Towards an IT maturity model for general practice information systems

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Abstract

Information technology within general practices has the potential to improve care subsantially. It is however unclear how these benefits can be realized. This research explores the possibility whether a maturity model for general practice information systems can enable the general practices, software vendors and other parties can support them in order to reach these claimed benefits.

Based on a literature study, the IT available for primary care with a focus on general practices are identified. These IT functionalities were laid beside the possibilities of a general practice information system (GPIS) to check whether these functions can be performed by this GPIS. This proved to be the case. From this literature study a classification of the research performed on the subject of primary care was also created, highlighting possible future research on the subject, were research is now lacking.

After the discovery that a GPIS can perform a lot of the IT functions in a general practice, a maturity model was selected through another literature study and was created with the information from the literature study on IT within general practices. Through several use cases and a comparative analysis, this maturity model was tested. From these tests, it was proved that a maturity model could indeed be developed in order to support general practices to improve their GPISs and consequently the IT maturity of the general practice.

Another conclusion from this research is that software vendors and the creators of guidelines for GPISs (such as the NICTIZ) can be benefited as well by this maturity model as it defines the next steps that can be taken to reach a higher maturity level.

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Inhoud

1. Introduction

1.1. Problem definition

1.1.1. IT & Health Care

Information systems are starting to become an integral part of almost any business. Within the corporate world, IT is having an increasingly larger impact on the business itself (Woerndel, 2008; UNCTAD, 2008). The quality of IT systems within the business world is more developed then the IT systems within health care (Bates, 2002). In healthcare, this (r)evolution has obviously not yet grown to its full potential.

In 2010 Skipr analyzed numbers from the ministry of public health and found that almost 500.000 people objected against the electronic patient record. Not only the large IT applications are not immediately accepted, even smaller matters, such as email, require more support (ICTrecht.nl, 2012). This resistance occurs despite the fact that it could become an important tool to prevent medical errors (Jamal, McKenzie & Clark, 2009) and if used correctly, IT has the potential to substantially improve care (Bates, 2002). Bates & Gawanda (2003) also state that "providing reliable, efficient, individualized care requires a degree of mastery of data and coordination that will be achievable only with the increased use of information technology".

There are however claims that IT may not improve care. Black et al. (2011) performed a systematic literature review on IT within health care and found that there was almost no beneficial impact because of the IT. No clear reason is defined why Black et al. found no beneficial impact. This statement is contradicted by Chaudry, Wang, Wu, Maglione, Mojice, Roth, Morton & Shekelle (2006) who found that "implementing a multifunctional system can yield real benefits in terms of increased delivery of care base on guidelines, enhanced monitoring and surveillance activities, reduction of medication errors and decreased rates of utilization for potentially redundent or inappropriate care". Chaudry et al. state however that it is unclear how other institutions can achieve similar benefits, and at what costs. This is an interesting point that Chaudry et al. make, and it is worth exploring if a way could be found to make health care organizations achieve these benefits.

1.1.2. General Practices

Within health care an increase in the use of IT can be found at General Practices (GPs[1]). IT within GPs has been growing more rapidly than those in hospitals. A reason for this is that GPs are smaller and easier to computerize (Benson, 2002). Not every country however, has the same IT capabilities. This is made clear by the fact that in the Netherlands in 2007 98% of the GPs had electronic patient records, while in Canada only 23% does (Grol, Faber, Braspenning & Timmermans, 2007). Despite the penetration of electronic patient records in the Netherlands Grol mentions that they are not being used

[1] From this point, GP is used as an abbreviation for general practice and not general practitioner.

to their full potential. This means that having IT in the general practice does not mean that it is being used to it's full potential. What is the reason for not reaching the full potential of IT within the general practice and how can we measure the use of IT? A study by Peek (2010) researched the satisfaction rate of general practice information systems in the Netherlands and found that the average satisfaction was rated at a 6.4 on a scale of 10. Why are the general practices not overly satisfied? Could this be a reason for IT not reaching it's full potential or is there another reason? This is a very important question when a lot of money is being invested into IT within the general practice. If the IT is not being used to its fullest, the care process could suffer.

Casalino et al. (2003) found that it is possible to stimulate GPs to use their IT. In order to reach this they found that external incentives are required and assistance in improving their clinical IT capability. This research will focus on the latter. As Devaraj & Kohli (2000) point out, the implementation of IT within the health care industry is benefited when the business processes are also re-engineered. This means that the health care practitioners need to adapt themselves to the new situation. It would be interesting to measure this adaptation and see whether the GPs are using their IT in a correct manner. An example of the usage of IT in a GP was shown in a study performed in New Zealand. General practitioners found their IT systems to be very time-consuming and they had a feeling that they are forced into using expensive systems (Didham, Marting, Wood & Harrison, 2004). These effects seemed to compromise the face-to-face relationship between the doctor and patient. This is an issue that could be resolved by improving the IT use of general practitioners, which makes them more effective in their use of the systems.

