have doubts and lots of challenges are to be overcome regarding the orientation towards a completely electronic information system.

Reasons therefore lie in the complexity of the hospital environment into which the EMR system has to be integrated. Basically the EMR has to support two basic functionalities: the input of information and retrieval of information. Yet there are many different scenarios for both aspects that have to be considered. On the input side there are insights from direct encounters between doctors and patients, laboratory or radiologic results, data directly obtained from the patients and so on. The EMR system must provide means to enter information in different forms (text, images, audio, etc.) and for different actors (nurses, doctors, laboratory staff, etc.) working at different locations in or outside the hospital. The same goes for the output of information. The EMR must therefore not be seen as an object that is moved around inside the hospital like traditional paper charts, but it is something that is accessible any time without local restrictions [68].

The EMR is further closely connected to a particular hospital and its hospital information system (HIS). This connection is important to support clinical staff as efficiently as possible in their daily work. Only a tightly fitted information system can offer all the interaction possibilities that have to be available for a successful integration into the hospital workflow. In this context the EMR is best seen as a collection of processes, instead of an object representing a set of hard facts. The complexity of the information a EMR can provide is best coped by displaying processes than mere results. In this context it is important to respect each hospital's own clinical guidelines, that exist regarding different aspects of patient care. These reasons explain why it is not possible to provide general out-of-the-box electronic medical record systems for hospitals [68]. Nevertheless it should be mentioned that there are companies which offer complete EMR systems that provide a wide range of possibilities for customisation and adoption to the particular needs of an organisation.

EMR Adoption Model

Determining the degree of EMR adoption of a hospital is difficult. This is because a complete adoption of an EMR system must manage a variety of complex processes as described above. The consequence is that hospitals adopt to a electronic health system step by step. Even few but essential features of EMR systems can significantly improve certain areas in the hospital workflow. The Healthcare Information and Management Systems Society (HIMSS) Europe has developed an EMR adoption model, in order to compare the level of EMR adoption in european hospitals. The model is based on a very similar model that HIMSS analytics developed for hospital in the U.S. and Canada. It consists of seven stages that represent the path of a hospital organisation towards complete EMR adoption and its participation in an electronic health record (EHR) [32].

EMR Adoption in Europe

This EMR adoption model in particular is used to classify hospitals all over europe. A statistic evaluation from surveys in hospitals of eight european countries show which countries are currently the most advanced regarding EMR adoption in their hospitals and which ones trail behind.

It can be easily observed that the distribution of the EMR adoption stages are not equally distributed. Hospitals of stages 0 and 3 form the biggest percentage in Austria, Germany, France and Spain. What is interesting here is that stages 1 and 2 are barely represented in those countries. That observation may be due to two reasons. First reason is that the increment from stage 0 to stage 1 is much bigger that from stages 1 and 2 to stage 3. In other words: The increments between single stages are unequally distributed. This explanation is based on the structure of the EMR adoption model. The second reason is based on hospital politics. For a stage 0 hospital it is apparently a costly step to get to stage 1. Once on stage 1 the advancement to stages 2 and finally 3 can be achieved more easily. Another explanation that can be derived from this statistic lies in the features that must be provided on each stage. Stage 3 demands for clinical and nursing documentation and optional decision support and error checking whereas stage 2 merely creates the foundation for a EMR system. This suggests that features for structured electronic documentation in stage 3 are greatly increasing the benefit of such systems. The distributions in Denmark and Sweden - no hospitals of stages 1 and 2 - underlines this statement. Consequently the first hurdle for these countries is to generally get one foot into EMR adoption and implement basic ancillary systems. This is a possible explanation for the high number of stage 0 hospitals. The fact that the biggest percentage of hospitals in Austria are classified as stage 3 indicates that the increment from stage 3 to 4 represents another hurdle for many hospitals. As a consequence, there is only a small percentage of stage 4 hospitals in Austria and Germany. Generally, northern European countries Denmark, Netherlands and Sweden are further advanced in this classification and have the greatest percentage of stage 4 and higher classified hospitals. Yet, also in those three countries an average of only 14% is classified as stage 6 or higher [8].

European EMR Adoption Model SM

Stage	Cumulative Capabilities
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing feeding outcomes reports, quality assurance, and business intelligence; Data continuity with ED, ambulatory, OP.
Stage 6	Physician documentation interaction with full CDSS (structured templates related to clinical protocols trigger variance & compliance alerts) <u>and</u> Closed loop medication administration.
Stage 5	Full complement of PACS displaces all film-based images.
Stage 4	CPOE in at least one clinical service area and/or for medication (i.e. e-Prescribing); may have Clinical Decision Support based on clinical protocols.
Stage 3	Nursing/clinical documentation (flow sheets); may have Clinical Decision Support for error checking during order entry and/or PACS available outside Radiology.
Stage 2	Clinical Data Repository (CDR) / Electronic Patient Record; may have Controlled Medical Vocabulary, Clinical Decision Support (CDS) for rudimentary conflict checking, Document Imaging and health information exchange (HIE) capability.
Stage 1	Ancillaries – Lab, Radiology, Pharmacy – All Installed OR processing LIS, RIS, PHIS data output online from external service providers.
Stage 0	All Three Ancillaries (LIS, RIS, PHIS) Not Installed OR Not processing Lab, Radiology, Pharmacy data output online from external service providers.

Figure 2.1: EMR Adoption Model [32]

Transfer from Paper to Electronic Records

The last section showed that the major part of hospitals in Europe possesses at least a basic form of an electronic medical record system. One of the main goals of the EMR is to make work more efficient and thereby to reduce the time that physicians and nurses spend for documentation purposes. This goal is especially significant in consideration of the fact that actually nurses invest more time in documentation than in direct patient care [29]. Yet, in many cases EMR systems struggle for the user acceptance, as they are facing a number of challenges and problems.

One reason for failure of EMR systems is the design of defective software. This includes

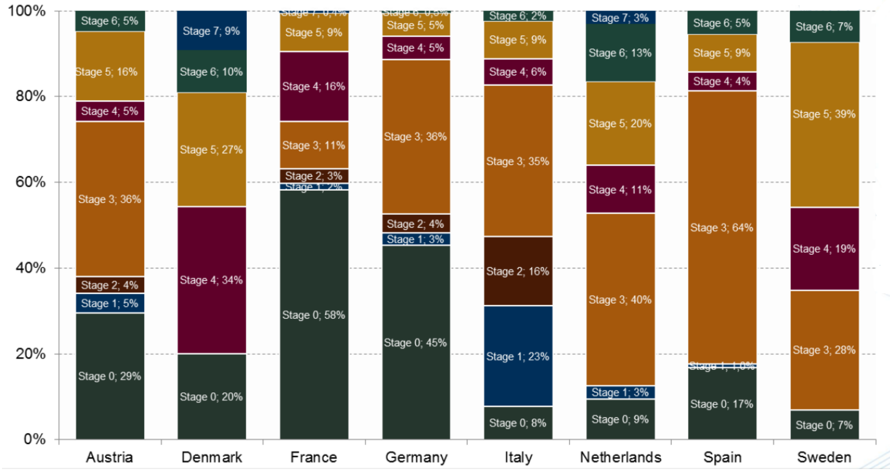

Figure 2.2: EMR Adoption in Europe [8]

software with obvious errors in the functionality of certain features on the one hand, and software that facilitates errors in clinical performance on the other hand [34]. The risk of making such errors is increased for example by ambiguous labelling of options or confusing composition of checkboxes, which makes it easy to make wrong and unwanted selections resulting in defective records. However, the mere functionality of the system is not sufficient. Quality of service like fast response times, negligible downtime, easy accessibility and an interface that is easy to understand and navigate are crucial factors for gaining the acceptance of the user [3].

Many interfaces for EMR systems are insufficient in daily hospital work, because they do not respect the circumstances under which clinicians have to work. Unlike in other professions physicians are constantly working together with other persons and therefore can usually not devote their entire concentration to the computer. Unclear interfaces make it easy to make a wrong selection or generally do something that was not intended. Physicians argue that such errors would not occur if they would use pen and paper and simply write down things [3].

Studies of experimental introduction of electronic record systems in health care settings show that a reduction of documentation effort is not easily achieved. An experiment in [53] showed that the documentation time of nurses did not recede. In contrary, a greater proportion of working time was spent for documentation with the electronic system. One might argue that this is a consequence of a new system and that clinical staff needs some time to get used to it and to learn how to integrate it in daily workflow. This argument is surely partly responsible for the increased effort. Nevertheless, even six months after introduction of the system the documentation workload was still higher than in the previous paper based system. Not before twelve months after introduction of the system, documentation time was back on the level before the experiment.

Experiences like these lead many physicians and nurses to be sceptical about the promised benefits of the EMR. Besides undeniable advantages of electronic records they claim that the work with an electronic system will be even more time consuming and distracting from actual health care tasks [67].

Many researchers have accordingly come to the conclusion that the successful transition from a paper based system to a EMR system not only depends on the faultless and reliable performance of the system but also many other challenges have to be overcome. The authors of [28] pronounce the need to respect ”the practices through which the document is written, read and used” [28] and that although theoretical classes and attributes relevant for the system have been identified, those practices have have been largely ignored within consultation. Those people, who finally have to be convinced of the system, are those who work with it every day, the hospital staff. As mentioned above, the change of workflow usually brings no direct improvement for the staff, even if it develops in a positive way in the long term. Therefore the acceptance and with it the success of the system is greatly depending on the patience and openness of the hospital staff towards the new technology. They are the ones who have to endure additional training units and the increased documentation effort during the transition phase. An extensive involvement of physicians in the development phase is therefore fundamental to create an adequate system that fits real world practices with tailored solutions [59].

However, flexibility and tailorability of EMR systems are not sufficient to completely replace every form of paper-based documentation in the hospital worklow so far. This is because there is no such thing as the perfect record in practice [18]. There is a great variety of miscellaneous situations in daily hospital work that each demands for documentation. To cope with this variety the easiest tool to use for documentation is pen and paper. The unique advantages of paper in this context is its micro-mobility since it can be easily handled, manipulated, reordered and reassembled [14], especially in comparison with electronic documentation systems. Paper-based artefacts often represent complex collections of inter-related forms, papers and documents [18] that can be hardly applied to an electronic system in this form. Moreover every clinician in every ward in every hospital has different practices of documenting the work before it gets finally recorded in the system.

A great part of the information that is collected by nurses and physicians in daily hospital work is not intended to be entered into the system. Such pieces of information are often provisional, incomplete and unstructured. Yet this form of information is crucial as a foundation for the creation of structured reports that are finally recorded. Thereby it closes the gap between the actual clinical workflow and the data recorded in the EMR, which is the reason why this form of paper-based information and is often described as transitional information [10,14,18,24,73]. Even if this transitional information is no part of the the official patient record, it offers additional knowledge about how and why the results in the patient record developed to their current state and should therefore also be documented in the EMR [14].

The problem of computerising lies in the contrast of the basic ideas of transitional information on the one hand and the EMR on the other. Per definition transitional information is something that is not finished and never to be finished or completed. It is altered permanently and new information is added or outdated parts are removed. Moreover information is usually spread over several artefacts and is not collected in one place in a structured way. Some of those artefacts are further not publicly accessible because they are personal documents like diaries, to-do lists, notes, assessments or letters that have been collected by individual clinicians. Such documents are not meant to be accessible and published to a wider audience than the creator itself [24]. This stands in contrast to the EMR system and the permanent character of its entries.

As soon as information is recorded in the EMR it looses something of its provisional character and gets perceived as something that is completed although it is not. Hardstone et al. state in [24] that ”the IT system was felt to freeze data in unhelpful or restrictive ways”. It gets obviously more difficult to change records that have already been recorded in the EMR than simply to change a personal note. This is especially the case if the accessibility of computers to make such changes is not sufficient. Sometimes there are just not enough computers available and nurses or physicians have to wait until it is their turn to use the computer [73]. Although this may appear a primitive problem its negative impact on the clinical workflow and therefore the acceptance of the users is undeniable.

To sum up things there are a lot of challenges that have to be overcome to successfully change from a paper-based system to EMR. In every case the EMR should be developed in close cooperation with the hospital staff to ensure that the system is tailored to their actual needs. This way the system is more likely to be accepted by the users. Besides technical requirements to an EMR like functionality and quality of service, the biggest challenge on the way to a paperless documentation is how to deal with transitional information. Verbal communication and handwritten documents allow clinicians to exchange information in a very effective way which is completely different than via an electronic system. Challenges here are not to completely replace these forms of communication but to find ways how to integrate the information into the EMR. Design opportunities that support the documentation of transitional information and methods to record handwritten notes are needed [14]. This way the EMR would be capable not only to display mere reports and results but the additional information could provide a complete documentation of the clinical workflow and allow to reconstruct the development of those results in a comprehensible way.

2.3 Standards and Interoperability

Problem Statement

Electronic Health Records (EHR), Computer-based Patient Records (CPR), Electronic Medical Records (EMR), and Electronic Patient Records (EPR) are basically very similar concepts. They all describe systems to create, manage and maintain a structured electronic patient record. The big issue here is that all those concepts are directly linked with an individual organisation and all data is referred to the particular patient via a locally assigned patient identifier. Those local dependencies create a situation that makes it a very difficult and complex task to exchange data between different health care organisations. This affects not only data exchange on regional, national or even international level but sometimes also intra-organisational communication. However, a national patient identifier which links all patient data on a national level is a very unlikely approach. The resulting widely spread situation in current health care is a collection of electronic and paper-based records that contains duplicate information due to constant re-entering, whereas other pieces of information are lacking or incomplete [71].

It is widely recognised that providing an integrated and relevant view of the complete health and health care history of each patient is essential in order to manage the safe and effective delivery of complex and knowledge-intensive health care, and to share this information within and between care teams. A survey of the US Medical Records Institute about EHR trends and usage documents that over 70% of received answers considered the need for sharing patient record information as the main argument for the introduction of EHRs from a clinical point of view [38]. Besides the benefits of direct interchange of EHR data between organisations there are other concepts that require standardised and effective interoperability. Information from EHRs can be directly forwarded to regional or national registers where the collected knowledge may be used to develop standards for prevention and treatment, which can further result in guidelines or other educational material. This way those newly gained insights finally return to the individual organisations, which can integrate developed guidelines into their local EMR systems [68]. Yet, it proves to be difficult to find a safe and effective solution to share electronic health records among respective organisations [38].

Challenges/Requirements

The awareness for the need of standardisation and interoperability for the exchange of EHR data between healthcare organisations exists since the introduction of EMRs. In 1996 the interest in so called electronic medical record systems (EMRS) was increasing rapidly and along with it grew the need to exchange this form of patient records with the help of contemporary technology. Consequently the authors of [41] developed a prototype for exchanging EMRS data based on an architecture that abstracts the clinical information from the particular underlying EMRS. In consideration of this already quite advanced approach, the question comes up why the health care sector is still lacking a generally recognised standard that has been explicitly developed for general clinical patient data interchange [38]. A possible explanation is that the development for a standard in the health care sector is fundamentally different to the development of other technical standards. An error in transmission that causes inconsistencies and failures in the EMR system may lead to missing, inadequate or misleading patient information increasing the risk for medical errors [71]. Technical malfunctions in this context can easily result in a direct negative influence on the patients' health due to misinformed hospital staff. Furthermore the scope of the development of a standard in health care involves a wide range of affected organisations and stakeholders that have to be respected resulting in a number of requirements.

To ensure a reliable communication a standard for data transmission and sharing is needed, which is implemented by EHR systems of all involved organisations. The approach that is closest to fulfil these requirements is called Health Level 7. This standard is widely used but not uniformly adopted and utilized [68]. However, a standardised technology for the transmission of data does not ensure that the communicated contents of those messages are understood. In order to exchange clinical patient data efficiently the first step for the receiving institution would be to identify the relevant parts of the patient record. This process proves to be not as simple as it might appear. Individual clinical statements can not be regarded individually but the context in which they are embedded must be respected to ensure that the original meaning intended by the composing physician is faithfully preserved and free of misinterpretation. The standard must be capable of communicating aspects in a rigorous and unambiguous way according standards for clinical terminology. This is of special importance for documents describing decisive aspects such as certainty, severity or absence of findings [38]. According to the complex clinical workflows and the way how patient information is collected bit by bit, the EHR information is no collection of simple data values but an equally complex accumulation of a variety of documents that are linked together as compound clinical concepts. One main goal of a standard would be to represent "every conceivable kind of health record data in a consistent way" [38]. What makes this even more complicated is the problem that a great amount of this complex collection of data is stored in form of paper-based records that are still in use in many hospitals or within isolated clinical databases. Bringing this conglomeration of data to a compact form that can be efficiently communicated with other organisations is a task even modern computerised health information systems have to struggle with. On the other side the receiving institution has to be capable of importing the transmitted information into its own system to make use of it efficiently [38]. Another challenge is that "the medico-legal nature and accountability of health care delivery places additional requirements on the rigour with which health record entries are attributed, represented and managed." [38] This means that a standard must grant the safe and relevant communication of patient data. The transmission of private patient information via the internet raises concerns regarding privacy and the protection of the patient data. Encryption of EHR data with a sophisticated mechanism as well as authorisation for accessing parties are therefore absolutely necessary steps for secure interchange [68].

Personal Health Records

Another approach to provide a complete electronic patient record to the organisation that is in charge for a patient at a particular point in time is the personal health record model (PHR). This concept puts the responsibility for maintaining medical records in the hands of the patients. Health information is entered either by the patient himself or by a authorised person for example the attending physician. The idea behind the PHR is a private and secure solution that gives the patient full control to access patient data anytime and anywhere. It contains relevant information from all healthcare providers that have been visited so far and provides interoperable methods for current healthcare organisations to access the data they need [71]. It is clear that this approach does not have the potential to make the interorganisational exchange of patient records redundant, yet in theory it simplifies the challenge to always provide a complete and up-to-date patient record when and where it is needed. However, there are serious concerns about this concept in practice. The usefulness of the PHR strongly depends on the motivation of the patient. It is essential that the patient understands the importance of maintenance and coordination of the health-related documentation with healthcare providers. Similar to the development of EHRs the challenges for the development of PHRs are of technical, social, organisational, legal and financial nature. Yet there is strong consensus that PHRs have the potential to bring decisive benefits to relationship between patient and provider if those challenges can be overcome [74].

Approaches

A consequence of the widespread sharing of electronic patient records is that this data reaches a variety of medical domains with each of them having particular demands to the EHR regarding the types of information needed. Moreover those demands may change with the constant development of clinical practices and the advances in medical knowledge. When sharing patient record information with another organisation or medical domain, a challenge must be to extract the information relevant to the receiving institution from the whole patient record. A principle to encounter this requirement which is widely known in health informatics as semantic interoperability is the so called dual model approach [38]. Basically it distinguishes the informational contents of the EHR and its form of representation by using a reference model and specific archetypes. The reference model holds is an information model that represents global characteristics EHR components, their interconnection as well as contextual information to meet ethical and legal requirements. The archetype is a formal definition of what information is needed. Therefore it specifies rules by which useful clinical templates can be generated from the reference model by defining and constraining relevant attribute names and values. The number of different archetypes that is needed consequently depends on the range of clinical activities that are practised within one EHR community [38]. Several concrete concepts have adopted this approach, such as the openEHR Information Architecture (cite openEHR), the European EHR Communication Standard (CEN EN 13606) and the development of templates for the Health Level 7 (HL7) standard [38].

2.4 Logging in Health Care

The activity of logging data in some form of logbook is something that exists for centuries. A widely spread association with the term logbook refers to a naval background and the logbooks that the captain of a ships used to document their voyages like Christopher Columbus did in the 15th century on his way to America. But even at this time logbooks could be found in many more professions than in seafaring. A very famous, or maybe the most famous, example for a logbook are the notations of Leonardo da Vinci, who did not only document advanced concepts and ideas in the engineering domain, but who was also very interested in medicine and produced various detailed records describing for example the human anatomy.

In general, logging describes the activity of storing data about certain activities or about single steps of one activity in a detailed way. In information technology those entries are usually stored in a log-file representing a collection of all log entries. Web-log mining, for example, describes the process of extracting patterns from web access logs. The log entries in this case consist of the URL that is requested, the IP address that sent the request and a timestamp. Every access to a web page is logged and the resulting log file that contains all those entries can then be further analysed for patterns [60]. However, many engineers in technical professions use a rather classic form of a logbook. "These logbooks are typically paper-based notebooks used by individuals to record personal, informal notes and information relating to a particular task or activity" [48]. Despite these examples logging is no concept that is constrained to technical domains alone, but it can be found in various fields, and especially in medicine logging and logbooks are utilized in many cases.

It lies in the nature of the field that the focus in medicine lies on interpersonal interaction and communication, and in many cases there are no computers directly involved in the actual patient care. Therefore many research experiments that examine certain behaviour of hospital staff make use of logging data in form of often handwritten logbooks and require the hospital staff such as nurses and clinicians to manually produce the log entries (e.g. [17, 65, 70]).

An exemplary research topic that is frequently addressed in this context examines the connection between hospital staff working hours and the potential to make errors. The problem of long shifts without enough time for recovery and especially night shifts that often result in drowsiness, exhaustion and struggle to remain is picked up in [17]. In order to gain detailed insights and to find out the actual causes for reduced performance of nurses a logbook was used containing questions about work hours, estimated sleep length and quality, fatigue, sleepiness, stress, errors or drowsiness while driving home. Nurses filled out that logbook every day for a period of two weeks. After this 14 day period the logbooks were collected and statistically analysed. The results of this methodology indicate that some of the mentioned factors are more decisive for nurses to commit errors than others, in this study those were for example struggle to remain awake and stress. Similar studies also use logbooks to study the effect of working hours and especially overtime working on hospital staff and the resulting quality of care for the patients [65, 70]. In [70], besides other methods for data gathering, clinicians were assigned to additionally log the daily hours they spend sleeping and awake. These studies show the potential of logbooks to record structured, personal information about individual participants over a period of time.

Leaving the task of logging to the patient is another possible application for logging in health care. This approach can help to reduce some of the workload of clinicians, since patients with chronic diseases like hypertension or special forms of diabetes are theoretically able to monitor their medical status themselves in many cases. Diabetics, who require insulin need to monitor their blood sugar and their diet in order to dose the insulin correctly. It is essential to educate those patients regarding their eating habits and the effects that an inadequate diet can have on their health. A promising approach to improve the awareness of diabetes patients is to use electronic logbooks or diaries, where patients can document their meals and in return receive information about nutrition facts like calories and carbohydrate, protein and fat content of a meal. Such immediate feedback about the nutrition facts of their meal showed to provide an efficient means for dietary education [77].

However, giving away responsibility to the patient is not necessarily a good solution. Its has shown that patients' reliability of documenting status information is pretty low, although it has a direct influence on their own health state. The authors of [50] examined the reliability of hypertensive patients. Participants were told to measure their blood pressure values twice a day with a special device and record their values in a logbook. Patients did not know that the device also stored measured values. Comparing documented values in the logbook with the stored values in the device allowed to make implications about the reliability and precision of the patients' documentation. A majority of participants omitted readings from the logbook or added phantom values. In return those readings, which were documented lacked precision, since only half of the patients showed a satisfying precision of logbook entries. These results arise justifiable doubts about the usefulness of self-measured blood pressure values and patient documentation in general.

2.5 Case Logs in Medical Education

An important role of logging and logbooks in health care is the support for medical education. A student's or a resident's logbook, usually called case log, can directly reflect the medics practical work experience, especially in procedure based medical domains. In Surgery, as the typical procedure-based discipline in medicine, logging is a common way to document operative experience of surgery residents. The operative experience refers not only to the quantity of operations but also to the variety of surgeries absolved. A complete and diligently maintained case log is decisive for a surgery resident's education, since a comprehensive compilation of operations is mandatory for the accreditation of surgery residents in the United States and in Europe equally.

In Austria and Germany there exists special operative catalogues published by the Österreichische Ärztekammer (Austrian Department of Physicians) respectively the Bundesärztekammer (German Department of Physicians) that have to be completed for accreditation. Those catalogues describe the guiding quantities for different types of procedures that should be accomplished during residency [9, 55]. In Austria the catalogue demands, besides certain knowledge, abilities and experiences, for 340 surgeries as a guiding value for the complete volume of a resident's case log. The required operations are mainly categorized by localisation, such as cranium, thorax or extremities and the type of operation, such as ostheosynthesis, amputation, arthroscopy or puncture of joints [55]. For accreditation the residents have to manually complete a particular document by entering their logged operative experiences and submit this document to the responsible department of physicians. In this respect the residents' logbooks represent a foundation for their structured education, which is largely based on curricula for further medical education and conversations between the resident and the guiding clinician [51]. The completion of the personal logbook is a process that holds on for several years during the education of surgery residents. The high overall number of operations that accumulate during this time, in combination with the variety of different categories of operations that are requested, make it hard for residents to keep an overview of their current progress. A structured form of logging personal operative experience that is adapted to the particular requested operative catalogue for accreditation could provide a great benefit for residents.

Such approaches are made in private medical education systems in the United States, such as an online resident case log system that allows residents to log their data via an online platform provided and maintained by the Accreditation Council for Graduate Medical Education (ACGME) [1]. The ACGME is a private professional organisation that is responsible for the accreditation of residency medical training programs within the United States. Accreditation is accomplished through a peer review process and is based upon established standards and guidelines [1]. The advantage here is that the ACGME is both the organisation that provides the logging service and the organisation that is responsible for accreditation. This circumstance, in combination with the structured form of logging via an electronic platform, facilitates the management of an accreditation-adapted personal logbook. Similar concepts based on the ACGME concept are do not only exist for residents, but also for already certified surgeons, in order to gain their recertification or certifications for specialities. Further, an adequate amount of annual operations is decisive for the quality of care a surgeon can provide, especially in procedure based domains like surgery [52]. Therefore the American Board of Surgeons (ABS) introduced the Maintenance of Certication (MOC) program. It is described as a ”continuous professional development program” [76] and requires ongoing participation in a national, regional or local outcomes database or quality assessment program [57].

Electronic Logbooks

According to the general development of electronic documentation in hospitals the trend for residency logging is going towards the use of electronic logbooks. Electronic logbooks have the edge over logbooks in paper-based in several aspects. Single log entries of interest can be found in a fast and efficient way, whereas a paper-based logbook requires its user to flick through pages and do a manual search. Entries can be further presented clearly arranged increasing the facility of inspection of the logbook. One of the greatest benefits of electronic logbooks in medical education is further the potential to provide comprehensive statistics about the current progress in meeting accreditation goals. All those factors contribute to the usefulness of the logbook and the amount of information that can be extracted from it. Presenting the data in a clear way and offering the possibility not only to inspect single entries, but also to generate new information that can be derived from the whole set or from subsets of entries. A practical example in this context is to find out the number of operations a resident has already conducted for a certain location or a certain type of operation. As explained above surgery catalogues for medical education are often separated by these attributes of the operation. Consequently finding out the number operations that fulfil certain criteria is a necessary step to keep track of the personal operative progress. While a paper-based logbook is naturally ordered chronologically or at least constrained to a certain order, an electronic solution allows to order and select the desired attributes and therefore adapt to the particular requirements, assuming that the entries are stored correctly and contain the necessary information and attributes.

Another problem that can be countered with the help of electronic logbooks, is the unequal distribution of operations among resident surgeons in many cases. A survey examining trainee satisfaction during surgery residency indicates that the lack of transparency of surgical procedure assignment in two third of the examined institutions was one of the main reasons for resident dissatisfaction [79]. As a consequence, the assignment of educationally relevant procedures is often perceived as unfair because assignment decisions are not made transparent. In other cases assignments may actually not equally distributed among equally qualified residents. The responsibility for the allocation of surgeries is up to senior staff members and the chief physician. However, they cannot be charged for unbalanced distribution when they are lacking possibilities to access current progress information of residents that can be further respected in the creation of surgery schedules. In 2008 the association of German surgeons presented an electronic logbooks that can be integrated in a hospital information system via a standard interface and allows an import of hospital data. This concept has two major advantages: Firstly the maintenance of the personal operation catalogue is facilitated since is it possible to access or print the current education progress at any time. Secondly, better accessibility of resident catalogues can also be provided to senior physicians and chief physicians, allowing them to review resident catalogues and respect them in surgery planning [51].

Generally one of main benefits of electronic logbooks is the variety of ways how data can be made accessible and how data can be presented. Besides ordering or filtering functions that have been mentioned above it can present data in form of graphs and statistics that can flexibly adapt to the data that should be presented at a time. These opportunities promote detailed examination of personal case logs and thereby support reflection of individually collected data. Resident reflection is an essential process in medical education, since it is prerequisite for the identification of quality improvement opportunities and for demonstrating competence in practice based learning [82]. In this context it has shown that electronic logging based on personal digital assistants (PDAs) significantly enhances learning by facilitating specific learning experiences and represents therefore an effective case documentation and reflection tool [33].

Limitations of Electronic Logbooks

The last section highlighted the potential use of electronic logbooks and the amount of new possibilities that are created. However, there are still problematic aspects of logging medical cases for educational purposes. A major problem seems to be that the success of the logbook, even in its electronic form like the ACGME case logs, is still depending on the motivation of the resident or student to enter the required data, since entries have to be recorded manually [12].

In 2002, a study examined the use of an electronic student encounter log for students in emergency medicine clerkship [43]. Results showed that only 60% of the patient encounters were logged by the students and that those entries further contained only an average of 60% of the patients problems, with a false positive rate of almost 20% for patient problems. This means that students not only failed to log a great number of patient encounters, but they also missed information or even added information that was not actually available from the patients' ED charts.

A similar study in 2007 required neurology residents to log their patient encounters in a web based logging application [21]. Participants' feedback on the experiment was similarly negative and indicated an overall dissatisfaction and lack of use of case log system. The reluctant use of the system was especially caused by the time consuming interaction with the system and led over half of the participants to agree that the case log system interfered with their education. Moreover 40% of the residents agreed that the case log system also interfered with patient care.

The before mentioned limitations of electronic logbooks are basically due to the effort that is needed for documentation and the consequently lacking reliability and precision of residents and students to log their personal experiences. However, the need for technologies to comply the necessary requirements in order to accomplish a comprehensive and reliable logging of patient encounters is indisputable. To overcome this problem the reasons for the lacking motivation of residents when it comes to logging should be considered. One explanation therefore is the timely effort that is connected with documentation issues. 60% of neurology residents stated that the logging of a single patient encounter takes them two minutes or more [21]. With respect to the high number of patient encounters that can occur especially in other medical domains like emergency medicine, the overall documentation time may easily rise to a level where patient care would be negatively influenced as a result of lack of time. Yet, documentation is an equally important task and cannot suffer under lack of time, especially since it is mandatory for residents of certain procedural oriented domains to accurately log personal experiences. Under this circumstances it is only logical that residents from a wide range of specialities would welcome more efficient methods that comply with case log requirements while saving time for patient care [5].

Automated Electronic Case Logs

The development of automated electronic case logs is a promising approach to counter the problem of missing motivation for manual log entries. As the term denotes the goal of such logs is not only to make documentation for residents more efficient, but to release them completely from manually maintaining a personal log. This is theoretically possible since all the information that is required in the logbook is usually existent in the hospital information system. An approach by Nagler et al. [54] combines data from a hospital patient tracking system, the electronic clinical documentation systems and the internal electronic registration and billing system. A unique encounter number, that exists for each patient encounter, provides a link between the three separate systems. The combined information from all three systems allows to access all data that is necessary to automatically create an electronic logbook of patient encounters for each resident. Moreover a logbook that is created this way potentially contains much more detailed information than a manually maintained logbook, since it can also access data, like ICD10 (International Classification of Diseases) codes or additional patient demographic data.

The most important advantage of automated electronic logbooks is probably still the time that can saved. A completely automated system that automatically forwards and processes EHR data to create a logbook would not require residents' participation, giving them more time to invest in actual patient care. Moreover the problem of reliability and precision of manually logged entries can be overcome and the automated system is no further depending on residents' recall and attention to timely entry. [5].

The automatic creation of resident logs makes use of a hospital's electronic clinical information system and identifies the data that is relevant for the clinician's logbooks (e.g. via data mining [5]). That means that the logs for every clinician are no longer created individually but the information system creates a log for physicians using centralised information. Information about the content of the logbooks are therefore centrally maintained, too. This way residents' individually created records are easily accessible for senior physicians and chief physicians. As explained before they can then use this information to adapt operation plans and shift schedules in order to grant a fair distribution of education opportunities for all residents. Besides those benefits for the individual trainees the comprehensive and precise information of automated case logs can be further utilized to gain overall experience of patient care in the hospital [54]. The gathered information can play an important role in research, such as examination of correlating factors between the quantity of a certain type of treatment performed by a clinician and its rate of success [52].

However, one must not forget that automatically created logbooks depend on the information provided by the hospital information system. Someone still has to enter this information into the system. That means that automated case logs do not completely relieve residents of their documentation tasks. The quality of the information represented in the logs is directly depending on the information quality in the HIS. Defective reports of patient encounters that find their way into the system are therefore consequently leading to errors in the derived logbooks. An individually maintained resident logbook that is not derived from the clinical information system would not be that delicate to incorrect entries in the HIS. In this context, the role of technology is not always to reduce redundancy of medical data as much as possible, as redundancy also has its positive aspects. Technology rather should be utilised to supply the distribution of correlated and consistent data in different places, while relieving hospital staff of the time-consuming effort of documentation [10]. The consequence of these considerations is that automated electronic logbooks should not be considered as the final solution to the high amount of documentation efforts that clinicians face every day, although they undoubtedly are a great step in the right direction. Research focus should also not forget to enhance and facilitate the documentation tasks in the hospital information system, which provide the foundation for the quality and usefulness of automatically created logbooks.

Furthermore the lack of standards and possibilities for interchange between hospital EHR systems and the resulting variety of information systems in use is hindering the rapid development of a general working concept for automated systems. The dependency on an individual hospital information system may further lead to the maintenance of additional logbooks with particular requirements for other organisations. This is because automated logbooks that have been created for inner hospital use may not provide sufficient information that for external organisations, such as the ACGME or the educational catalogues for residents in Austria and Germany.

2.6 Case Logs and Data Mining

The role of case logs in medical education is frequently treated in current research. However, the field of education is only one subtopic in the variety of applications of logging data. The insights gained to improve medical education are mostly based on retrospective examination of logging data to enhance reflection about a trainees progress. However, the subjects to examine with retrospective studies in health-care and reflection are not constrained to medical education, of course. Collection and storing of logging data can be used to analyse all kinds of processes that occur in a hospital.

Typical studies about education examine the effect of working time restrictions on resident experience (e.g. [12, 15, 36]). Besides studies to improve education, there are two other major areas in healthcare in which the analysis of logs in form of retrospective studies is used. On the one hand there are studies that examine the organisational side in health care. On the other hand the focus lies on the generation of medical insights by using logging data.

Lots of different processes are executed in hospitals with the help of many involved actors working on different sites. Coordinating all those separate processes and combining their results in the best possible way is essential in order to provide efficient patient care. However, the complexity and high number of involved events and actors, as well as the high amount of produced data, is difficult to overview. Still, in the end all relevant process documentation data can be found in the hospital information system, in the form of so called event logs. The information of one event log must refer to a particular case and, secondly, to a single well-defined step in the overall process, such as a lab test for example. Moreover it may include information about the performing actor of the event, a timestamp of the event and optional specific data elements that are connected with the event. Event logs in this form can be used as input for process mining.

Process mining is an effective tool to analyse the complex interconnection of health care events that can be used to generate insights of how complete processes are really executed. Figuring out actual workflows in hospitals and the acquisition of process knowledge are prerequisite in order to enhance and streamline those processes [44]. Although the low number of publications about process mining in healthcare indicate that this is a relatively unexplored field, there is some research work that suggest how process mining can be successfully applied in certain medical domains (e.g. [45, 61, 62]).

Retrospective studies that concentrate on medical factors usually make use of physicians' case logs in order to study the effects of physicians' practices and experiences on medical treatment outcomes. A typical question of many patients directed to the attending physician before an operation is: "How many times have you done this before?". Patients expect the surgery to be successful more likely when the responsible surgeon has done this type of surgery many times before. With the help of retrospective studies examining the case logs of surgeons and the respective outcomes of their operations allows to answer questions like these. Results of study comparing the rate of success for resections for oesophageal cancer patients between high-volume surgeons and low-volume surgeons indicate that a surgeon's case volume can drastically influence the mortality rate in such difficult operations [52]. In this case only the quantity of already performed operations was respected, whereas there are other examples where the information of clinicians' case logs are decisive. The logged data can help to reproduce and compare the detailed development of patient treatments with same or similar complications. This approach allows to identify those factors that may have a decisive influence on a successful patient treatment outcome [81].

These examples show how data logging can effectively contribute to improve patient care in hospitals on the one hand on an organisational layer and on the other hand by gaining deeper insights in practical medical treatments.