Recall however the systematic review of the impact of health technology in medical care by Chaudhry et al. (2006) which mentioned that health technology improves medical care. Do their findings extend towards general practices? For example when (most of) the IT systems are used properly, it should not be more time-consuming. When these are used correctly a general practitioner will see the benefits and be more stimulated to use the IT systems. When this happens, the system, though expensive, should return its investment. This also counters the statement from Black et al. (2011) that IT in health care has no beneficial impact. Taking into account the results by Chaudhry et al. (2006), we believe by increasing the level of expertise and the extent to which an organization uses their IT, these issues will be resolved.

1.1.3. Primary Care

A General Practice is part of the "primary care". Primary care entails the part of health care that has the first contact with a patient. Other examples of primary care are dentists, physiotherapist and psychologist. As we can see from the literature described above, a lot of focus goes into general practices, however the other types of primary care have to deal with developments in information technology as well. Currently information technology support for clinical care, research and education in oral medicine is poorly developed (Schleyer, Mattson, Ríordáin, Brailo, Glick, Zain & Jontell, 2011). This corresponds with the amount of literature that is written about dental informatics. The other types of primary care get even less attention in literature. This leads to the belief that IT within primary care is an immature field.

1.1.4. Netherlands

Because the Netherlands has a high penetration of electronical medical records and general practice information systems, this is an ideal place for research on IT and general practices. According to the LHV (the Dutch national general practitioners society) (LHV, 2010) and Grol et al. (2007) almost every general practitioner in the Netherlands has a general practice information system (GPIS). These systems encompass a large part of the IT capabilities of a general practice.

This research will focus on these general practice information systems, more specifically the GPISs in the Netherlands because more information is readily available and we want to discover wether a single system could encompass most of the IT capabilites of a general practice. If the results of this research prove beneficial, a similar study could be performed regarding the rest of the primary care.

1.1.5. General Practice Information Systems in the Netherlands

General practice information systems (GPIS), are systems that are used by a general practice to assist them with their tasks. In the Netherlands there are currently around ten software suppliers, whom supply these systems to general practices according to Peek (2010) who researched the satisfaction of GPISs among general practitioners in the Netherlands for the LHV (National General Practitioners Association of the Netherlands).

A GPIS supports the basic tasks of a general practice and possibly much more, depending on the system and the degree of implementation into the practice. The LHV performed a research in the Netherland on satisfaction of these systems. In this research they defined a few basic functionalities the systems have:

1. Calendar
2. Management of “episodes”
3. Consult registration
4. Prescribing of medication
5. Repeat prescriptions
6. Processing received mail

Beside these basic functions, more functions were tested, such as:

1. Support Chain-care
2. Support for prevention
3. Information provision to the patient
4. Online patient contact, appointments and prescriptions
5. Electronic moving of patient records
6. Administrative functions (mostly financial)

As can be seen from these functions, a GPIS embraces much of the IT tasks that need to be performed by a general practice. Does this mean that a GPIS can account for most of the IT functions of a general practice found in literature and whether the (proper) use of a GPIS can increase the maturity of a general practice. In the next chapter will be examined how a maturity model can be developed with the

literature we found on IT and general practices . Afterwards GPISs will be examined further and a maturity model will be created.

1.2. Research Objective

In previous chapter was concluded that increasing the level of expertise and extent to which an organization uses their IT is benificial to a health care organization. This is called "IT maturity". In this research we want to find out how mature a general practice information system (GPIS) is (and in extension the general practices who use them) actually are and we will aim to create a model that will measure current IT maturity and provide means to increase the IT maturity of these GPISs. In order to reach an answer to these questions, a way or a tool with which a general practice can assess their GPIS's IT maturity and consequently improve their maturity has to be developed.

A research that comes close to this goal is the research of Plomp, Batenburg & Verheij (2011), who looked at the interorganizational IT in primary care. They analyzed the level of adoption of interorganizational IT within 49 general practices, compared them and looked if they could find determinants that affect their adoption level. This study looks at the adoption level of the IT within a general practice. The adoption level differs from maturity because a maturity model will look at more aspects than just the use of IT. Besides that, the research focuses on one aspect of the IT within GPs and does not yet provide any guidelines on how to improve the IT which is were we see an opportunity.

Recently two other researches have been performed that try to achieve a similar goal. First there was a study by Empirica, which is "an internationally active research and consulting firm concentrating on concept development, the application and development of new information and communication technology and the information society." In 2008 they performed a study that aimed to measure "the availability and use of ICT by primary care physicians in the EU27 and EEA countries" (Dobrev, Haesner, Hüsing, Korte, Meyer, 2008). The research was performed through a telephone survey. They provide a clear overview of the availability and use of IT within General Practices within the researched countries. This research looks at the complete picture of General Practice in a country and does not zoom in on a single General Practice. This study is a benchmark between countries.

The other study, performed by Tapp, Bekkers, Braspenning, Edwards, Eriksson, Grol, Kuch and Elwyn (2009), makes a step forward in this. In this research they tried to develop a maturity matrix for Family Practices as an organizational assessment tool. This tool encompasses the entire family practice, of which IT is just a part. The IT that is assessed in this model, is a small fragment of the entire model. It is very large and time-consuming, which caused family practices in the study to drop out. We aim to achieve a model that is less time-consuming and will look at IT on a more comprehensive level. This research is however very valuable for our purposes.