2.7 Mobile Computers in Hospitals

The third and last section in this literature review draws attention to the usage and role of mobile technology in health-care. The need for mobile solutions has increased significantly with the introduction of electronic hospital systems. The transition of paper-based records to electronic health records is complicated since paper-bases records provide some unique features and advantages compared to electronic solutions. This leads to the fact, that the transfer to electronic documentation frequently results in an increase of documentation effort instead of the reduction that is aimed for. One of those important advantages of paper is its mobility. Patients and nurses can take a paper-based record with them, and make official entries or simply jot down quick notices or annotations wherever needed. This characteristic of paper suits the need of clinicians and nurses to access and edit patient relevant information at the right time, and ideally at the right location [73]. EHR systems cope with this requirement by maintaining patient data centralized, and allowing access to patient records anytime. Access to patient records at the right location, however, is always depending on the electronic infrastructure of a hospital. This means it is generally depending on the provision of specially designed places that offer desktop computers to allow access to the system [73]. This constraint to certain locations is one of the reasons for the reluctant deployment of electronic patient records in many hospitals. An electronic hospital information systems combined with mobile technologies could provide the basic functionality to counter this problem and allow system access at the right time and and the right location.

On the one hand there are promising approaches for how hospital environments can benefit from the use of mobile technologies. Mobile technologies, and especially smartphones, coupled with the HIS and EMR systems are a fast emerging technology that offer innovative approaches with the potential to improve health-care in many ways [13]. On the other hand there are problems and barriers regarding the deployment and acceptance of mobile technology and especially mobile phones in clinical settings.

Due to the widespread usage of smartphones and their ever growing influence in our daily lives nowadays the term mobile technologies is often immediately associated with smartphones. Since the release of the first iPhone in 2007 the success of smartphones has constantly grown. They have influenced many areas in daily life but also in research including medicine. However, awareness about the potential benefits of mobile solutions has existed before and literature provides some interesting approaches for how this technology can be integrated into hospital information systems. Technologies that have been used include personal digital assistants (PDAs), wireless tablet PCs and wireless mobile computers-on-wheels. The basic goal, independent of the particular technology applied, is to allow ”ubiquitous access, and remote access to up-to-date patient information” [73].

However, not all mobile technologies provide the same degree of local independence, which is mostly depending on the dimensions and the weight of a device, but also the on its form of user interaction and other factors such as endurance of the battery. On the contrary small and very mobile devices might be limited in their benefit for the user, if the screen size of a device is to small to see certain details or if interaction is limited because of too small or imprecise buttons, for example.

A computer-on-wheels (COW) is a desktop computer placed on a mobile cart and equipped with wireless network to proved mobile access to the EHR system [73]. It is an example of a mobile device that allows full user interaction and access with the tradeoff of reduced mobility. The intention behind this concept is to allow nurses to bring the COW into patient rooms so they can enter patient information directly into the system, without having to use paper records that are later transferred to the HIS. Although the COW was specifically designed to be easily moved around, evaluation in a real hospital setting showed that only a small minority of nurses actually brought the COW into patient rooms. The main reason for this refusal was the bulkiness and clumsiness of the device, which resulted in the continued use of paper notes. Long term evaluation indicated further mobility-reducing problems like unreliable network connectivity, insufficient battery life and suboptimal ergonomics. These issues, as well as usability problems, have to be kept in mind for the development of mobile device in medical settings, although the inappropriate dimensions of the device remain the main problem in case of the COW.

In comparison to COWs, PDAs represent a completely different level of mobility. The compact dimensions of PDAs allows nurses and physicians to carry them with them wherever they go and access, enter and retrieve patient information at a patient's bedside [30]. Yet, studies about the usage of PDAs in hospitals indicated problems regarding the mobility of the devices. The authors of [30] examined the usefulness of certain mobile devices for their application in clinical settings. Regarding PDAs they identified the often unpredictable battery lifetime of the devices as the main disadvantage. It was not clear how long the PDA's battery will last in daily hospital work, which makes the PDA a useful but not absolutely reliable device. Other problems that occurred during the use of the PDA showed that hospital staff is often not used to the interaction with such devices [69]. In one case a nurse was not sure about the meaning of some of the keyboards keys, and thought that commonly used abbreviations like "tab", "shift" or "cap" refer to medical expressions. Another problematic factor was the stowage of the PDA and the pen that is used for interaction, during and in between tasks.

Besides increased mobility, PDAs offer some completely new forms of interaction with a EHR system. Using context awareness to enhance PDA software is one of those possibilities [69]. Depending on time and current location, the device can automatically access patient data and present currently relevant data on the display. If a nurse moves with her PDA from one ward to another, the device can identify the change of location and display an overview of patients of the ward the nurse is currently located in. In the same manner the presented information can change depending on the current time and for example include reminders for scheduled patient appointments. While this approach offers a lot of interesting possibilities the conclusion of this study pronounced that it is decisive that the automatically triggered actions of the system do not result in lack of control for the users, hindering them in carrying out assigned work tasks.

Smartphones in Hospitals

Besides the presented solutions, such as computers-on-wheels and PDAs, smartphones have become an adequate alternative to those technologies. In some sense, smartphones represent the evolution of PDAs combined with cellular phone technology enhanced with additional hardware. Over the last years, research has consequently acknowledged the potential benefit for medicine, that smartphones offer with their possibility for nearly universal data access also for medicine [4].

One of the main reasons that promote the interest of research in the usage of smartphones in hospital is based on the wide distribution of smartphones among hospital staff. There is a variety of studies about this topic. Not only the percentage of hospital staff that owns a smartphone is examined, but also the usage of smartphones in the context of hospital related tasks. Naturally, the overall smartphone distribution percentages differ strongly from study to study depending on the year of publication, the country and especially on the framing conditions that are chosen for the selection of the participants. For instance, the percentage of physicians owning a smartphone in the United States has increased from 64% in 2009 to over 80% over the past five years [4]. An online survey in the United Kingdom of 2012 [58] further indicated that the distribution of smartphones is higher among medical students than among already certificated physicians. Results of the same study show that around 73% of the questioned smartphone owners use medical applications on their device during clinical activities. Interestingly the majority of physicians with smartphones are iPhone users [20,58]. This is very likely due to the greater amount of high quality medical and scientific software that is available in the Apple App Store compared to competing services such as the Google Play Store , the Blackberry App World or the Windows Phones Store [4].

Advantages of Mobile Phones over Paging

Although the main focus of smartphone development has shifted from actually phone calls to web browsing camera improvements and other features, the connection to cellular networks and the possibility to make phone calls is a key feature especially in clinical environment. The need for communication supporting devices is partly caused by the inherently mobile nature of clinicians' clinical practice [25]. Direct mobile phone calls allow physicians to efficiently coordinate patient care, exchange information with their colleagues, and get informed about lab results independent of their current location. This is essential for providing quality patient health care [83]. Despite these advantages, many hospitals still rely on a pager system as the official means for communication among hospital staff. This form of one way communication is very limited in comparison to the use of mobile phones. Pager systems usually only displays the number of the incoming call or a short message. Clinicians then have to find a hospital phone to call back the number that has paged them. Poor communication caused by one way messages and frequent interruptions through paging messages are further major communication issues and may lead to inefficiencies and errors [83]. Indeed, permanent phone calls can be equally or even more distracting like pager messages, of course. Yet, the use of smartphones, or mobile phones in general, allow clinicians to choose the mode of communication according to the importance of the message. Urgent issues can be communicated with direct phone calls, which guarantee that the message is successfully and timely delivered to the recipient. Matters that are less urgent can be sent via asynchronous communication means, such as short messages or emails, to reduce the impact of disruptions. In this context, a study has shown that physicians using a smartphone for communication received about three times as many emails as phone calls. All involved physicians, nurses, and other health professional perceived an improvement in efficiency over pager communication [83].

Smartphone Specific Advantages

Besides the advantages of cell phones over pagers for communication, there is a set of several other advantages that promote the specific enforcement of smartphones in clinical settings [4]. They offer permanent connection to the internet and thereby access to all kinds of medical resources, such as medical textbooks, drug references or institution-specific guidelines that can assist physicians ideally at point of care. Medical applications facilitate the efficient access of these resources and provide additional functionality, like medical calculators for drug dosing, or support physical examinations by offering tests for hearing, eye-sight and colour-recognition. Moreover smartphones can help to support the communication between patients and physicians. Patients have the right to be informed about treatments and procedures that are undertaken in the hospital. However, explaining medical procedures to patients can turn out to be difficult. Multimedia material like illustrations and videos can be easily presented to the patients with the help of smartphones to improve their understanding, even at bedside. Image material can also help to overcome cultural or linguistic barriers and to explain general procedures. This is especially important in the context of healthcare and its affection by migration and globalisation, which inevitably leads to situations when clinicians have to communicate with patients from foreign countries without a shared language. Text-to-speech applications and recently also speech-to-speech applications may provide a useful tool for translation in such situations. Moreover the coupling possibilities of smartphones with EMR systems represent another advantage. Smartphone solutions have been developed that allow full access and editing of electronic medical records [4]. The advanced hardware of modern smartphones including fast internet connection and growing display sizes further also allows to efficiently transfer and edit image data in the context of ”picture archiving and communication systems”(RIS/PACS). Smartphones can be integrated in education systems for students, residents and also certificated physicians. The web-based ACGME Case Log system provides a mobile web page for the improved use of the system with hand-held devices [57]. Another educational application is the provision of highly individualised scientific contents, or virtual learning environments that promote the idea of continued medical education and help physicians to keep track of the most up-to-date developments in medicine [4].

Concerns regarding Smartphones in Hospitals

After all those arguments for an integration of smartphones in hospitals it is a justified question, why the enforcement of this technology is going on only reluctantly. The reason therefore is a set of problematic aspects that induce several arguments against the use of mobile phones in hospitals that repeatedly occur in literature. Since a smartphone is basically a mobile cell phone, with a huge load of additional features of course, it also inherits all the problems that have been identified for the use of mobile phones in hospitals. Mobile phones are permanently emitting electromagnetic waves, even when there is actually no phone call made. These waves are potentially dangerous to cause electromagnetic interferences (EMI) in electronic devices. The influence of electromagnetic waves on medical devices, such as pacemakers, implantable defibrillators, infusion pumps, monitoring equipment and other devices has been treated in [16, 40, 63]. The authors of [40] describe the problem of electromagnetic interference as a real and significant problem, since even small changes and alterations of the mentioned devices can have a negative effect on patients' health. This potential risk has led to prohibition of mobile phone use in hospital areas in the UK [40]. Nevertheless, all of these studies found that there were no interferences measurable, when the distance of the mobile phone to the device was greater than two meters. After further investigations, the prohibition in many hospitals was relaxed, or the prohibition was reduced to only local bans in critical areas, because it has shown that mobile phones pose little or no risk to hospital equipment [25]. There is an international consensus that banning mobile phones from hospitals, and therewith abandoning the use of smartphones with all its promising benefits for fear of EMI that might influence patient safety, does not make sense. In fact, a survey among physicians indicated that the risk of errors and injuries through EMI is much smaller, than through delays in communication, which occurred less frequently among those who uses mobile phones instead of pagers [16].

Another problematic issue that occurs regularly in the context of mobile phone use in hospitals is the role of mobile phones for spreading bacteria [6, 7, 25, 63]. The discussion about this subject has emerged from a rise in nosocomial infections since the increased use of mobile phones in hospitals. First studies in 2006 [7] examined the general potential of mobile phones to carry bacteria known to cause nosocomial infection. Results demonstrated that 96,2% of the examined devices were contaminated with bacteria and that 15% of those devices contained bacteria that are known to cause nosocomial infection. This high percentage of contaminated devices poses a significant risk for infections especially in hospitals where many patients' immune system is already weakened by other diseases and therefore especially prone to infections. The absence of regular cleaning might be a critical factor in this context. A similar study found equally high contamination rates with only 10% of participants stated that they are regularly cleaning their phones [78]. It showed that the cleaning of the phone must occur on a daily basis to significantly reduce the growth of bacteria on the phone [63]. Its is therefore essential for hospital staff to obey strict hospital guidelines concerning hand hygiene on the one hand and cleaning of the devices on the other hand, in order to reduce the the risk for infections to a minimum. Further possible approaches to enhance the situation are the introduction of regular cleaning routines for mobile devices and the introduction of anti-bacterial materials for mobile phone surfaces [78].

Interestingly, there are other problems regarding the acceptance of smartphones that are notable from the point of view of outsiders. Negative reactions of some members of the public [25] can occur when they notice physicians frequently checking their smartphones. The fact that smartphones are in most cases not yet officially acknowledged as a medical support tool for clinicians, can lead observers to the assumption that physicians check their smartphone frequently on behalf of private matters. This misunderstanding may cause patients to feel disadvantaged and thereby it may strain the relationship between patients and clinicians. Making smartphones, and mobile phones in general, an official means for communication in hospitals could help to prevent such misunderstanding and to significantly improve communication among hospital staff [25]. The authors of [2] describe more issues and the effect of smartphones on the patient-physician relationship. It showed that electronic hand-held devices that are used during direct patient-physician conversations lacked some requirements that are easily fulfilled when paper charts are used. Physicians' actions are poorly visible for patients and therefore hard to comprehend. For the physician, on the other side, it is harder to gesture and to re-establish eye contact after device-interaction, and the interface demanded a high degree of attention from the physician. The use of smartphones in direct patient interaction bares the risk of worsening patient-physician collaboration, which could lead to missed conversation details resulting in wrong diagnoses.

Official guidelines for the use of mobile phones and especially smartphones are not only reasonable to promote the smartphone as an official tool to support medical tasks, but also to prevent actual misuse of smartphones. On the one hand the wide range of different features offered by modern smartphones is helpful to support a variety of medical tasks, on the other hand it may be distracting from those tasks. Accordingly, several literature findings (e.g. [22, 23, 39, 66] conclude that there is, besides the benefits of smartphones in clinical practices, a high risk for distraction. Smartphones are potentially dangerous to claim attention of hospital staff in moments when attention should be exclusively devoted to patient care. Individual cases have proven that interruptions through messages or phone calls may cause the receivers to neglect their actual primary tasks [22]. But not only direct incoming calls and messages can be sources of distraction. Cain [11] expresses concerns about the great amount of time that is allocated to social media discourse while on the job. Although single access and interaction with social media networks lasts only short in most cases, such interactions represent an interruption of work, and the overall time that is expended for social media use during one day can reach a significant amount to influence patient care. 19% of residents in inpatient rounds believed that they missed important information because of distraction from smartphones [39]. The general opinion to counter the problem of distraction, is again to establish hospital policies and guidelines regulating the use of smartphones for health care workers [39, 66].

The use of social media platforms, such as facebook or twitter, among hospital staff can further lead to privacy and confidentiality issues concerning private patient information. By posting patient relevant information, images or both on social websites, patient confidentiality can be easily breached by hospital staff [66]. Numerous examples illustrate the penalisation of individuals of the health care team, because of ill-advised or unthoughtful posts violating the confidentiality of patient information [11, 66].

All in all, the use of smartphones in health care institutions arises some concerns. Electromagnetic interference, spread of bacteria, patient acceptance through hindered patient-physician relationship, distraction and privacy concerns are identified as the most urgent problems to face. For all those issues, researchers propose regulation actions from the hospital administration in form of guidelines. Gill et al. [22] developed a set of best practices for the use of smartphones in hospitals that demonstrate how those guidelines could concretely look like for the identified problem fields:

Regarding EMI:

- Create no-cellular/no-smartphone zones in sensitive areas like intensive care units (ICUs), operation theatres, and critical care units.
- Establish cellular-/smartphone-restricted zones, as well as cellular-/smartphone-friendly zones.

Regarding bacteria:

- Promote hygienic use of devices in health care settings through the use of gloves and sanitizers.

Regarding distraction:

- Store personal devices out of reach, and encourage the use of organization-provided devices that contain preinstalled job-specific functions and apps.
- Regulate the kind of ring tones, alert tones, and other such sounds used by health care professionals on their phones at work.
- Regulate access to social-networking sites like Facebook, Twitter, and YouTube, and promote an intracompany communication network in the workplace.
- Create specific hotspots where personal devices may be used during breaks.

Regarding patient privacy:

- Ensure that prior permission is obtained before taking photos and videos at work. While taking photos and videos, all must adhere to organizational ethics and conflict-of-interest policies.
- Ensure that all digital data is appropriately encrypted, and that the network and devices associated with the network are password-protected.
- Ensure high-security computing networks, with regulated use of outside devices.

2.8 Mobile Medical Applications

Although smartphones may significantly contribute to improved communication in hospitals, they are not exclusively designed for the application in clinical settings, of course. It is the availability of thousands of medical apps for all kinds of purposes, that allows to add medically relevant functionality to the device, unfolding the full potential of smartphones as an all-round medical device in hospitals. Many physicians have already recognised this potential, which is confirmed by the high percentage of medical app use among physicians owning a smartphone. Studies indicate that especially young doctors are open for innovative solutions, since results of an online survey in the UK indicate, that more than 75% of junior physicians own medical related smartphone apps, and 50% answered that are using those apps several times a week [58].

Moreover the frequency of use of different types of medical apps was examined in that study. Among junior doctors, disease diagnosis and management apps, and drug reference apps were identified as the most frequently used types. In contrary, procedural case documentation apps scored very low, as over half of the participants are not using these apps. However, a likely explanation for this result is the lack of apps that are currently available, that truly facilitate physicians' documentation tasks instead of creating additional documentation effort. As most of the documentation is depending on the particular hospital information system, an app with the potential to truly relieve clinicians of some of their tasks, would likely need to be linked to this hospital information system. Yet, since individual hospitals are seldom directly involved in app development phases, this connection, and therewith the creation of a truly efficient procedure documentation app, is hard to achieve. Interestingly, Payne [58] also posed the question if participants would be willing to use a hospital specific applications, and 75% approved this suggestion. It remains to be seen, if such specific hospital applications can offer possibilities for effective procedure documentation.

The idea of hospitals providing individual apps is insofar interesting as the lion's share of all medical apps is published by smartphone software developers, respectively by the app stores of Apple and Google. Searches for term "medical" conducted in 2012 delivered more than 4200 results in Google Play and over 5000 results in the Apple App Store [22]. Despite this huge number of available apps, it appears that some medical domains have been disregarded for the development of specific applications. Franko [20] examined the availability of smartphone apps for surgery and therefore conducted searches in the two dominating app stores using combinations of keywords for orthopaedic surgery. The result contained 61 apps in the Apple App Store and only 13 results in Google Play, with only half of them having more than five reviews. It is unlikely that the missing interest of surgeons is the reason for those low numbers, since the study also indicated that the great majority of surgeons would welcome more orthopaedic related apps. It is rather likely that scarce quality and high average prices ($22.39) explain the reluctant use of existing applications.

A general lack of quality of content and reliability turns out to be one of the major issues for medical apps. Quality and content of medical information provided by websites on the internet, in general is highly variable [72]. Medical applications frequently obtain their contents from such sources and therefore face the same problems concerning the reliability of the provided information. Furthermore, there is currently no official organisation or institution, which is in charge of validating the content of published medical applications. The app stores are free to publish anything, as long as its contents do not violate app store content guidelines, regarding for example sexuality, violence or racism. However, critics fear that a stronger regulation of the medical app market could stifle the fast and innovative development in this field [19].

In September 2013 the U.S. Food and Drug Administration (FDA) has issued a document ”to inform manufacturers, distributors, and other entities about how the FDA intends to apply its regulatory authorities to select software applications intended for use on mobile platforms (mobile applications or ”mobile apps”)” [56]. This document further explains that a mobile medical application is only affected by regulation, if the application is either used as an accessory to a regulated medical device, or if the application transforms a mobile platform (e.g. a smartphone) into a regulated medical device. According to the definition of the FDA a smartphone turns into a regulated medical device, when it is ”intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease” or when it is ”intended to affect the structure or any function of the body” [56].

2.9 Summary

This literature review started with the presentation of multiple forms of electronic records that are currently in use. They facilitate many documentation tasks in hospitals and sometimes offer completely new possibilities. However, the fact that there exists such a variety of different approaches shows that there is not one perfect solution. Each approach has its advantages, but also limitations that complicate the introduction of an electronic documentation system to replace paper-based documentation. The common situation is therefore often a mixture of both forms. Paper is typically used for transitional documents that provide a simple and easy way to quickly capture information. Another issue is the interoperability and exchangeability of electronic records with other medical institutions. Although there are standards for exchange of medical records, none of them has been widely adopted.

The application that is developed in the course of this thesis does not directly deal with electronic patient records. Yet, the aim of the application is to make an existing documentation process more efficient and add value to it. All presented forms of electronic records basically pursue the very same idea. For this reason, it is important to know and to understand the effects induced by the introduction of electronic tools to replace paper-based solutions.

Existing electronic logging solutions for residents exist mainly in the United States. The ACGME offers a web-based logging tool that allows residents to efficiently log their operative experience. Since the ACGME is also responsible for accreditation of residents, this web-tool is a comprehensive solution that does not require additional transfer of data. Although this model is currently not applicable in Austria, knowledge of such existing solutions together with their strengths and weaknesses is very helpful for the development of the application.

The impact of smartphones on medical related tasks is quickly growing. Besides the possibility to directly communicate with colleagues there is a variety of tools that aim to support physicians in their daily tasks. However, critics raise concerns over the use of smartphones in hospitals. Electromagnetic interference and increased spread of bacteria are frequently named issues. Despite those negative points smartphones are widely distributed among physicians. This promotes the idea of using the smartphone for personal documentation for surgeons.

The ongoing thesis addresses the development of a personal electronic documentation tool for surgeons. This literature review created a basic awareness of the current situation of electronic documentation, logging solutions and the use of smartphones in hospitals, especially by calling attention to potential benefits, considerations and concerns.

CHAPTER 3

Methods

The previous literature review covered the broad context of electronic documentation in health care, especially concerning logging and the use of mobile phones and smartphones in hospitals. This general understanding is prerequisite for the further proceeding, as it gives an impression of how related studies were conducted, which aspects are to be considered and which results to be expected in this thesis. However, information gained from the literature review is mostly too general to directly derive design requirements for an application. An exception to that is closely related literate about experiments identifying general design implications, which are to be considered for higher-level, more general topics (e.g. mobile applications for hospital staff [43, 69]) and may consequently contain relevant insights for the development of any application in this field. Moreover, the literature review serves as a foundation for the successive interviews to be described. Conducting the literature review before the interviews has two major advantages. Firstly, a lot of precious interview time can be saved, since the exhausting literature review already answers a lot of relevant questions that might have been part of the interviews otherwise. Secondly, there are many new questions that come up during the literature review. The interviews can then be used to answer these questions or to comment on certain problems from the interviewee's point of view. The next step is to use knowledge gained from literature review and interviews to create a prototype of the application. This prototype is then tested by surgeons in their real working environment and iteratively improved based on feedback from testing participants.

The combination of these three methods leads to a constant refinement of design requirements for the application. In practice, this exact order of methods, as seen in 3.1, could not be kept entirely due to scheduling issues with participants. But although phases partly intersected, the general structure and interconnection of methods remained unchanged.

1. literature review is the most general method, including a wide range of related topics

2. interviews are restricted to the context of Austrian trauma surgeons

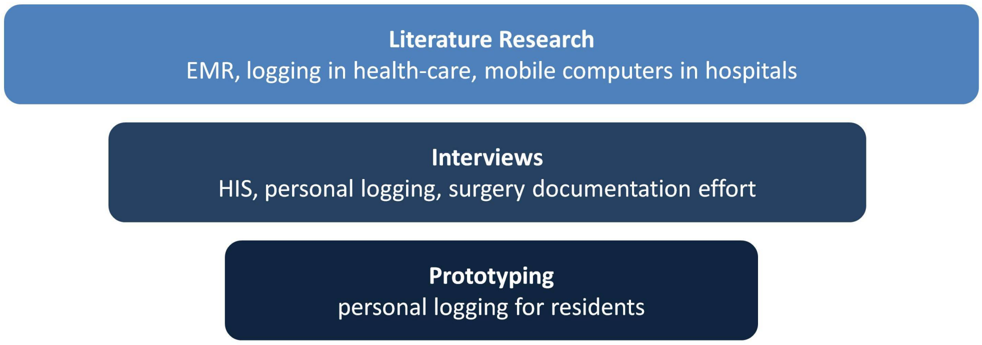

Figure 3.1: The constant refinement of methods is going from literature review, which is the most comprehensive method, to prototyping, as the most specific one

3. prototyping identifies problems and requirements to the application that residents not necessarily aware of and thus where not mentioned during the interviews

Naturally, interviews and further discussions about the prototype had to be scheduled with respect to the residents' timetables. This lead to the situation that personal meetings with residents and surgeons took part over a longer period of time. Some of the earlier interviews overlapped with literature research, whereas there were also later interviews that took part when the prototyping phase had already started. It showed that this intersection of methods was not hindering but rather helpful to lay focus on different aspects during the interviews, depending of the progress of the other methods. Earlier interviews contributed more to understanding the environment of the hospital and the documentation guidelines that residents and surgeons have to follow. In this sense, those interviews supported basic knowledge of the field that was created during literature research. Interviews that were conducted later, did not have to clarify basic questions any more. Consequently, they focused on more specific requirements to the functionality of the application.

3.1 Interviews

Interviews were conducted with six surgeons and surgery residents in total. First contact with all participants was made by my brother, who himself is a surgery resident in the same hospital. Including him, there were four surgery residents, three of them are residents for trauma surgery and at the end of their third year of their residency. The fourth resident is in the beginning of his residency for general surgery. Furthermore one surgeon that shortly completed residency and one senior surgeon partook in the interviews. The senior surgeon is further partly responsible for the hospital's information system and the involved in hospital policies regarding mobile devices at the workplace, which offered interesting possibilities for the interviews.

Still, the group of residents was considered the most important group of interviewees as they represent the actual target group the application shall be designed for. Interview topics with these four residents focused on current solutions for their personal operation documentation, features

Participant	Medical Field	Role	Annotation
P1	Trauma Surgery	Resident	3rd year
P2	Trauma Surgery	Resident	3rd year
P3	Trauma Surgery	Resident	3rd year
P4	General Surgery	Resident	1st year
P5	Trauma Surgery	Senior Physician	Responsible for HIS and mobile device policies
P6	Trauma Surgery	Senior Physician	Recently finished recidency

Figure 3.2: Participant table for the interviews

of an electronic solution depending on their individual requirements and their willingness to use smartphones or other electronic devices for documentation purposes. On the contrary, main focus of attention during conversations with the two older surgeons lay on the more general surgery documentation process of the hospital with notable positive or negative aspects, as well as possibilities and potential of integrating smartphones and tablets in this process.

Interviews with the residents took place in a private apartment. Visiting the physicians at their working place would have been problematic, since there is always the possibility that the interview gets interrupted because of unforeseen events. Therefore, a private apartment was chosen to create an relaxed and informal atmosphere. This point is especially important since the interviews followed an exploratory approach. Creating a comfortable environment and using a loose interview structure should help to create the situation of a conversation rather than an official interview, so that interviewees can talk freely without the feeling of being interrogated. This motivation was also relevant for the chosen time of the interviews. Interviews were arranged in the evenings, when participants were off duty. During working hours surgeons are often influenced by stress and time pressure, which would possibly have hindered participants to give relatively time-consuming, detailed answers and explanations.

Directly before the interviews participants received an information sheet giving them about basic information about the study. After reading the information sheet they completed a consent sheet stating that participants agree with the partaking in the study, the recording of interviews and the grabbing of digital photos of personal logbooks, all under the condition of confidentiality.

Interviews are mainly intended to cover three main topics, which are: surgeons personal logbooks or their personal solution how to keep track of their case log, the hospital information system of their particular hospital representing the prototypes environment, and finally their personal involvement in further operation documentation besides the management of personal logbooks, such as the creation of official operative reports. While the focus of interviews with residents actually lay on personal logbook solutions, both other topics helped to bring forward the conversation and to clarify the direct environment a logging application would be placed in. However, since all participants, except of one resident, are working at the same hospital, some questions that concern general hospital guidelines and documentation procedures were posed mainly to the surgeons and only one resident. This way a good overview over the local documentation practices can be created based on the opinions of three hospital staff members in three different positions. Following interviews with the other residents could then focus on the more interesting part about personal operation logging.

Interviews were planned to be semi-structured with a prepared catalogue of main questions that should be clarified during the conversations. At the same time prepared questions must not interrupt the flow of the conversation. The goal here was to let the participants talk about their personal experiences freely and explain "why & how" they do things, since it was very likely that some factors that are brought up in an open conversion are not covered by the questions. According to this general principle, the semi-structured form that was prepared beforehand was mostly desisted during the interviews, as it became clear that all prepared main questions were soon answered while the participants were talking about their involvement in the documentation process. This circumstance made an explicit questioning for single details not only obsolete, but in many cases it would have also disrupted the flow of the conversation. Details that were potentially missed during the conversation were therefore shifted to the end of the conversation, or to the end of one of the three main parts, while cross-checking if all main conversation topics have been discussed.

There were no notices made during the interviews in order to fully concentrate on the conversation. For this reason, all interviews were recorded using a smartphone. The audio files were then analysed regarding participants' statements that may used to derive design requirements for the application. Durations of the interviews ranged from 18 minutes to 50 minutes. There were no complete transcriptions of audio files made. This is firstly due to the length of the interviews. Secondly the open conversation style of the interviews led to a relatively sparse distribution of relevant information. Instead of comprehensive transcription analysis of the interviews resulted in dense short summaries. They sum up residents' statements and opinions regarding the three main topics of the interviews as well as other relevant statements that may not directly concern the three main topics, such as patient data confidentiality for example. The following process was to derive concrete design requirements from those summaries. Therefore, residents' opinions regarding specific subtopics have were compared. In some cases, those opinions can be turned into concrete design requirements very directly, such as the set of attributes that have to be included for one operation. For other topics this process is more complicated. Especially when participants showed different opinions about the certain topics. The integration, of ICD10 codes is such a topic. For controversial topics, the opinion of the majority of participants and results from literature research decided if and how to respected these issues in the design requirements.

3.2 Prototyping

Prototypes are frequently used when it comes to evaluating the usefulness of new technologies in medicine. Especially prototypes of mobile solutions on PDAs have been have been exhaustively tested in hospital environments (e.g. [2, 69]). Whereas the sheer functionality of an application can be tested in a laboratory setting, it is indispensable that it gets also evaluated in the very environment it is designed to be used in. Only this way, it can prove its value and usefulness to target users. Moreover, the variety of situations that occur in the daily work of a surgeon might demand for certain user interactions with the application, that were not respected during the design phase.

The main goal that the prototyping phase aims for is to answer the following general questions: Does the application actually help surgeons to save time they spend on documentation, or does it, in the worst case, lead to an increased effort? Does it facilitate the documentation process for surgeons? Does it increase the awareness of surgeons about their own case volume and help them to overview their personal progress? Besides those main questions, the prototyping phase will give information about the usefulness of single features and about possible additional side effects that usually occur during the use in a realistic testing environment. Proving the technical completeness, or searching for technical bugs respectively, is not a main goal of the prototyping phase here. However, all identified errors of this kind get also fixed during this phase, of course, since faultless technical functionality should be a basic requirement.

Interviewees confirmed the result of several studies that Apples iPhone is clearly the most popular smartphone amongst physicians [20, 58]. At first contact with the interviewed residents, they all owned Android smartphones, which is why the application is targeting Android devices. Unfortunately, two of the four residents changed from Android devices to Apple iPhones shortly afterwards, Thus, new participants had to be found for the prototyping phase, since the application was still developed for Android. After a short meeting with an explanation of the application and the aim of this work, the new group of four residents received the installation file for the application via email. This way of distribution allowed a quick and easy installation directly via their smartphone.

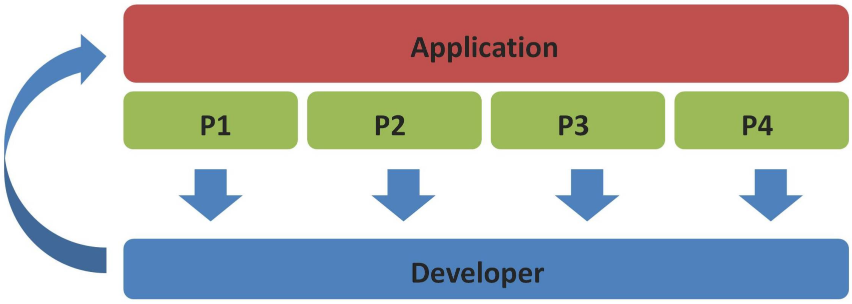

Figure 3.3: Participants (P1-P4) send individual feedback to the developer. Thereupon the developer applies the according alterations on the application. Again all participants give feedback on the new version.

The total duration of the prototyping phase was approximately eight weeks. However, individual durations for single participants differed slightly. It was sometimes difficult to find an appointment for a personal explanatory meeting with each participant, before they received the application for the first time. Problems, criticism and suggestions were constantly collected. According alterations to the application could then be quickly applied. Again the application was sent out to the participants after changes had been made. These updates of the application did not imply great effort for installing or transferring already entered data for the participants. All user entries were kept in the freshly installed version. This way, participants could constantly work with the latest version of the application, including latest alterations and improvement. The direct reaction on feedback further ensured that incoming feedback always referred to current problems that had not yet been reported, or such issues that already had been solved but the according version was not yet redistributed. Such a small and direct feedback loop was only possible in this phase, because of the manageable number of participants, of course. Figure 3.3 visualises the feedback loop. One iteration practically describes one distribution of an updated version to the participants. Depending on participants' feedback some iterations included only very small changes while others contained greater changes in functionality. Therefore it was hard to plan a specific number of iterations for this approach in advance. Yet, due to the very small feedback loop the relatively high number of iterations that was expected, was confirmed.

CHAPTER 4

Findings

4.1 The Hospital Information System

All surgeons that participated in the interviews were working in medium sized emergency hospital in Vienna at that time. The hospital has three main electronic documentation systems which complement each other. The first of these three system is exclusively for scheduling, planing and documenting surgeries and therefore the most interesting system in this thesis as it is very closely related to the personal operation log. Interviewees referred to the system as OP-DMS, which stands for operation documentation management system. Each surgery that is conducted in the hospital is finally recorded in this system including a detailed operation report. The OP-DMS is connected to the general EPR system via a unique patient identifier that is assigned to each patient. This EPR record includes patients' demographic data and reports from different departments. It is also used to administer patients to further examinations, in case an X-ray for the particular patient is required, for example. The third system is the picture archiving and communication system (PACS). The PACS contains photos and, in some cases, videos of operations, ordered by patient names and identifiers. Moreover, resulting images from X-ray examinations or from magnetic resonance imaging (MRI) are stored here.

4.2 Surgery Documentation Process

Depending on the urgency of an injury and the availability of operation rooms the surgeon schedules a surgery that is then entered into the OP-DMS by a secretary. Name and diagnosis of the patient to be operated are adopted from the EPR system with help of the patient's identification number. During surgery there is one nurse in the operating theatre, who is exclusively responsible for documenting the operation process, while the operating surgeon is commenting each performed step of the procedure, such as for example beginning of the operation, moment of the first cut, moment of suturation, and end of the operation. The nurse is directly entering the surgeon's comments into the computer and thereby creates a log that allows to reconstruct the course of the operation. After surgery is finished the surgeon goes to the dictation room and dictates a detailed report of about one to two minutes describing the operation. The device that is currently used for dictation is based on audiotapes. Afterwards the audiotape gets picked by a secretary, who then listens to the audiotape and transcribes the dictated report to the computer system. This completes the operation report, that is on the one hand saved in the OP-DMS system and on the other hand handed out to the operating surgeon on paper. Figure (report) shows an example of such an operation report.

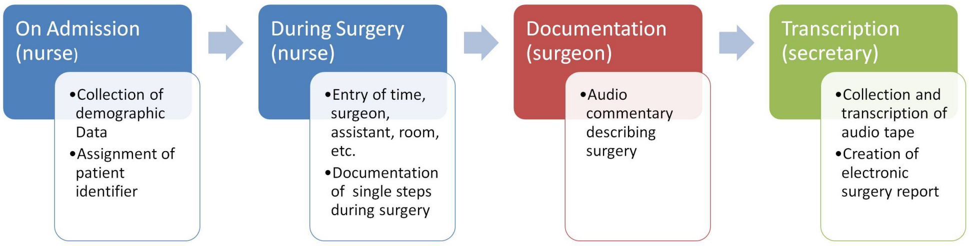

Figure 4.1: Surgery documentation process in the hospital

4.3 Personal Documentation Solutions

Residents are required to fulfil certain amounts of operations in the course of their education. Therefore they should maintain a personal list of operations they have conducted so far. There exists no official guideline for Austrian surgery residents describing an exact structure of these logbooks. The minimum requirement is to include essential information about the operation, such as the body region, the type of operation, the diagnosis, and the date of the surgery. Consequently, residents have developed different strategies how to create and maintain their personal logbooks.

The table in figure 4.3 summarised relevant aspects of the two identified solutions regarding expenditure of time, awareness and accessibility of the personal case volume.