There are other initiatives that have been set up in order to measure IT within healthcare. For example in the Netherlands, the NIVEL (Dutch institute for research in health care) has created the EPD-scan (Electronic Patient Records scan). This EPD-scan sifts through the patient records of General Practitioners and looks at de completeness, actuality of the records, medication safety and more (Nivel,

2012). This scan looks mostly at the quality of the Electronic Patient Records and does not include all IT used within the General Practice and focuses mostly on the data level.

The goal of this research is therefore to build upon the knowledge that was accumulated from these studies and use them to develop a maturity model/tool with which a GP can assess their general practice information system, not on just the data level, but on actual use. The focus of this research will be in the Netherlands. With this model/tool they can see on how mature their general practice information system is; where the general practice could improve and also provide guidelines how they can improve these systems. Because the model says something about the GPIS of a general practice, in extension this says something about the maturity of the general practice itself, because the system is an integral part of the organization. Another possibility of the model is assessing a specific GPIS of a software vendor and benchmark it with other GPISs from competitors.

1.3. Research Question

To reach such a maturity model, the following research question was created:

How to develop an IT maturity model for Dutch general practice informations system that can support general practices to improve their IT maturity?

To be able to answer this question a few aspects need to be addressed:

1. What is the Information Technology that is used within primary care?
2. What research has already been done about IT within a General Practice?
3. What functionalities does a general practice information system provide?
4. How can a maturity model for general practice information systems be developed?
5. How can a maturity model be validated?
6. How can the maturity model be used to advise a General Practice on the choice or use of a general practice information system?
7. How can the maturity model be used to improve the maturity of a General Practice information system within general practices?

1.3.1. Research Method

In order to answer the questions stated above, the research will need to be performed through a few steps. The following Process-Deliverable Diagram, as described in van de Weerd, Brinkkemper, Souer & Versendaal (2006), has been developed to display the activities in this research and the results of these steps:

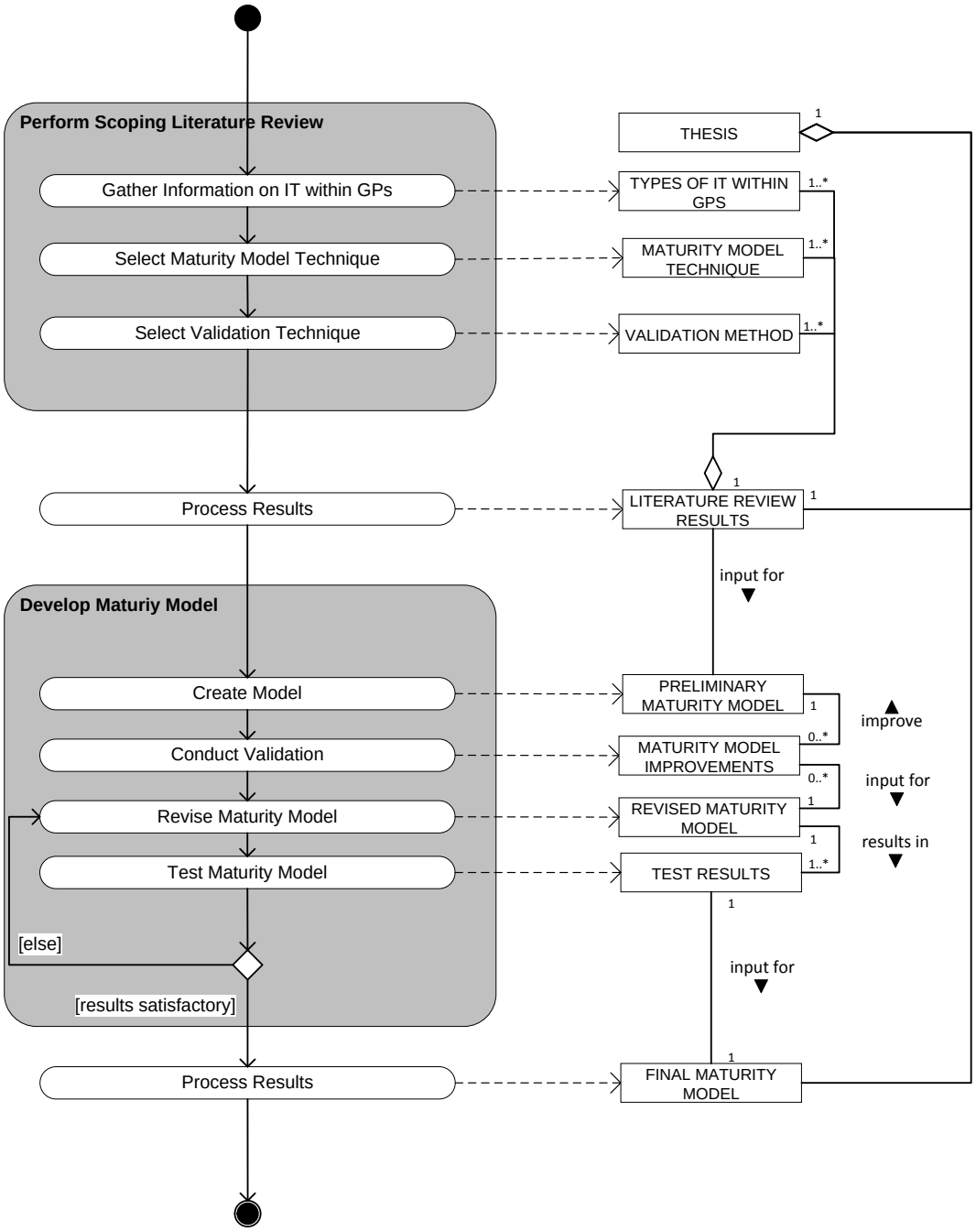

Figure 1 - PDD of the research

In the table below, the activities will be shortly described. Below the table a more elaborate description of the research will be given.

Activities	Sub activities	Description
Perform Scoping Literature Review	Gather Information on IT within GPs	A literature study is performed that will look at all the IT that is available in general practices and what benefits they have.
	Select Maturity Model Technique	From the literature study, the best suitable technique for developing a maturity model will be chosen.
	Select Validation Technique	The best (and most viable) way to validate a maturity model will be selected.
Process Results		The literature review results will be combined and processed into results
Develop Maturity Model	Create Model	A first version of the maturity will be developed from the results of the literature study.
	Conduct Expert Validation	The maturity model will be validated by experts.
	Revise Maturity Model	The first version of the maturity model will be improved upon through the comments of the expert validation.
	Test Maturity Model	The maturity model will be applied and reviewed in general practices.
Process Results		The results from the maturity model development stage will be gathered and analyzed.

Table 1 Activity Description

1.3.2. Scoping Literature Review

A literature study will be performed in order to better understand the subject (Hart, Boeije & Hox, 2005) and to create a base of the maturity model. A scoping literature review tries to find and analyze a wide range of literature that is relevant to the research question. A scoping literature review has the advantage that it exposes the researcher to a large volume of published literature in an efficient and cost-effective format, which is what this research requires due to time constraints. (Rumrill, Fitzgerald & Merchant, 2010).

Information Technology within a Primary care

The first research topic will be the information technology within primary care, with a focus on General Practices. Primary care is looked at as a whole in order to cover as much literature as possible, because these also discuss general practices. It needs to be outlined what Information Technology at Primary Care ís. What is meant with information technology? Do only information systems count, or also the e-mail capabilities, eye measurement systems, online agenda etc.? Another subject that will be looked at is the research that has already been done regarding this topic. The results of this study should provide the answers to the first two sub questions. It will show what IT is available and being used in primary

care and will also provide a clear overview of the research that has already been performed on this topic. In the next steps of the research, the focus will shift to GPs.

Developing the Maturity Model

It is important to define maturity, as this will provide a solid base for the following steps. Following this is the decision on the type of maturity model that will be developed. Will we use one of the more popular models, such as the Capability Maturity Model described by Herbsleb, Zubrow, Goldenson, Hayes & Paulk (1997), adapt such a model to fit GPs or should we create our own type of maturity model? This will be the next step in the literature review, where literature about maturity model development and maturity models will be analyzed. From this study we will learn how to develop the maturity model.

1.3.3. Maturity model development and validation

After the literature study, a first version of the maturity model can be created. This will be the first input for the final maturity model. The creation of such a model will be an iterative process and it will require more input and revision before a final model can be reached. This preliminary maturity model will be basis from which we can start with validation. What the best procedure for this step is, will be researched in the literature review.

Goal of research

The goal of this research is to create an overview of the written literature about IT within primary care. From this literature study a model of IT maturity within General Practices will be developed and assessed if it can be of value to General Practices. In following studies this model could then be applied at General Practices to see if it is of practical value and possibly improve the care process of General Practices. This improvement could be in efficiency, cost reduction, better care etc.

1.4. Societal Relevance

Healthcare is a large cost for the Dutch government, in 2011 the expenses for health and welfare was 90 billion Euros and every year these costs are increasing (CBS, 2012). Any way that could increase the efficiency and lower the costs within health care is very welcome. There is also a large number of General practitioners in the Netherlands. In 2013 there were 8.865 general practitioners active in the Netherlands in 5.088 practices (van Hassel, Kasteleijn & Kenens, 2014). Imagine how many people can be better assisted in their health care process if the process at a general practice was improved.

A model/tool with which general practitioners can assess their general practice information system maturity and see how they can improve helps the healthcare in the Netherlands, which could benefit patients, patient flow and cost. If the model/tool is validated it can also be used as a benchmark for GPs with which they can measure their IT maturity. Such a tool is not available at the moment.

1.5. Scientific Relevance

This research will provide a meta-analysis on literature that has been performed on the topic of general practices and IT, showing where the blind spots are. This will enable future research to be performed on areas that currently have not seem much light, providing the scientific community with very relevant research.

This research will also perform a comparative analysis and assement of general practice information systems in the Netherlands through a maturity model. The tool will look at multiple systems and assess them on their maturity which has not been performed yet on the subject of general practice information systems.

2. Scoping Literature Review

In order to gather as much information as possible about the IT within General Practices, a scoping literature review is performed. A scoping review has a "distinct advantage of exposing readers to a large volume of published literature in an efficient and cost-effective format" (Rumrill, Fitzgerald & Merchant, 2010). The scoping literature review gives the researcher a broader view of the topic at hand, while a systematic approach dives deeper into the literature, while providing a smaller overview. The goal of this literature review is to create an overview of the IT that is being used within primary care, which makes the scoping literature review the most suitable.

2.1. Method

Rumrill, Fitzgerald & Merchant (2010) describe in a step-by-step guide how a scoping literature review can be performed. The steps described by them will be the guideline as to how the literature review will be performed. These steps are the following:

1. Identify the initial research questions
2. Identify the relevant studies
3. Study selection
4. Charting
5. Collating, summarizing, and report the results
6. Optional consultation stage

2.1.1. Identify the initial research questions

For this first step they state that the researcher needs to determine the research questions that are required to be addressed. As can be recalled from the introduction, this step has already been performed.

From these questions an appropriate search strategy can be composed. Through the Utrecht University, we have access to some of the largest literature databases in the world. The libraries used for this study are:

1. Scopus
2. Pubmed
3. Omega (University Utrecht Library, 2012)
4. Google Scholar

The first two of this list, Pubmed and Scopus, are well-known among researchers. Scopus is, according to their website, "the largest abstract and citation database of peer-reviewed research literature" (Sciverse 2012). Pubmed is one of the, if not thé largest database in the medical field, containing over 22 million citations for biomedical literature (Pubmed, 2012). Pubmed is well-known by researchers in the field of Medical Informatics and therefore is a must-have for this research.

Omega might be less well-known. This is the search engine that gives access to all the digital material that is available through the University Library of the Utrecht University. Omega gives access to multiple large publishers, such as Elsevier, Ebsco, IOS Press and Jstor, ranging over thousands of journals.

Finally Google Scholar was used. Google Scholar is a well-known search engine for literature, despite that it might not yet be seen as the most reliable source. Aguillo (2011) however states, that as long a great care is taken in handling the search results, especially considering overlap, it makes "a serious and free competence" to other bibliometric search engines. Because of the care that has to be taken with the use of Google Scholar, we decided to only include the top results to be included into our research. Despite its dangers, we deemed it necessary to include Google Scholar to prevent the creation of a “blind spot”.

Search strategy

To be able to reap the most, and most of all relevant results from these databases a proper search query had to be developed. To do this, the research questions had to be analyzed to define the most important subjects. These questions are:

- *What is the Information Technology that is used within primary care.*
- *What research has already been done about IT within a General Practice.*

IT

In every question the most important one subject is: IT.

Primary Care

All questions are also regarding primary care, being specifically mentioned within two questions.

Maturity

The last important term that we can deduct from these questions is maturity. Does the IT increase maturity, or in other words improve the care.

From this we can say that we want a search query that contains: IT + Primary Care + Maturity. However this would only gather a select group of results. In order to increase the relevant results, synonyms that are available for each keyword have to be included. Below the result can be seen:

Synonyms IT	Synonyms Primary Care	Synonyms Maturity
IT	Primary Care	Maturity
ICT	General Practice	Advances
Information Technology	Family Care	Innovation
Communication Technology	First Contact Medical Care	Improvement
E-Health	Family Physician	Changes
Computerization	Family Medicine	Productivity
	Family Doctor	Efficiency

Table 2 Terms search query

These terms were then incorporated into a single search query that would search the databases for combinations of these terms within the columns, while including one term from every column.

Database	Search Query	Results
Scopus	(TITLE-ABS-KEY((it OR "Information Technology" OR ict OR "Communication Technology" OR e-health OR computerization)) AND TITLE-ABS-KEY(("Primary Care" OR "General Practice" OR "Family Care" OR "First Contact Medical Care" OR "Family Physician" OR "Family Medicine" OR "Family Doctor")) AND TITLE-ABS-KEY((maturity OR advances OR innovation OR improvement OR changes OR productivity OR efficiency))) AND SUBJAREA(mult OR medi OR nurs OR vete OR dent OR heal OR mult OR ceng OR CHEM OR comp OR eart OR ener OR engi OR envi OR mate OR math OR phys) AND PUBYEAR > 1999	4604
Filters:	Published from 2000 till present Subject areas: Health Sciences and Physical Sciences	
Pubmed	(IT | "Information Technology" | ICT | "Communication Technology" | E-Health | Computerization) AND ("Primary Care" | "General Practice" | "Family Care" | "First Contact Medical Care" | "Family Physician" | "Family Medicine" | "Family Doctor") AND (Maturity | Advances | Innovation | Improvement | Changes | Productivity | Efficiency)	242
Omega	(IT | "Information Technology" | ICT | "Communication Technology" | E-Health | Computerization) AND ("Primary Care" | "General Practice" | "Family Care" | "First Contact Medical Care" | "Family Physician" | "Family Medicine" | "Family Doctor") AND (Maturity | Advances | Innovation | Improvement | Changes | Productivity | Efficiency)	30
Google Scholar	(IT | "Information Technology" | ICT | "Communication Technology" | E-Health | Computerization) AND ("Primary Care" | "General Practice" | "Family Care" | "Family Medicine" | "Family Doctor") AND (Maturity | Advances | Innovation | Improvement | Changes)	17500
Filters:	Published from 2000 till present	