Paper-based logbooks

One strategy is to use a small paper notebook to keep track of operations. Directly after the operation the resident jots down the identification number of the patient and the type of operation performed. Figure 4.2 shows one exemplary page of a resident's paper logbook. This sparse set of attributes is not sufficient to cover all required information, as it lacks essential attributes as mentioned above. The reason therefore is often insufficient time or lack of motivation to enter the exact localisation, diagnosis, assistance and so on. Furthermore, a list in paper based form is not very practicable. It is less structured and therefore not as clearly arranged as an electronically maintained list. Moreover it is difficult to copy and to share it with others. This point gains further importance, since the list has to be presented to the chief of the hospital once in a while. A structured computer based and imprinted list is surely more adequate for those occasions, than a handwritten notebook.

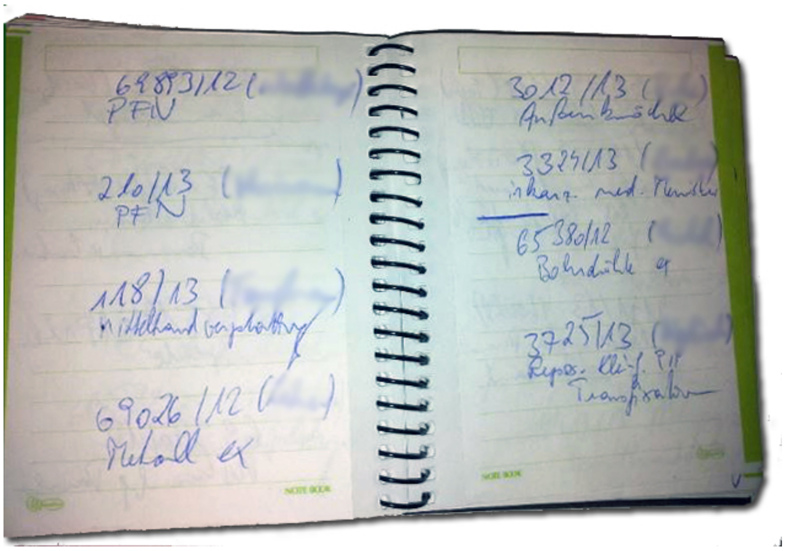

Figure 4.2: This figure shows one page of a resident's paper logbook. Each entry includes a number, identifying the patient and below the conducted surgical procedure. The names of the assisting surgeon is put into brackets on the right side (assistants' names have been blurred)

With respect to these arguments, the resident transfers the entries in the notebook to an excel file. This is usually done approximately once in a semester. Therefore, the resident has to access the OP-DMS system at a computer at the hospital and search for his operations based on the patient identifiers that have been noted. Then it is mostly copy-and-paste work to extract the required information from the official operation reports and create or update the personal excel list. Patients' names and identification numbers are also transferred. Yet, as personal patient data is not relevant, they are left out for the official version of the list. Based on the number of operations conducted, this look-up and transfer process can take up to several hours. In short, the paper logbook plays the role of a temporary storage, which contains only the necessary information to look up all relevant aspects in the OP-DMS afterwards.

Despite its redundancy, this approach has its advantages that make the use of a paper based logbook comprehensible. The first positive aspect is the constant accessibility of a personal paper notebook. Information is stored locally on a small book that can easily carried around all the time, instead of server-side storage that would require a computer for access. This allows the resident to look-up specific operations or flick through the book to get an overview of the personal case log whenever needed.

However, the search for certain groups of operations or single operations is very inefficient in paper based form. This disadvantage grows increasingly worse when the number of recorded operations grows to several hundreds. Yet, with respect to the educational catalogue for surgeons, knowing the absolute number of operations of a certain type might be very interesting for the resident. The resulting excel list on the other hand greatly facilitates look-up, but is usually, unlike the notebook, neither constantly available nor up-to-date at the very point of time. Accordingly the resident confirmed that his awareness about the current state of his personal case log is very vague.

On the contrary, the notebook always contains a complete collection of all operations, since the resident is recording the entries directly after surgery is finished. The fast and uncomplicated entries in the notebook are prerequisite for the up-to-date state of the notebook. Time-consuming or extensive data capturing procedures would not go well together with the often cramped timetable of surgeons that leaves few time for personal documentation.

Still, the inclusion of only rudimentary information remains the downside of this approach. It further requires additional effort of transferring the paper notebook into digital form. Although the work of entering detailed information can be thereby shifted away from busy working hours to more suitable occasions, it still needs to be done. Moreover, the look-up of single operations in the OP-DMS can be very time-consuming in total.

Paper-based logbooks	Regular OP-DMS imprints
Expenditure of time:	
+ Fast and uncomplicated entries - Depending on resident's motivation - Time consuming transfer to excel lists	+ No manual entries required + No direct time expenditure +Quick transfer to excel lists
Awareness:	
+ Individually adaptable to personal requirements and preferences + Comprehensive personal case log - Little awareness about current progress - Costly look-up of individual entries - Manual search - No summarised information	+ Advanced filtering functions + Effective searching + Summarised information - Little awarness about current progress - Hospital depending, may not include a complete case log
Accessability:	
+ Fast and easy access + Almost ubiquitous access - Less structured	+ Structured Form - Depending on computer availability - Only accessible from hospital computers

Figure 4.3: This table summarises pros and cons of both presented solutions and compares them regarding expenditure of time, awareness of the personal case volume and accessibility of the case log

Regular OP-DMS Imprints

Residents pursue another strategy to keep track of their personal case log. Interestingly, this approach does not actually include the management of an extra case log at all. As described above all details that are relevant for the personal logbook can be accessed via the OP-DMS system. This system allows physicians not only to simply view conducted operations, but additionally offers some filtering functionality that can be used to filter all recorded operations by certain attributes. A database request, filtered by the first operating surgeon, consequently results in the case volume of the particular surgeon in this hospital. Figure 4.4 shows an exemplary screenshot of a database request. Additional filters may further help to assess the number for certain types of operations. Residents, who are following this approach, access the system a few times a year and imprint a list of their current operation case log, to get an overview.

The main advantage of this method is that it takes little effort for the actual documentation. In fact, surgeons themselves do not even have to enter additional information besides the documentation they have to do in the course of the creation of the official reports. This saves time and nerves. Secondly, the mentioned filtering functionality allows to get an overview of absolute numbers and particular types of surgeries.

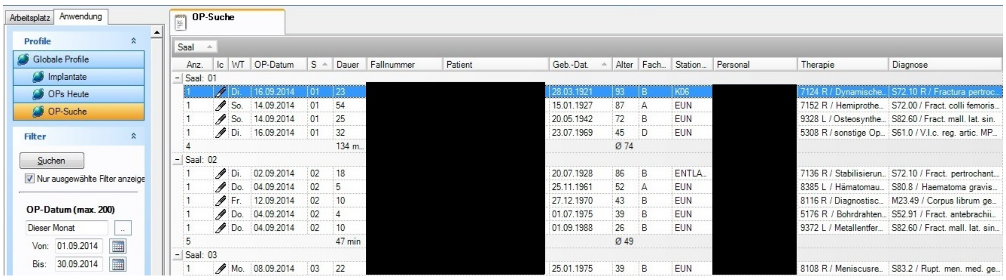

Figure 4.4: This figure shows a screenshot from the operation management system. All operations in the hospital can be filtered by operating surgeon in order to receive a particular surgeon's case log. Information is displayed very detailed but not fitting to educational requirements. (Black boxes cover patients' personal information as well as residents' names)

However, residents are depending on the availability of computers that allow access to the hospital system, in order to review their case logs. Although available computers can be easily found in the examined hospital, it has shown that a lack of computers exists in other hospitals [73]. Moreover, residents have no possibility to quickly check their case log in spontaneous situations. Officially, residents are expected to absolve regular meetings with their head surgeons in the course of their medical education ("Weiterbildungsgespräche"). The goal of these conversations is to give the head surgeons an impression of the current educational progress of the resident. Yet, interviews have shown that the coordination of surgery scheduling according to residents' current operative experience is greatly influenced by short and often spontaneous conversations instead of officially scheduled meetings. It may be very helpful in such situations to have exact knowledge about the personal educational progress, in order to give chief surgeons a detailed statement including surgeries the resident is missing. Dependency on local computers and the lack of quickly accessible notes do not allow to quickly recheck personal case logs in such situations. Another disadvantage of this method is its dependency on the hospital's particular operation management system. One hospital might not offer them the possibility to gain experience in all surgical disciplines they have to complete in the course of their certification. Thus surgery residents often work in several hospitals during their residency. Since patient records and operative records are generally not shared among hospitals, it is not possible to access information about surgeries that have been conducted in another hospital. Consequently, a complete personal case log that includes all operations from all hospitals a resident has worked for is not accessible from the surgery management system of a single hospital.

Further, the majority of interviewees preferred to spend a few minutes directly after surgery for documentation and in return have a complete and up-to-date case log at their disposal. However, one surgeon stated that he prefers to do all the work at the end of the year. In the end, this is an individual decision and depending on personal preference and attitude.

4.4 Design Requirements

Based on the interviews, there have been identified two methods about how residents keep track of their personal case log. Each method is connected with a number of advantages and disadvantages that have been described in the previous section. These findings can be further used to derive a set of requirements for a personal electronic logbook. The motivational backgrounds of those requirements are diverse, yet they can be roughly categorized in three types.

Requirements on Functionality

This category describes fundamental features, that necessarily have to be supported by a logbook solution, in order to efficiently support residents during education. They can be considered as the most important requirements and prevalent for the applicability of the logbook. However, these features represent only the very basic core functionality, what is still far away from a sufficient solution.

- Completeness of education-relevant information

  The official education catalogue, which is in Austria provided by the ÖÄK, demands for a set of absolute numbers of certain operation types. However, it is neither sufficient nor informative for residents to record only the type of an operation, for example arthroscopy or osteosynthesis. The problem is, that there exists uncertainty among questioned residents, which attributes are officially demanded to be logged by the ÖÄK. For this reason, both, residents and already certified surgeons, had different opinions about which attributes should be included for a personal case log and which are not necessary. To sum it up, all four surgery residents agreed that the entry of the following attributes is a sufficient minimum set of attributes that complies with the requirements of the ÖÄK.

  - Region
  - Diagnosis
  - Operation
  - Date
  - Patient Data

- Confidentiality of Patient data

There are some privacy and data security issues to be respected, since the logbook includes patient related data. Originally, the design of the application was not intended to include any connection to actual patients, in order to avoid such issues. However, all interviewees recommended to give the possibility to record patient information as well. Recorded patient data includes the first name and the last name of the patient plus an unique patient identifier that is assigned to the patient upon admission in the hospital. This identifier is needed, in order to find corresponding official operation reports that include all detailed information about an operation (see section for surgery documentation process). This connection to detailed reports is necessary for cases, which require more detailed information about a specific logbook entry than recorded in the logbook. In order to prevent unauthorized access to patient data, the application must at least be secured with a password needs to be entered before any patient related data is presented to the user. A further step to protect patients would be to use only initials instead of full patient names. However, residents stated that they would like to include full patient names. In addition, complete patient names can still be easily found in combination with patient identifiers. The interview with P5 was especially enlightening in this context. He pronounced that despite the usage of a password, patient confidentiality remains a delicate subject when storing patient related data on private mobile devices (compare guidelines in section 2.7). Officially, private smartphones are actually not allowed in the hospital. Yet, they are tolerated among hospital staff. The tendency here goes towards the introduction of hospital owned devices, that stand at physicians' disposal, and are only to be used for hospital related issues. Although this idea already exist for some time, it is not yet established. Therefore, the majority of physicians uses their personal smartphones nevertheless.

- Reduction of expenditure of time

  One of the main goals of the application is, to decrease the timely effort for resident operation documentation. The possibility of creating resident case logs automatically by accessing information directly via the HIS, was shown in [54]. However, the direct export of patient related data from the HIS to residents' private mobile devices is, according to the interviewed senior surgeon (P5), impossible to realise in Austrian hospitals, due to privacy issues. In return, it is essential to reduce the time that is currently dedicated to the documentation for education purposes to a minimum. More concrete, this means to decrease the effort for the creation of new entries and the retrieval of collected data. In the context of a smartphone application, an approach to achieve this is to avoid typing of long expressions and instead use other input methods that are more adequate to the interaction with smartphone. An example are lists with by default or previously entered values that require only a few taps to make a quick and comfortable selections. Yet, there is a huge number of different diagnosis and operation types and lists could quickly get crowded and therefore hard to overview. Combinations of typing and selecting from lists in form of automatically completing text fields may consequently be a suitable solution for user input for large lists.

- Retrieval of absolute numbers for education catalogue categories

Besides the reduction of time expenditure the second main goal of the application is to facilitate the extraction of officially demanded numbers from the personal case log and to increase residents' overall awareness of their educational progress. Requirements of the education catalogue are mainly, but not exclusively, categorized by operation region or by operation type. The application should provide according filters to extract absolute numbers for a certain category. However, the minimum attribute set, as described above, does not include a direct assignment to the categories of the education catalogue. For this reason, filtering functions for region, diagnosis, and operation type should be included, which allow to create individual queries and thus facilitate the retrieval of operations that match a certain education category. Residents agreed that this possibility of creating individual queries is an absolutely sufficient solution compared to direct assignment and filtering of categories, especially since the assignment of an operation to a given education category may not only be clear. Interviewed residents preferred to have a little more freedom and options to configure the application, instead of having to assign an operation to a certain category that actually does not perfectly fit.

- Data Export

  Although there are different approaches how residents maintain their personal operation catalogue, they all concur in the fact that the final product is an excel list. Consequently, all interviewed residents asked for a possibility to transfer the collected data, which is stored on their mobile devices, to their personal computers in some form table chart, preferably an excel file. Interviewees named two reasons for the necessity of an export feature. Firstly, exporting the data to another device serves as backup in case of a crash of the application and subsequent loss of data. In fact, information cannot really get lost, since all relevant data can still be acquired from the HIS. Nevertheless, regular exports create a helpful redundancy of data preventing loss of data if a single device crashes. Secondly, residents might further edit or process their operation catalogue. Whereas the smartphone application allows quick entries and overviews, a desktop computer is the better choice for applying eventual major changes on the list (e.g. formatting issues before submission), or just to review the log on a bigger screen.

Requirements on Usability and Efficiency

The following section discusses challenges that can be classified as secondary challenges. They may be not absolutely necessary for the basic functionality of the application, yet they have significant influence on the usefulness, practicability of the application and therefore also on residents' acceptance.

- Adaptability to individual requirements

  All interviewed residents uttered different preferences about which information they want to record in their logbooks. Two residents also entered the assisting surgeon and/or a more exact denotation of the conducted operation, besides the minimum attribute set. Their personal solutions, like paper-based logbooks or manually maintained excel lists, do not restrict residents to a specific attribute set, but they are free to choose which additional attributes they want to include. Therefore, it was a great concern to all interviewees that the application does not force the user to fill in attributes, which are not in accordance with the users' interests. This issue is also to be respected when the application proposes default values for selection. Residents don't want to find themselves in the situation, where there are many possible options available but non of those absolutely fits. Amongst others, these restrictions were a reason why other operation documentation tools did not work form them. The logical consequence is to let residents decide themselves what kind of additional information they want to record. Presettings and default values make sense and can save time, but there always has to be the opportunity to expand the application with own values, so that residents are not restricted to the contents of the application.

- Fast and ubiquitous overview

  Primary challenges include the possibility to retrieve absolute numbers of certain operation types. This knowledge is not only interesting at the end of residency, but there might also occur situations when an exact and quick overview of the personal progress may proves to be helpful. As mentioned in (cf. section 4.3) the awareness of senior surgeons of their residents progress is mostly obtained during spontaneously occurring conversations. The interviewed senior surgeon, who is involved in the operation scheduling, confirmed that senior surgeons do not have an impression of residents' progresses, and that it is up to the residents to give the senior surgeons this information. Consequently it is only productive that residents have a detailed overview at their disposal that can be quickly scanned during talks with senior surgeons.

- Up-to-date information

  When it comes to giving feedback to senior surgeons, only an up-to-date overview is constructive. In the end, the up-to-dateness of the logbook is depending on the resident's motivation and if he or she is consequently willing to make entries directly after surgery. However, a simple and user friendly interface for the creation of new entries promotes the willingness of residents to immediately enter new operations. All residents stated that this kind of documentation would be almost no additional effort as long as it does not take longer than one minute. Since they have to do an official operation report after surgery all the same (see surgery documentation process), this moment in the dictation room would be also perfectly suited for the personal documentation with the application.

- Independence of hospitals

  During their six years of residency, residents spend only have of the time for their actual speciality. Trauma surgery residents for instance complete three years of trauma surgery and another three years with the practice of related surgical domains. In many cases residents cannot complete their entire residency in one hospital, since hospitals are often specialised in very specific medical fields and thus do not offer the complete spectrum of treatments that is demanded for certification. Yet, the hospital, in which an operation was conducted, is not relevant for the residents' operation catalogue. For this reason, a logging application should not depend on the HIS of an individual hospital. On the one hand this would not be practicable because of the variety of standards and systems in use. On the other hand, a HIS depending application would be extremely complicated to enforce, due to hospitals privacy policies. Therefore the focus of the application should lie on a purely personal documentation tool that is decoupled from an individual HIS.

- Support multiple diagnosis

  Sometimes there are more complex injuries that include more than one diagnosis. Injuries of the knee, for example, often affect multiple parts of the joint like the cruciate ligament and the meniscus, that are often treated in one operation. Regardless of the fact that both injuries are medicated during one surgery slot, those are actually two diagnoses with two different treatments. Therefore, residents usually enter such surgeries as two separate operations, in order to complete their operation catalogue faster. Region, date and patient data of the operation usually stays the same. Documentation time can be therefore further decreased, by offering the possibility to add additional diagnosis and according treatments in such cases.

- Data Import

  Data export was demanded as one of the main features by all interviewees. Besides the originally intended purpose to create a structured list at the end of residency, it can be used to create backups of the current operation catalogue. In case of a crash of the application, loss of the phone or any other other situation that makes it impossible to access the data on the smartphone, it makes sense to provide an import feature, allowing to reintegrate hitherto existing entries into the application. This is also an important feature for the prototyping phase. Third year residents already possessed large operation catalogues with partially more than 200 entries. Manual transfer of all entries to the application would be very costly. The import feature allows them to integrate their existing excel lists into the prototype application, creating a more realistic testing situation.

Value Adding Features

The focus of all challenges described so far lay on the functionality and usability of an application with the single goal to support the maintenance of a personal catalogue, tailored to the requirements of the official education catalogue for Austrian emergency residents. However, extending the scope of the application beyond the mere educational background, there is much space for additional features augmenting the value and range of possible applications. The following list contains an extract of such potential value adding features that came up during conversations with the participants.