Table 3 Search queries

As can be seen from these results, Scopus and Google Scholar provided far the most results, however the question rises whether these are all relevant. In order to make the results relevant a filter was introduced for these two databases. In order to keep the results manageable within the time constraints for this study and because IT is a fast-changing world, we filtered the searches to literature published áfter 2000.

The query in Google Scholar was slightly adapted. This was a necessity because Google Scholar did not allow for such a long search query.

Because of the high amount of results on Scopus and Google Scholar we decided to set a limit for the results. With the time constraint in mind, it was decided upon using the first 20 pages of Scopus results, which meant we ended up with 400 results from Scopus and through the comments of Aguillo (2011), whom stated that much care has to be taken with the results from Google Scholar decided to also use the first 20 pages of results. This resulted in Google Scholars top 200 results. There is trust in the search

engines that they have sorted their results on relevance, and can assume no valuable literature was lost during this selection. When we combine these 600 results with the 242 results from Pubmed and 30 from Omega, this accumulated into 872 literature results.

2.1.2. Identify the relevant studies

The next step is to define a target number of studies that are going to be looked at. This is done to set a goal on how much literature there is going to be looked at. The result from the final step will be examined to find relevant studies and this will set a target to reach. This number can be influenced by depth of the review, breadth of the review, time available etcetera. For this study, time is a constraint, however completeness is also important, which means that we have to make a tough decision on how many studies we want the review to consider. This research finally settled on 150 studies. This was doable within the time constraint, however also would give a good overview of IT within primary care.

Now we had to identify which literature is relevant for the research. A few filters can be applied for this.

1. Duplicate Filter

The first step that was taken, was to remove the duplicate titles from the results. This provided 830 results. 42 Results were removed because they were duplicate.

2. Title Filter

The following step was to check whether all found literature was useful. Only literature that described IT, Primary Care and its effect is relevant, however in the results some papers did not qualify these descriptions (despite the search queries). In order to select these, a filtering based on the titles was performed. Every item that was clearly not about one of these terms was removed. For example, "Where should family medicine papers be published - Following the impact factor?" was a title that was removed. However "An analysis of computerization in primary care practices" was kept. This filter reduced the number of titles drastically. We ended up with 305 articles that, as far as could be deduced from the title, were relevant.

3. Abstract Filter

Finally a filtering was performed on the abstracts. Through reading the abstracts we could be sure that literature was relevant. This resulted in 228 studies that could be used for the next steps in our scoping literature review.

A last filter we want to apply is a date-filter. In the world of IT everything changes fast . This is also the case for IT within primary care. What this would mean for literature that after too long a time, it can become irrelevant, because new technologies outperform older technologies. However, no such a time frame could be discovered, so in this study we settled on 10 years. This would mean that we would disregard al literature previous to 2002. This finally left us with 210 studies to review.

4. Final filter

Finally results were discarded due to irrelevance, which could not have been deducted through previous filtering. Terms were used in the title and in the abstract that left it ambiguous whether it described IT

or other methods. For example “The medical home: growing evidence to support a new approach to primary care” by Rosenthal (2008). We could not anticipate whether he would describe information technology as a part of a medical home. This was not the case, however was only discovered after closer reading. Another reason was that the title and abstract made it unclear whether they focused upon primary care or the entire health care. In the end there were 25 papers that were removed for this reason. Besides these, 34 other papers were unfortunately discarded, because there was no access to the full text versions through the Utrecht University. This meant that we remained with 152 papers. Very close to the target we had set.

2.1.3. Study selection

Finally the last step of the selection is performed. This step has to ensure that enough studies are selected for the review. It comes in play when not enough studies have been found and the selection criteria have to be expanded. However from our previous step, the target that was set was reached, which means we can move on to the next step.

2.1.4. Charting

Charting "organizes the data to represent the core descriptive elements of the scoping literature review"(Rumrill, Fitzgerald & Merchant, 2010). This means the themes, trends and patterns in the articles at a general level will be described.

In order to make the results manageable and create an overview of the literature, every study will be classified into different categories. Because we want to find out which IT is available within primary care, we decided to classify the *type of IT* being researched within the studies. For example articles describing implementation of EMR, would be classified in the category EMR.

Type of IT

In Table 3 Search queries

the categorization of types of IT can be found. How this list was achieved, is described below.

Type of IT		*Description*
Exchange of Information	***P2P*** ***D2D*** ***P2D*** ***P2D2D***	Exchange of information describes any communication type were data is transfered. This transference can occur between patients (P2P), doctors (D2D), Patients and Doctors (P2D) and communication types that take both parties into the loop (P2D2D).
Decision Support systems (DSS)		“(Clinical) Decision Support Systems are computer systems designed to impact clinician decision making about individual patients at the point in time that these decisions are made.” (Berner, 2006). In short: these systems should assist the doctor in making a decision.
Registries		Within registries, data is stored. For example “patient registries are based on clinical information collected in a

	systematic way and regularly updated" (Baggi, Mantegazza, Antozzi & Sanders, 2012). Another example is the prostate cancer clinical quality registry which has the purpose to collect information systematically on all men diagnosed with prostate cancer "aiming to assess patterns of presentation, care and outcomes, allowing an assessment of quality measures and the evaluation of variation" (Evans, Millar, Wood, Davis, Bolton, Giles, Frydenberg, Frauman, Costello, McNeil, 2012).
Electronic Medical Records (EMR)	Electronic Medical Records (EMR) are often also called Electronic Patient Records (EPR) or Electronic Health Records (EHR). EMR refers to the electronic storage of patients medical information (Steward, 2005). This could be seen as a type of registry. However, this is a popular topic within the field of Medical Informatics, that it was decided upon to give it its own category.
Patient emancipation	"Emancipation means setting people free from the control of more powerful others, from subjection to them, from their intellectual, moral or spiritual fetters." (Williamson, 2008). In this research we defined IT for Patient emancipation, as IT that educates the patient and assists the patient in diagnosis/treatment. It 'sets the patient free' from doctors and gives them more control over their own treatment.
E-learning	Gensichen, Vollmar, Sönnichsen, Waldman & Sandars (2009) describe E-learning as "distance learning using information technology to deliver educational instructions to learners, and computer-based learning using computers (and the web) to aid in the delivery of standalone multimedia packages for learning". The subject of learning within primary care is very diverse.
Robotics	
eCoach	An eCoach is any information system that provides the patient with assistance. This could be a Web-based guided self-help course, as described by Geraedts, Kleiboer, Wiezer, Mechelen, Cuijpers (2013) that assists patients with depressive symptoms, or an internet-based self-management program for youth with arthritis described by White, Stinson, Lingley-Pottie, McGrath, Gill and Vijenthira (2012).
Telemonitoring	Telemonitoring makes it possible to "monitor patients remotely so that clinicians can intervene early if there is evidence of clinical deterioration" (Chaudhry, Mattera, Curtis, Spertus, Herrin, Lin, Philips, Hodshon, Cooper, Krumholz, 2010).

Medication Safety	Medication safety refers to any system that ensures that medicine is prescribed safely. An example of this is E-prescribing which is thought to "improve the prescribing process and reduce errors and the costs related to dispensing errors" (Jariwala, Holmes, Banahan, McCaffrey, 2013).
IT in general	Some papers will not be focused upon a part of information technology, but will describe IT in general. As we have noticed in the filtering, a lot of papers describe the Health Information Technology (HIT) without specifying a specific application or system.
Internet	The availability of access to the internet
Mobile	These studies looked at the use of mobile technology in primary care.
Education	These studied the education of the use of information technology. This differs from E-learning, because the learning is not done through information technology, but "regular" learning.
Intervention Program	A primary care intervention program "should help correctly identify all eligible and at-risk patients in a health care system and direct pertinent clinical information to the responsible provider in an easily actionable way." (Lester, Ashburner, Grant, Chueh, Barry & Atlas, 2009).

Table 4 Type of IT (Brainstorm)

The first step in the creation of this list was a brainstorm session. This session was held in order to have a starting point to define types of IT. During this brainstorm session a first list was created. This classification was based on experience and "grey" literature.

There is however awarenss that not all existing Information Technology is known and defined through this brainstorm. Therefore this list was continuously updated throughout the charting process, when any new types of IT were brought to attention within the literature. This provided with some new types of IT, but some types were not found at all. Below these absent types are described.

Absent types

From the classification created in the brainstorming session, the following categories were not found within the examined literature:

Administrative Systems

Administrative systems, are information systems aimed at assisting the staff in their administrative tasks, such as finances, appointments, e-mail etc. Administrative systems were not found within the research results. When querying "Administrative systems primary care" within our four used literature databases, no proper results regarding this topic are generated. This points towards the conclusion that there has not yet been a lot of research in this topic specific for Primary Care. However, it might also not be worth it.

Domotica
Also called "Home Automation". Home automation is "the introduction of technology within the home to enhance the quality of life of its occupants, through the provision of different services such as telehealth, multimedia entertainment and energy conservation" (Gill, Yang, Yao, Lu, 2009). Domotica and Robotica also seems to be a topic on which little research is performed. When searching for Domotica in our databases (without the addition of primary care) only a hand full of results are found and for Robotica (in combination with primary care), no proper results are found. These are very ill-researched topics and a lot of progress can be made here. Here we can also stop and wonder: is this primary care?