- Additional Visualisations

  Absolute operation numbers are actually the only important parameter for the ÖÄK catalogue. In return, this does not mean that only a presentation of absolute numbers is interesting to the residents. In fact, in case of the residents, the percentage of education catalogue completion can be considered even more important than absolute numbers. Visualisations in form of diagrams, charts and graphs help the user to realise this information in a fast and demonstrative way. Moreover, visualisations allow to create and display relations between operations, e.g. the distribution of body regions among all operations. Another example is to illustrate the timely distribution of conducted operations. This feature could be used to identify decreases of a resident's surgery assignments in the long term and to argument for their claim to be more respected in operation scheduling. Although this kind of information is not officially demanded, it supports a more comprehensive awareness of a resident's operation experience.

- Advanced sorting and filtering functions

  Whereas visualisations are an advanced form of presenting the collected data, it may also be interesting to provide additional, meaning educational irrelevant, contents that can be visualised, sorted or filtered. An example for such advanced attributes is the storage of the assisting physician. Opinions about the importance of this information were divided, yet the fact that the inclusion of this information was proposed by residents shows, that there generally exists a willingness to enter additional information beyond the officially demanded parts.

- Integration of ICD10/MEL codes

  ICD10 stands for International Classification of Diseases in its 10th revision. These codes help to exactly describe specific injuries. Strain and rupture of the anterior cruciate ligament, for example is described with the ICD10 code S83.53. Usually physicians do know some of those codes by heart, yet it is impossible to know all of them, due to the huge number of codes that requires physicians to look-up particular codes.

  The MEL catalogue on the other hand contains all types of single medical accomplishments. It is mainly used for assignment of medical treatments as a basis for the billing procedure. In comparison to the ICD10 codes the MEL code describes the type of operation that is conducted. A common example here is the MEL code NF020, describing an arthroscopic operation of the knee joint.

  Consequently ICD10 codes in combination with MEL codes theoretically allow to precisely describe the diagnosis as well as the treatment of an injury. Moreover both codes are known to the resident at the latest when an operation is finished since they are part of the official surgery documentation in the hospital. Further they could be entered quickly and provide a way for efficient data entry. For these reasons, both surgeons suggested to include ICD10 and MEL codes in the application. Residents, however, uniformly negated the need for such codes for a purely personally used logbook.

- Categorisation by hospitals

  Another example is the categorisation by hospitals. As described above, the hospital in which a hospital is conducted is basically irrelevant. All the same it can make sense to add the particular hospital in the log entry. The explanation lies in the patient identifiers. Assuming the case that two patients from two different hospitals have the same patient identifier, the hospital is needed to conclude the distinct identity of the patient. Though this may be a quite unlikely scenario it justifies the inclusion of the hospital for a operation entries. Since the hospital does usually not change frequently, but at the most once in a few months, the additional documentation effort for residents could be minimised by using a default hospital. Resident's opinions in this point are also diverging, thus it appears to be the best solution to leave this decision to the user by giving the possibility to enable the use of additional attributes.

- Image integration

  The variety of smartphone features like cameras, sensors, microphones, etc. offers further possibilities for potential value-adding application features. During interviews, residents were asked if and how they use their smartphones during daily routine in the hospital. Two residents mentioned that, amongst other things, they use their smartphone cameras to take pictures of x-ray images of operations, especially if an operation was rather complicated and/or very well done. Integrating images into the application would create a connection between the image and recorded attribute set. This way the application could provide a central spot, where photos of x-ray images could be maintained. However, the outcome of further investigation and questioning about a camera feature was, that the potential benefit would not compensate the additional effort for the user and the risk of violating patient privacy.

- Audio recording

  As described in section 4.2, residents record an audio commentary of the operation process directly after surgery. This is the same timeslot that is intended for the use of the personal operation log application. Available features of the smartphone could be used here, by recording the audio commentary directly with the integrated microphone. After short testing interviewed residents confirmed that the quality of their smartphones would be absolutely sufficient for their usual documentation. With this solution, it would be much easier to forward the audio record to the transcribing secretary in digital form, than it is with the current tape-based solution. However, similar to image integration the recording of the audio commentaries goes away from a purely personal operation log for residents towards a completely mobile surgery documentation tool, that would exceed the scope of this work.

4.5 Summary Table of Requirements

The table in figure 4.5 gives a summary of all identified requirements. All requirements have been assigned a number, in order to reference them more easily in the following sections of this thesis. Moreover requirements have been prioritised according to their importance for the application.

Code	Requirement	Priority
R1	Completeness of education relevant information	5
R2	Confidentiality of patient data	5
R3	Reduction of expenditure of time	5
R4	Retrieval of absolute numbers	5
R5	Data Export	5
R6	Adaptability to individual requirements	4
R7	Fast and ubiquitous overview	4
R8	Up-to-date information	3
R9	Independence of hospitals	3
R10	Support of multiple diagnoses	3
R11	Data Import	3
R12	Additional Visualizations	2
R13	Advanced sorting and filtering	2
R14	Integration of ICD10/MEL codes	2
R15	Categorisation by hositals	1
R16	Image Integration	1
R17	Audio Integration	1

Figure 4.5: This table summarised the list of identified requirements. Requirements have been prioritised from 1 (least important) to 5 (most important).

CHAPTER 5

The Application Prototype

The prototyping phase mainly fulfilled the following two purposes:

1. Interviews and literature research result in a number of requirements for personal logbook solutions. In subsequent steps these requirements were applied on the concrete case of a smartphone application. There were different possibilities of how to implement the identified requirements in form of concrete features in the application. On the creation of a first version of the prototype, this decision was to be made by the developer. Prototyping offered a possibility to evaluate the usability and usefulness of the chosen implementation with help of the participants, representing potential users.

2. Testing of the prototype included using the application in real world situations and working with the application over a longer period of time. Resulting frequent and target oriented interaction with the application, allows residents to assess the functionality of existing features, and to realise new requirements that may have been missed.

5.1 Prototype Stages

Figure 5.1 illustrates the development of the prototype throughout different stages. The first version, which was created after literature research and first interviews represents the initial point for further development. Following interviews and testing of the prototype by participants lead to further changes in the application. The most important changes are summarized in stages that represent milestones in the development of the application.

5.2 The Final Prototype

The final version of the prototype provides full functionality for education relevant documentation as well as a number of features to enhance usability. It reflects the great number of considerations and decisions that have been made about the design of the application during the

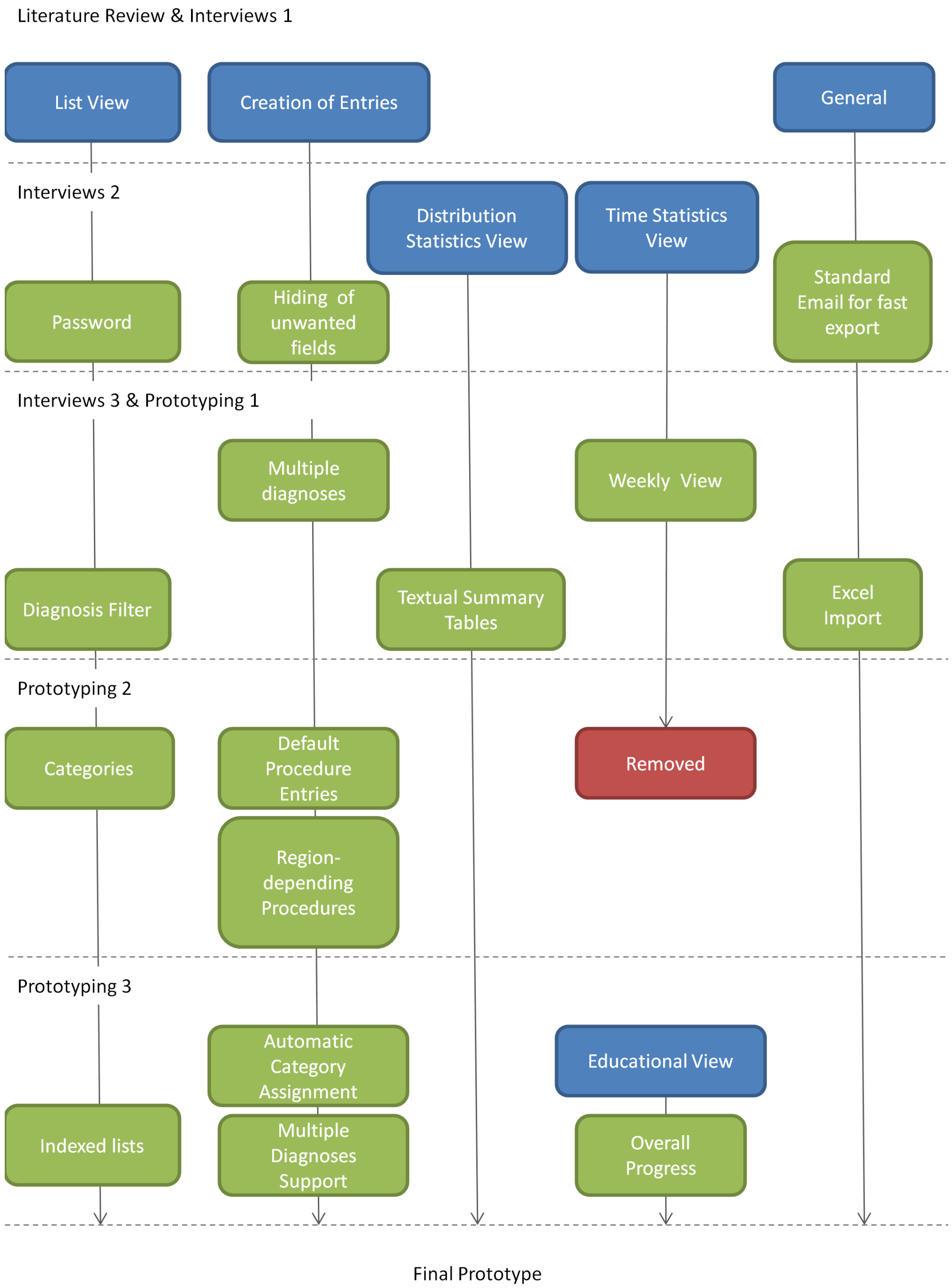

Figure 5.1: Development of the application through different prototyping stages. Blue boxes describe main parts of the application. Green boxes refer to specific features that have been added in those parts.

literature review, interviews and the prototyping phase. The final result is a hi-fi prototype for Android mobile devices. The decision for a hi-fi prototype was made, because residents should autonomously work with the application during the prototyping phase.

The basic structure of the application contains of three main views (fig. 5.4):

1. A list view of operation entries
2. A statistical view for summarised information
3. An education catalogue view for quick overview of educational progress

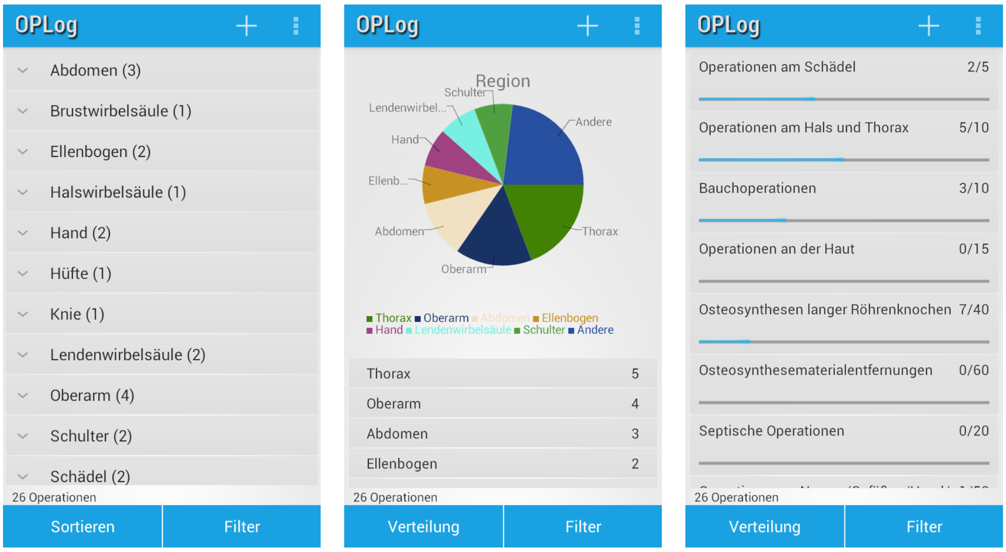

Figure 5.2: The three main views of the application are: the operation list view (left), statistical view (middle) and education catalogue view (right).

5.3 Operation List View

This is the standard view that is displayed to the user as the default view. It basically contains a list of all operations that have been entered so far. The list view is directly derived from paper based logbooks and excel lists that residents are currently using. The similarity to their already known solutions allows residents an easy transition to the electronic logbook and thus increasing user acceptance. Besides the mere adoption of current logbook solutions to the smartphone, this list view offers additional interaction possibilities. As numbers of collected operations can grow up to a several hundreds, sorting the list by certain attributes makes sense to facilitate the handling of the list. This is achieved by organising the list in two levels. List items on the first level summarizes operation entries that share same values for certain attributes. Sorting the list by region, for example, creates one list item for every region that has been recorded. Selecting one region reveals the second list level, which contains all actual entries that have been entered for this region. This list concept, illustrated in figure 5.3, increases clarity of the list by polling single entries in groups. Besides dates, sorting is available for different attributes of operation entries, such as operation type, region and education category assignment.

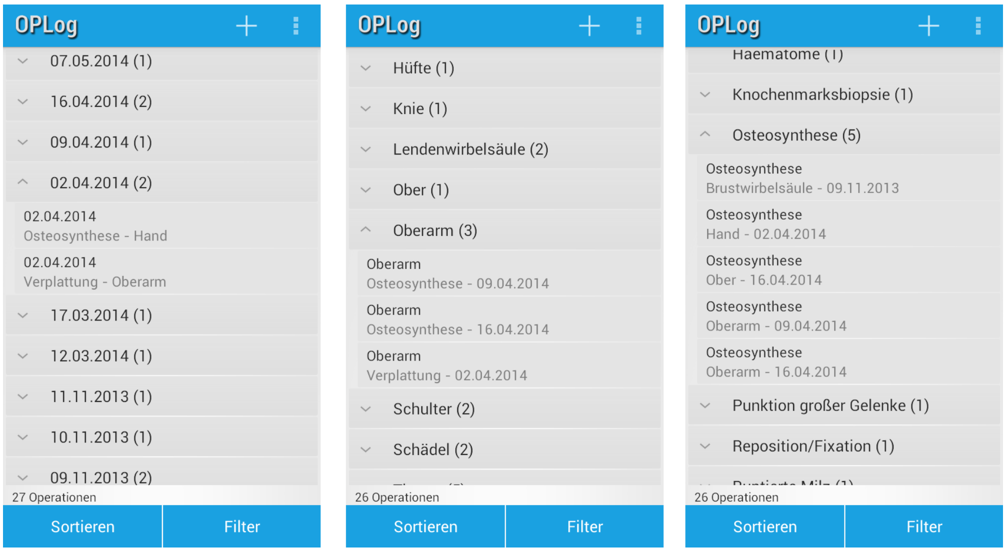

Figure 5.3: The operation list view supports sorting by date (left), region(middle), or procedure (right).

Besides the sorting of operations, there is a filtering function that can be applied on the list view. Actually filters are not only applied on the list view, but on all three main views: operation list, statistics and education categories. As explained above filters are an essential tool to quickly retrieve absolute numbers for certain procedures or regions. Moreover, filters can be applied for particular education category assignments or filters for different attributes can be combined to select a specific subgroup of operations. This allows to review and check all operations that have been assigned to a particular category, edit wrongly assigned operation entries or add a category to such entries, that have not been assigned yet.

5.4 Statistical View

The operation list view provides a comprehensive and detailed view over the resident's entire case log. While this completeness is helpful and necessary in many cases, it turns out to be contra productive when the user's intention is to get a quick overview. Finding out absolute numbers for certain operation types may be a possible case. One possibility is to use filters in combination with the operation list view to get this information. The disadvantage of this approach that it requires the user to set the filter for each operation type to retrieve absolute numbers. For this reason, the statistical view offers absolute numbers for each entry of a particular attribute. All procedures with corresponding absolute numbers can be directly displayed. For more detailed queries, this feature can be additionally combined with filters. Thereby, the overview of procedure types from the example above, can be restricted to a certain region, such as the hand.

The result is a table of all procedure types that have been performed on the hand region. Possible users for such detailed queries are not only residents, but also surgeons who plan to do an advanced speciality education, for example as a hand surgeon. Similar to the normal trauma surgery residency, there is some form of education catalogue containing absolute numbers for different types of procedures performed on the hand. Besides the pure textual representation of information in form of a table, the statistical view also supports a graphical illustration of the data in form of a pie chart. While pie charts are not suited to display absolute numbers, they are useful for pronouncing the distribution among operations. The data table in comparison, contains absolute, detailed numbers. Chart and table are therefore combined to provide a comprehensive overview of collected data.

5.5 Education Catalogue View

The third main view is the education catalogue view. It displays the user's progress for each of the official categories for trauma surgery residency. Each category is displayed with the corresponding number of demanded operations and the current number of operations that have been assigned to this category so far. Thereby this view represents the most concrete reflection of the resident's current educational progress. Both other views almost entirely depend on information from the user and are therefore theoretically applicable also for other surgery specialities than trauma surgery. The education catalogue view, in contrast, strongly depends on predefined categories and according absolute numbers. Consequently, this strong dependency restricts the target group of this view to trauma surgeons, while other surgery fields cannot make use of this feature so far. Providing catalogues for other surgery domains will therefore be one of the most important future steps, in order to expand the target group of the application.

5.6 Creation of New Entries

The three main views give the user a comprehensive overview of the collected data whereby each view focuses on different aspects. Yet, before data can be prepared and displayed it has to be collected by the user. The entry of new operation data is the actual effort that has to be made by the resident. Consequently, one main goal of the application is to reduce expenditure of time for documentation. More concrete, this means to optimize the process of entering new operations into the application. The following list summarises a set of features that have been implemented and describes how they contribute to speeding up and facilitating the entry of data.

- Hiding of unwanted attributes

  Based on preferences of the residents, there there have been identified additional attributes, besides the minimum set of attributes (cf. section 4.4). Depending on these preferences, unwanted options can be hidden. Instead of just leaving fields blank when the additional attribute shall not be used, removing those fields completely from the layout creates a slimmer and clearer interface. Entry of patient identifiers including full names has been identified as an essential feature for all questioned residents. However, the interviews indicated that the patient identifier is an essential piece of information, as it provides the

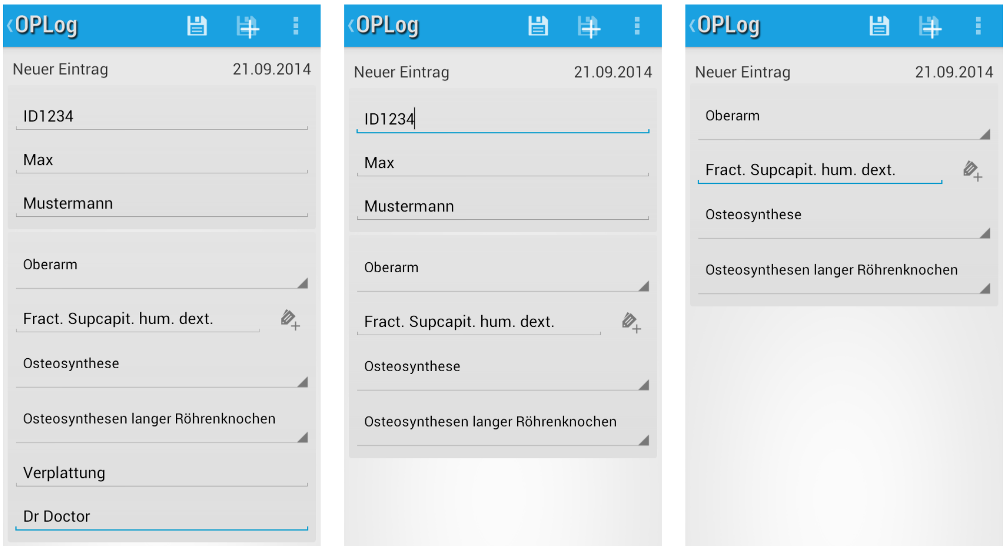

Figure 5.4: This figure shows three versions of the view for creating new entries. The level of detail for entries can be adapted according to resident's preferences in the application settings.

connection to the HIS. Patient names, in contrast, are to some extent redundant information, since they can be easily found out with the help of the identifier. Furthermore, leaving out full patient names eases the constantly prevalent issue of patient data confidentiality. For this reason, there exists the possibility to turn off the support for full patient names completely. Again, this slims down the layout of several views on the one hand and and to eases privacy concerns on the other.

- Storage and provision of user entries

  Attribute values for diagnosis, procedure type, or region often appear repeatedly. Therefore, the application stores users' inputs upon successful operation entry. User data is maintained in a local database on the device and can then be used to speed up the entry of new operations by offering previously entered information for selection. There are two possibilities how this selection can be implemented. Procedure type and attribute can be selected via a dropdown list that opens upon tap. The dropdown list is very suitable here, because it does not require the user to use the keyboard, but instead allows to quickly select the desired item with two taps. It has to be kept in mind that the dropdown list is only efficient in this case, since the number of entered operation types is expected to remain relatively low. For other fields the amount of different user entries is expected to be higher and therefore no lists are used here. A list with too many items slows down the selection process, since it is harder to overview for the user and requires scrolling and searching for the correct item. Instead, there are text input fields in use that offer automatic completion of the typed expression (fig. 5.5). This allows residents to quickly choose from large lists of items, by typing just a few characters and selecting from a strongly reduced list.

- Provision of region dependent procedure types

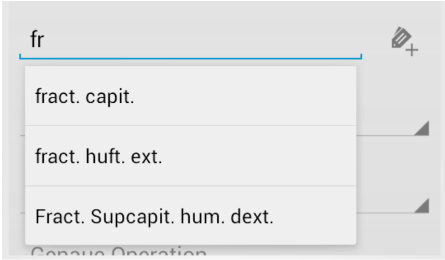

Figure 5.5: The combination of text input and dynamically adapted lists allows quick selection also for large lists.

The official education catalogue already names a few examples of typical procedures, for some of the categories. These examples are included in form of default operations in the application. Some of these procedures can be further exactly assigned to a certain region. As an example, a brain probe operation can be directly assigned to the head region, whereas a stomach operation is assigned to the abdomen (fig. 5.6). The application can use this connection to filter the list of selectable procedures, as soon as a region was selected. Again, this feature tries to keep the selection list small and easy to overview, making it easier for the user to find the correct item.

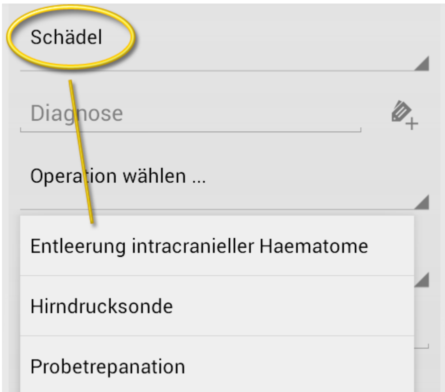

Figure 5.6: On selection of a region, the list of procedures is automatically filtered to display only fitting procedure types.

- Automatic assignment of categories

  Operations can be assigned to a particular category of the official operation catalogue. On selection of the procedure type, the application automatically selects the assigned category. Default procedures already are connected to categories, whereas user created operations are not assigned to a certain category. For this reason, it is prerequisite for this feature that the procedure already has been assigned to a category before. There is no automatic assignment made before the user selects a corresponding category and stores the entry. Users always have the possibility to overrule the automatic assignment, of course, since there might always occur a case where the assignment is not adequate, or where the entry shall be assigned to no category at all.

- Entering of multiple operations in a consistent surgery setting

  If a patient has suffered more complex injuries, there might exist more than just one diagnosis. Each diagnosis usually has an according treatment, respectively an according procedure type. Although multiple procedures can be conducted during one single surgery slot, residents can theoretically enter each procedure as a single operation into their logs. For these cases, the application offers a feature that allows to store multiple operations for the same surgery setting more easily. The surgery setting describes the date, the patient data, and the assistant, since these are the attributes that usually do not change during one surgery slot. Upon creation of a new operation entry it is possible to save the operation, while staying in the operation entry view with the same surgery setting selected (fig. 5.7). Diagnosis, procedure and the category assignment are reset and can changed for further entries.

Figure 5.7: When it comes to saving an entry there is are two possibilities: Storing the entry and return to the overview (red circle), or adding more entries with different diagnosis and procedure but unchanged surgery setting (yellow circle).

- Checking for completeness of data

  The application checks if all attributes from the minimum attribute set have been selected, before an operation entry can be stored. If something is missing, there is a pop-up issued that informs the user, which fields are missing. This feature does not directly save time during the entering of new operations. However, it ensures that there is no incomplete data stored and thereby indirectly saves time and effort to find and correct these errors.

5.7 Summary Table of Features

Features	Related Requirements	Status
Operation List View		
Indexed lists	R4, R7	implemented
Filtering and sorting functions	R13	implemented
Statistical View		
Graphical representation of case volume	R7, R12	implemented
Table-based textual summary	R4, R7	implemented
Education Catalogue View		
Summarised educational progress (in per cent)	R4, R7	implemented
Creation of new Entries		
Possibility to hide unwanted attributes	R6	implemented
Storage and provision of user entries	R6	implemented
Provision of region dependent procedure types	R1, R3	implemented
Automatic assignment of categories	R1, R3	implemented
Entering of multiple operation entries in a consistent surgery setting	R3, R10	implemented
Checking for completeness of data	R1	implemented
General		
Data Export	R5	implemented
Default Email Adress for Export	R3, R5, R6	implemented
Data Import	R11	implemented
Password security	R2	implemented
Configurable level of detail	R6	implemented

Figure 5.8: This table summarises the list of implemented features with there references to single requirements from figure 4.5.

CHAPTER 6

Discussion

The concept of the resulting prototype was really appreciated by all surgeons and especially by the surgery residents that were involved in this project. They liked the idea of maintaining their case log in a clean electronic form and at the same time saving time while doing so. Yet, the prototyping phase again showed that a great part of residents' acceptance of the application depends on individual preferences. Two participants showed by far the greatest interest in the application. Whereas the rest of the participants used the application only sporadically and additionally to their own documentation, these two entered all their operations into the app and thereby collected around 40 and 80 operations respectively. Accordingly, the lion's share of feedback came from this subgroup, which shaped the development significantly during the prototyping phase.

The foundation of the concept, however, was built during literature research and the subsequent interviews. Consequently, the majority of identified requirements and derived concrete features base on interpretations of the interviews. Therefore, it is important to be aware of the significance of the conducted interviews. A great part of the findings from the interviews was generalised and considered to be valid for the complete target group.

Admittedly, there are some limitations regarding the interviews, raising doubts if the results can be interpreted in this more general way. Firstly, the sample size of only six participants was relatively small. Secondly, all interviewees, except one, are working in the same hospital and therefore represented a point of view about surgery documentation, which is heavily influenced by the conditions in the examined hospital. Thirdly, all interviewees practise the same speciality. Finally, all participants are colleagues, who are exchanging experiences and sharing best practices regarding medical issues, but also personal documentation solutions. All in all, these points demonstrate how much all interviewees have in common and how they are influencing each other. As a consequence, from the beginning, findings about personal documentation were not expected to differ fundamentally and to represent a wide range different opinions.

Retrospectively, these supposed weaknesses do not weigh too much, which is partly due to some simple adaptations. The possibility for detailed and exhaustive interviews compensated for the small size of participants. This way it was possible to generate a deep understanding of the field, instead of catching a greater number of short impressions. This general understanding further exceeded mere explanations about the particular participant's individual preferences, but the open style of the conversation also allowed talks about colleagues and their habits.

Consequently, the following can be said about the significance of the conducted interviews. Unquestionably, the sample size is quite small and participants represent very similar opinions and preferences, due to their shared working place and similar states of education. On other side, the subject of this thesis, personal operation documentation for trauma surgeons in Austria, is equally special. Since the aim of this work was to create a very tailored solution, the choice of a very specific participant group is fitting. Therefore, interviews helped to gain diversified impressions within the subject of the thesis.

According to this assessment, requirements derived from the interviews are to be considered equally valid. It has to be kept in mind that the list of requirements claims not to cover really all requirements, that are necessary to respect for a successful solution. It rather presents a number of exemplary requirements illustrating the different types of challenges that had to be respected during development of the application.

A highly automated solution that can directly access electronic patient records stored in the hospital's official EMR system had to be discarded already very early after the first interviews. By then it was clear that this would cause a lot of concerns regarding patient data confidentiality. One expert from the interviews made this very clear: "Da kann man die Welten nicht verbinden" (*"One cannot connect the worlds here"*)

Another point can be derived from interview findings. There is a discrepancy of giving proof in form of absolute numbers on the one hand, and partly loose regulations on the other hand. Although the education catalogue of the ÖÄK defines clear numbers for each category, it seems that residents regard those numbers rather as a guideline, instead of a fixed goal they have to achieve. The application, in contrast, is in this regard derived from the catalogue. It works with exact, absolute numbers and explicit assignments of categories, although this might be sometimes difficult in practice. It is a balancing act to support surgery residents as much as possible, by offering them a tool for documentation and predefined selection options based on the catalogue, but at the same time allowing them enough flexibility to use the application, according to their interpretation of the catalogue specifications.

In this context, the prototyping phase was a valuable method in order to assess, if this balance was successfully implemented in the application. The prototyping process can be therefore seen as a form of formative evaluation. Participants' feedback can be considered as an evaluation of an actual state of the application that helped to refine it bit by bit.

During the prototyping phase it turned out that the very agile form of application developing used in this project has one big advantage. More structured forms of iterative software development may require regular feedback from participants in fixed time-intervals. Physicians who work in hospitals, however, usually have relatively irregular working hours. Night shifts, 24-hour shifts and duty on weekends made it difficult to find regular appointments with residents. The approach used in the prototyping phase respects this issue by sharing common ideas with other agile development methods. It is similar to extreme programming, its short iteration cycles and its capability to adapt to changing or extending user requirements. However, the complexity and structure of the approach was further reduced to fit the scope of this project. Adapting iteration cycles and the abandonment of fixed feedback schedules allowed participants to give feedback per email whenever they found time. Firstly, this approach saves valuable free time, which is of special importance for very busy target groups. Secondly, the freedom to decide when to give feedback may further increase the overall willingness of participants to participate in the development, by not feeling urged to give feedback in any case. Instead participants can give feedback whenever they really notice something to improve or criticise, increasing feedback quality.

Yet, prototyping faces similar issues like interviews, as participants only represented one hospital. Therefore, the final version of the application is indirectly depending on the particular hospital practices. Again, this underlines the need of sufficient flexibility to allow usage of the application in relation to varying hospital practices.

However, formative evaluation did not comprise all features of the application. The potential of some features can only be tested in the very real-world situations they are meant to support. Due to missing opportunities, evaluation did not include an assessment of the value of the application at the end of residency, or its support during educational conversations with head surgeons.

For further development and for anybody who plans to use a similarly agile approach there is a very important thing to keep in mind. Despite the loose structure of this prototyping phase, a structured documentation of the feedback process is even more important than in more structured processes. Otherwise, it is very difficult to reconstruct the development process. This is definitely an important lesson learned from this thesis.

There is another circumstance that could not be tested. Residents in the examined hospital have sufficient opportunities to operate. Completion of their case logs is therefore only a matter of time and does usually not need further engagement. In other clinics residents often face a situation, in which they do not have the opportunity to conduct enough operations to complete their case log without delay. Awareness of their own case log is more valuable to those residents, since they might have to busy themselves with the allocation of operations.

Working with surgeons in the course of this thesis revealed some job-related issues. Firstly, the fully packed and irregular timetables make it often hard to schedule personal meetings. As a consequence of their packed timetables and the also the mental strain of their jobs, it was hard to motivate some participants to use the application regularly during the testing phase and thereby to incur a little extra documentation effort.

At the end of this discussion it can be said that the personal electronic logbook for surgeons on a smartphone is a concept with potential for surgery residents to save time and to increase awareness of their progress during residency. Similar to findings in the literature research, interviews and prototyping confirmed the increasing willingness of physicians to use smartphones to accomplish daily hospital tasks. It must be mentioned that exceptions did exist, but the majority of participants from interviews and prototyping absolutely appreciated the further development and publishing of the prototype.

CHAPTER 7

Conclusion

This work describes theoretical and practical aspects for the development of a personal electronic logbook application for surgeons. The result is a prototype smartphone application that allows trauma surgery residents to document their personal case log more efficiently on the one hand, and increases awareness about their educational progress on the other hand. Before implementation of the application, several methods were applied to identify specific design requirements for the specified target group. Literature research treated three main subjects that are related to this work: electronic documentation, logging in health care and the role of smartphones in hospitals. The central element of electronic documentation in hospitals is the HIS, the hospital information system. It maintains patient data in a centralized way, reducing inconsistencies and providing access for all authorized actors. Problems are the transition from paper-based hospital work to electronic systems and the lack of a widely adopted standard that is uniformly applied. Logging in medical education is necessary to document the educational progress a resident makes during residency. The majority of approaches for electronic logging solutions come from the United States. There are web based logging systems for residents, but also for certified surgeons to gain specialisations or for maintenance of certification (MOC). Literature further covers approaches for the automatic creation of resident logs based on the data in the HIS, which is however problematic to integrate into existing hospital information infrastructure. Smartphones in hospitals play a constantly more important role in daily hospital work. The possibility to call colleagues directly instead of paging them improves speed and quality of communication. Medical applications are useful tools to support daily tasks such as drug medication. However, smartphones are not completely accepted in hospital environments. Studies have shown that mobile phones in general are a medium for bacteria spread in hospitals. In addition, they pose risk of electromagnetic interference with sensitive electronic medical devices, if the phone is in close range. Physicians may further be distracted by personal matters, when they use their personal smartphones during work. Moreover, the storage of patient data on personal devices is problematic regarding patient data confidentiality. A possible solution may therefore be to offer hospital own smartphones for hospital staff.

After exploring this theoretical background of the work, the practical part for the development of the application began. It should be mentioned, that the practical part aims to create an application to support a very special target group. Focus lies on finding out concrete requirements of the target group and offer according features that are most helpful to the residents. Features should be implemented with the main goal to reduce the documentary effort of residents to a minimum while maximising the applications use.

At the beginning there were explorative interviews with surgery residents and certified surgeons. One the one hand, interviews helped to get an impression of current personal documentation solutions of the participants. On the other hand, they gave concrete insights in the electronic documentation process in a particular hospital. Interviews further extended and deepened knowledge gained from literature research. In combination, those two methods provided sufficient knowledge to create a first prototype of the application.

This prototype was consecutively improved in the subsequent prototyping phase. Feedback from a group of testing surgery residents lead to improvements of the application, based on the residents needs and preferences. This phase was especially helpful to evaluate, how identified requirements are best implemented in the application, and how freshly integrated features are received by the residents. The most important insight, was to make additional features configurable and offer enough flexibility. Residents feared to to be restricted to certain presettings of the application. Instead the application should propose and offer selections, while allowing to overrule them. The resulting final prototype respects identified requirements by offering particular supportive features. Consequently, residents subjective opinions showed that documentation with help of the application is a fast and easy alternative for maintaining a personal case log.

Motivated by residents' positive feedback on the application, I plan to continue the development of the application beyond the scope of this thesis. Future work in this subject will be the expansion of the application for other process oriented medical fields, that require physicians to maintain a case log. This basically includes all surgical residencies, but also the acquisition of surgical specialities (e.g. hand surgery). Further investigations in the particular field and additional quantitative research with physicians will be needed. The next goal will be to bring the application in a robust state that can be published on Google Play Store. This allows to easily address a great number of potential users and to assess the interest of surgery residents all over Austria.

Appendix

Interview Summary – P1

Operationsplanungsprogramm:

Planung, Dokumentation: OP DMS
ASTRA : Patientenverwaltungssystem, Berichte von versch. Abteilungen, da werden keine OP eingetragen
Bilddatenbank PACS zur Bildverwaltung
bei planung: termin eintragen wann operiert werden soll, plan erstellen
nach der operation: vollkommende dokumentation, hautschnitt etc, zunähen
jeder patient hat ID, OP DMS mit ASTRA verbunden über die ID

Persönliches Logbuch:

entsprechende Anzahl Operationen nachweisen
sollte operationskatlog führen, Form ist egal
aktuell: Datenauszug aus DMS wo er Erstoperateur ist, über PCs die im Krankenhaus stehen, ausreichend PCs sind vorhanden
operationssuche nach Operateur, eingriffen, Patienten
liste erfassen, Chef zeigen, der das ganze absegnet
jedes halbe Jahr einmal ausdrucken
es wäre praktisch das jeden Tag aktuell am Telefon zu haben
Operation, Diagnose, Datum, Lokalisation, Assistenz

Awareness, Überblick über eigenen Stand:

"ich weiß nicht wo ich aktuell stehe, aber das wäre wichtig"
ungefähr weiß er bescheid,, aber keine genauen Zahlen

Ausbildungskatalog

Ausbildungsliste Unfallchirurgie:
Einteilung in App nach diesen Kategorien *nicht unbedingt immer hilfreich*
die gewählte Einteilung lässt *individuelleres auswählen* zu
allerdings Teilweise nicht exakt zuweisbar auf Ausbildungskatalog (z.B. Röhrenknochen)
alternativ wäre eine Ansicht wirklich zugeschnitten auf den Katalog sinnvoll

Nachträgliches Einsehen des Logbuches

ein nachträgliches Ansehen, Analaysieren der gesammelten Logdaten (im sinne von reflection) ist eher weniger sinnvoll, nützlich, da diese Informationen auch im OP Bericht vorhanden sind, wird aber kaum wieder eingesehen

Einfluss der Oberärzte/Erfüllung des Katalogs

Rücksprache mit Oberarzt: *keine festgelegten zeitlichen intervalle*. zB Er fragt wieviele gemacht wurden von einer Sorte und berücksichtigt das (Hier ist es natürlich gut eine genaue Auskunft geben zu können).

Die Rückmeldung an den Oberarzt allerdings selten, "*wäre aber sehr gut. damit der oberarzt bescheid* *weiß" "Für die Ausbildung sehr förderlich*"

Initiative eher von den Assistenzärzten aus, nicht von den Oberärzten. Ausgedruckten Katalog vorlegen.

In wie weit wird das Feedback berücksichtigt? Je *nach verfügbarkeit der operationen die benötigt werden, aber generell ja*

Keine probleme bestimmte op gruppen zu erfüllen. Eigentlich nur die die nicht im Haus gemacht werden.

Wechsel des Krankenhauses während Ausbildung: Wann und wo operiert wurde ist egal, Hauptsache gemacht.

Nach der Ausbildung. nicht mehr so relevant. Trotzdem gut zu wissen für die eigene persölich Dokumentation. Z.B. Auch bei einem wechsel in ein neues Krankenhaus. "wie oft haben sie das schon operiert?" kann man genaue werte vorlegen.

Wird die liste überprüft? Check mit Operationssystem? Nein eigentlich nicht, wäre aber leicht gegen zu checken. Eventuell stichprobenartige Überprüfung des Chefs.

Alle Daten die im Log sind auch teil des Operationsberichts

Dokumentation während der Operation

Schwester dokumentiert zeitgleich während der Operation

genaue Dokumentation mit genauen Zeiten, hautschnitt, zunähen, etc.

Ergebnisse der Operation nicht berücksichtigt/nicht dokumentiert

Komplikationen werden im OP Bericht vermerkt. die der Operateur diktiert direkt nach der Operation

Operationsbericht ist kein Zwang, ja nach Krankenhauspolitik(!) was darin stehen muss.

Aufnahme des Diktats. Aufnahme mit Diktiergerät, Kassette abholen, anhören und abtippen, 1-2 min Diktierdauer des Bericht.

2-3 Stunden nach der Operation ist der OP Bericht meistens verfügbar. Ist aber auch nicht entscheidend wie schnell das verfügbar ist.

ICD codes.

Bei der aufnahme des patienten wird der Code eingetragen
sonst eher uninteressant

Interview Summary – P2

Persönliches Logbuch:
er trägt Operationen mit ID Nummer des Patienen, Namen und Operation
nachträglich in den Computer eintragen, irgendwann, dazu mit der Nummer den OP Bericht heraussuchen und trage die restlichen Daten ein (Datum, Assistenz)
Buch als zwischenspeicher sozusagen/transitional doc
Eintragung in der Excel Liste, Kategorien wie in der App (Schlüsselbein?!)
Sonstige Eintragungen in das Buch? Nein, keine Eintragungen nur das was nötig ist.

Einmal im halben Jahr wird umgetragen, 2-3 Stunden, copy und paste und erstellt die Liste

Überblick? "Nein muss ich ehrlich sagen nicht". Ungefähr ja, aber genaue Zahlen, nein. Wäre aber geschickt.

Kommst du genug zum Operieren? Um den Ausbildungskatalog gut zu schaffen ja!

Patienten ID als Möglichkeit zu Rückverfolgung. Patientennamen sind im Buch dokumentiert, aber bei der offiziellen Version kommt der Name weg.

Genaueres für OP berichte.

Er schaut schon immer wieder mal an z.B. die wievielte Arthroskopie ist das jetzt. "Aber das ist halt mühsam weil das muss man immer abzählen, oder Excel aber das ist mir zu aufwändig"

Hauptsächlich interesssant ist die reine Anzahl der Operationen

Rücksprache mit Oberärzten:

bei Vorstellungsgesprächen bei Wechsel des Krankenhauses (Gegenfächer) muss liste abgegeben werden einerseits für das Krankenhaus das man verlässt andererseits für das neue Krankenhaus, oder bei Weiterbildungsgesprächen im eigenen Haus

nicht unbedingt verpflichtend, aber praktisch nachzuweisen, z.b. bei verwandten Fächern, kann man nachweisen welche hinsichtlich dieses Faches relevanten Operationen man schon gemacht hat.

Liste abgeben nach der Facharztprüfung bei der Anrechnung. Liste wird vom Chef unterzeichnet. Damit hat man die Operationen offiziell gemacht.

Wäre schon interessant nach Krankenhause auch einzuteilen, aber eigentlich nicht entscheidend.

Theoretisch Weitergedacht

Automatische Auslesung der OP Daten aus dem OP DMS und anzeigen auf dem Handy, automatisch erstelltes log: schwierig wegen dem Aufwand der Anbindung an das Krankenhaussystem, Problem der Patientendaten

Wenn das schnell geht selbst einzutragen, 10sek ist das kein Problem, ICD Codes uninteressant

Interview Summary - P5

Persönliches logbuch

Er selbst führt keinen katalog mehr. Holt er sich über OP DMS
Für spezialisierung aus OP Berichten heraussuchen
Diagnosebezogen lässt sich das herausfinden.

Awareness, Überblick über Fortschirtt der Assitenzärzte

Einteilung, "wir wissen nicht was fehlt"
nur genereller überblick
da muss der AA kommen und sagen was ihm fehlt

Datenschutz

Für Namen eventl. nur die Darstellung der Initialien. Aber trotzdem den ganzen Namen speichern.
Eventl Einteilung in 2 Sicherheitsstufen mit kompletten Namen.

Passwort sicherung!!

teilweise kein WLAN aus Angst vor anzapfen

Smartphones im Krankenhaus

Private Smartphones sind im Krankenhaus nicht erlaubt.
Man darf nicht ins WLAN des Krankenhauses mit privaten Handies.
Aktuell Testphase zur Verwendung der eigenen Devices. zB zur Medikationsberechnung
Trend zur vollkommmenen Abschirmung der Daten im Spital

Anforderung an eine Handy applikation

ICD10 Codes eintragen!
Es gibt eine automatische Diagnosenverschlüsselung.
Unter dieser Nummer, soundsoviele Operationen.

Patientenzahl wichtig für die Verbindung zur großen Datenbank und OP Berichten

Auswahl für Operationsarten vordefiniert und eingeteilt nach Region
plus die Option fürs eintragen neuer Operationen

Doppeldiagnosen berücksichtigen
für jede zusätzliche Diagnose eine zusätzliche Operation
Option für den Export als 2 oder mehrere Einzelne Operationen
Dadurch spart man sich das mehrmalige Eintragen von Patientendaten und Region

Sonstiges

Keine! Standardisierte Berichte! Rechtliche Sicherheit ist hier ein großer Faktor. Wird vollkommen abgelehnt.

Keine Übernahme von Daten aus dem System.

"Da kann man die Welten nicht verbinden"

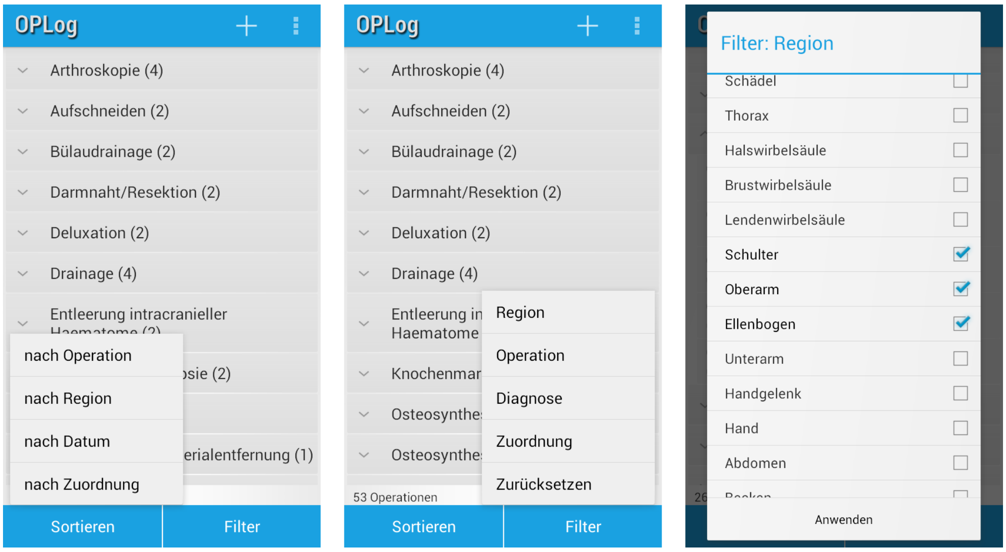

Figure .1: Screenshots showing popups for sorting (left) and filtering (middle, right)

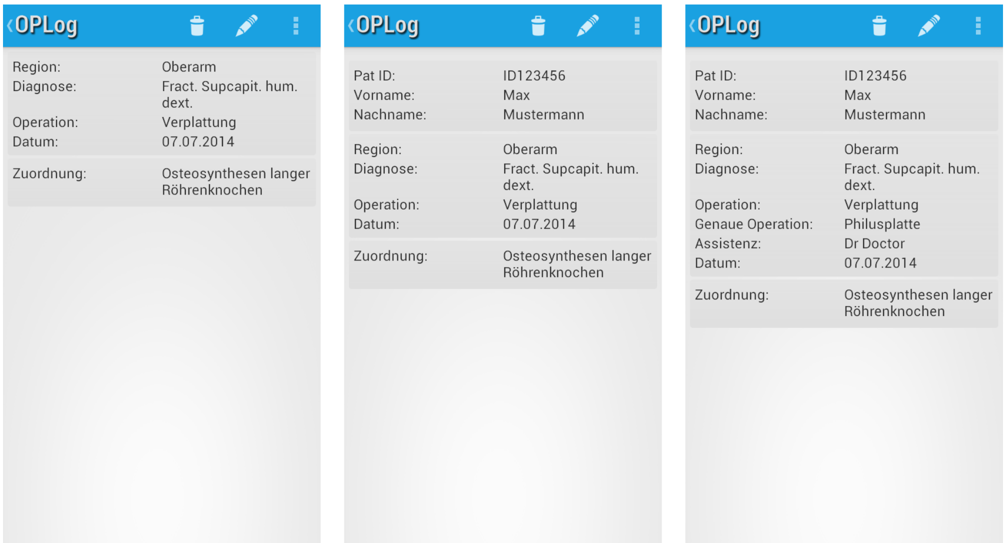

Figure .2: Screenshots showing Operation detail in different configurations

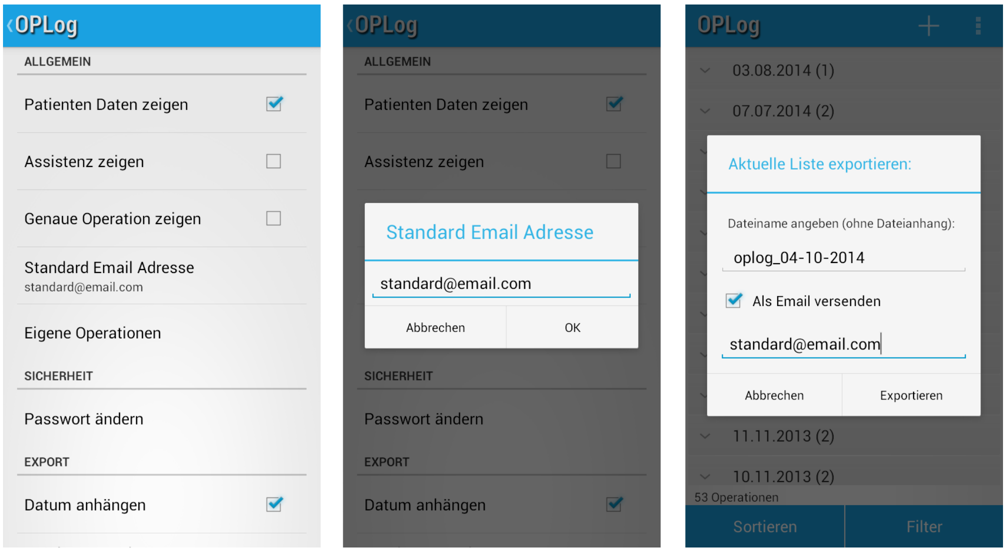

Figure .3: Screenshots showing the settings menu (left), standard email feature (middle), and export popup (right)

```java
public class Operation implements Serializable{

    private static final long serialVersionUID = 1L;

    private int id;
    private String region;
    private String diagnosis;
    private String operation_type;
    private String category;
    private String exact_operation_type;
    private String assistent;
    private Date date;
    private String patient_id;
    private String patient_firstname;
    private String patient_lastname;

    public Operation(){
    }

    public Operation(String operation_type, String exact_operation_type,
            String diagnosis, String anatomics, String exact_anatomics,
            String assistent) {
        super();
        this.operation_type = operation_type;
        this.exact_operation_type = exact_operation_type;
        this.diagnosis = diagnosis;
        this.region = anatomics;
        this.assistent = assistent;
    }
    public int getId() {
        return id;
    }
    public void setId(int id) {
        this.id = id;
    }
```

Figure .4: Code Example 1: Extract from the Operation class representing logbook entries

```java
public void showFilterPopupMenu(View v) {

    OnMenuItemClickListener filterItemClickListener = new PopupMenu.OnMenuItemClickListener() {
        @Override
        public boolean onMenuItemClick(MenuItem item) {
            switch (item.getItemId()) {
            case R.id.filter_region:
                showFilterRegion();
                return true;
            case R.id.filter_operation_type:
                showFilterOperationType();
                return true;
            case R.id.filter_category:
                showFilterCategory();
                return true;
            case R.id.filter_diagnosis:
                showFilterDiagnosis();
                return true;
            case R.id.remove_filters:
                removeFilters();
                return true;
            default:
                return false;
            }
        }
    };

    PopupMenu popup = new PopupMenu(this, v);
    MenuInflater inflater = popup.getMenuInflater();
    inflater.inflate(R.menu.menu_filter_list, popup.getMenu());
    popup.setOnMenuItemClickListener(filterItemClickListener);
    popup.show();
}
```

Figure .5: Code Example 2: Extract from the Operation List View for creating the popup menu for filters

```java
private void updateCategorySpinner(String operation_type) {

    if (operation_type.equals(chooseOperationString)) {
        categories.setSelection(0);
        return;
    }

    String category = db.getCategoryForOperationType(operation_type);
    if (category != "") {
        int pos = adapter_category.getPosition(category);
        if (pos > 0) {
            categories.setSelection(pos, true);
        } else {
            categories.setSelection(0);
        }
    }
    else {
        categories.setSelection(0);
    }
}
```

Figure .6: Code Example 3: Extract from the Activity for new entries showing automated selection of categories

```
public void storeUserEntries() {
    // assistants
    if (!stored_assistants.contains(assistants.getText().toString())
            && !assistants.getText().toString().equals("")) {
        db.addAssistant(assistants.getText().toString());
        Log.d("oplog", "new assistant stored"
                + assistants.getText().toString());
    }

    // update category for operation_type
    int otId = db.getIdOfOperationType(operation_types.getSelectedItem().toString());
    int catId = db.getIdOfCategory(categories.getSelectedItem().toString());
    db.updateOperationTypeCategory(otId, catId);

    // exact_operation_types
    if (!stored_exact_operations.contains(exact_operation_types.getText()
            .toString())
            && !exact_operation_types.getText().toString().equals("")) {
        db.addExactOperationType(exact_operation_types.getText().toString());
        Log.d("stored", "new exact operation type stored: "
                + exact_operation_types.getText().toString());
    }

    // diagnosis
    if (!stored_diagnosis.contains(diagnosis.getText().toString())
            && !diagnosis.getText().toString().equals("")) {
        db.addDiagnosis(diagnosis.getText().toString());
        Log.d("oplog", "new diagnosis stored: "
                + diagnosis.getText().toString());
    }

    // store additional diagnosis
    for (int i = 0; i < ll_diagnosis.getChildCount(); i++) {
        AutoCompleteTextView actv = (AutoCompleteTextView) ll_diagnosis
```

Figure .7: Code Example 4: Extract from the Activity for new entries showing the storage of user entries in a local database

```
List<String[]> assignmentList = db.getCategoriesWithCounts();
for (String[] values: assignmentList){
    String category = values[0];
    int demanded = Integer.parseInt(values[1]);
    int done = Integer.parseInt(values[2]);

    allEntriesCount += Math.min(done, demanded);
    allEntriesDemanded += demanded;

    View entry = getActivity().getLayoutInflater().inflate(R.layout.list_item_edu, null);
    TextView ass_title = (TextView) entry.findViewById(R.id.category_title);
    ass_title.setText(category);
    TextView ass_count = (TextView) entry.findViewById(R.id.category_count);
    ass_count.setText(done + "/" + demanded);
    ProgressBar ass_progress = (ProgressBar) entry.findViewById(R.id.assignment_progress);

    ass_progress.setProgress(done);
    ass_progress.setMax(demanded);

    int dp = dpToPx(1);
    LinearLayout.LayoutParams layoutParams = new LinearLayout.LayoutParams(
            LinearLayout.LayoutParams.MATCH_PARENT, LinearLayout.LayoutParams.WRAP_CONTENT);

    layoutParams.setMargins(0, 0, 0, dp);

    categories.addView(entry, layoutParams);
}

allEntriesCount += 100;

//set contents for overview item
all_count.setText(allEntriesCount + "/" + allEntriesDemanded);
double percentage = (allEntriesCount*100/allEntriesDemanded);
all_percentage.setText((int)percentage + "%");
```

Figure .8: Code Example 5: Extract from the Education catalogue view showing the calculation of catalogue completion

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