Robotics
Robotics can be described as robots that assist the doctor or patient with their process. For example Fasoli, Krebs, Stein, Frontera & Hogan (2003) describe Robotic Therapy, were they provide robot-assisted "to exercise the hemiparetic shoulder and elbow during planar reaching tasks"

Serious Gaming
Serious gaming is the field of gaming where games "are designed to entertain players as they educate, train, or change behavior" (Wit-Zuurendonk, Oei, 2011). This goes one step further then E-learning, because serious gaming aims to change behavior and not educate. The topic of serious gaming has the same issues as Domotica and Robotica. However when we exclude primary care from our search query, it finds more results. The fact that the results are reduced when adding "primary care" also raises the same question: Does it count as primary care or is it a topic that requires more research?

Above classification should bring an answer to our first question: *"What is the Information Technology that is used within primary care."* What remains to be answered is whether these IT systems are an indicator of maturity. This question will be answered based upon the results of the researched studies. Did they see an improvement due to the IT implemented? For every study we would check whether the IT was beneficial, detrimental, or whether no difference was found.

Charting type of IT

First we will look at the types of IT encountered within the studies that were examined. Below a table can be found which shows what Type of IT is described within the literature and in how many studies these were found.

Type of IT	Number of studies
EMR	57
IT in General	48
Exchange of information (P2D)	16
DSS	14
Medication Safety	9
Registries	7
Patient emancipation	4
Intervention program	4

Exchange of information (D2D)	2
E-learning	2
eCoach	2
Exchange of information (P2P)	2
Exchange of information (P2D2D)	1
Telemonitoring	1
Internet	1
PDA	1
Education	1
Total	**173**

Table 5 Type of IT found (Note: The reason that the total number of studies in above table is higher than the examined studies, is that some studies describe more than one type of IT.)

Something that catches the eye is the relative absence of Exchange of Information from patient to patient. Apparently this subject is not yet popular enough for research. Even though patient to patient communication is becoming larger every day. In the Netherlands for example a lot of forums exists where patients discuss with each other. Take for example the following forums, that have thousands of posts: http://www.kankerpatient.net/, http://www.borstkankerforum.com/forum, http://www.longforum.nl/, http://www.hypomaarniethappy.nl/phpbb3/. This is a very interesting and valuable topic. According to Yli-uotila, Rantanen & Suominen (2013), patients have an enormous need for information and emotional support. According to them, the inability for the public health care system to meet these needs, leads them to the internet.

But does patient to patient communication actually count as Primary Care? Patients themselves are not considered primary care. When the exchange of information happens between a patient and a professional within Primary Care, it becomes Exchange of Information between a patient and a doctor. This could explain why our search query did not give a lot of results regarding this topic.

As can be seen from the table. Internet is only discussed in one study (Andrew, Pearce, Sydney, Ireson & Love, 2004). This was one of the earlier studies, when internet access was not taken for granted in everyday business. Almost half (43%) of all the subjects “only” had a dial-up connection. In other studies, internet access is taken for granted.

Mobile technology is also only described in one paper (Adusumilli, Tobin, Younge, Kendall, Kukafka, Khan, Chang & Mahabir, 2006). In this study the experimented with PDA’s in New York. Besides this paper no other focuses on mobile applications. Some studies mention them as a form of access to their IT or web-based systems, but not as a standalone application.

Education was a topic that was overlooked at the brainstorm. All of the categories created, were aimed at treatment or patient, however education for the use of IT systems within a primary care facility was overlooked. This differs from E-learning, because the learning is not done through information technology, but “regular” learning.

Finally intervention programs seem to be a recent development within primary care. The papers describing this topic are all written after 2011, except for the one by Lester et al. (2009). Because of this, it is not unreasonable that there has not been much research on this topic.

Goal of the research

To give an answer to the second question "*What research has already been done about IT within a General Practice.", w*e tried to categorize the papers into the goal of the research. For example, did the research look at the implementation of IT, or at the Effect of IT on patients?

In Table 6 the final result of this classification can be found.

Goal of Research		Description
Self Efficacy		This looked at the patient's ability to use information technology by themselves.
Usability		Whether the information technology was usable by both patients and doctors.
User Acceptance		Did the users (both patient and doctor) accept the IT within the care process?
IT Access		These studies looked at whether access to IT was available.
IT Growth		IT is an evolving subject, did the IT "grow" over time?
Effect of IT on	**Patient** **Process** **Provider** **Finances**	A lot of research has been done on the effect of IT on primary care. This effect can be on the patient, the process, the provider (the doctor/practice), but also the effect on the financial situation.
Implementation		Research that tried to look at the process of implementation of IT.
IT Safety/Security		IT within primary care has a major privacy implication, therefore research has also been done that looks at the safety and security of these IT systems.
Data quality		Studies classified as research into data quality, looked at the quality of data in regards such as consistency and redundancy (Tai, Anandarajah, Dhoul & de Lusignan (2007).
Prevalence of Use		User acceptance looks at the attitude towards the IT, while prevalence of use looks at whether IT is being used at all (disregarding acceptance).
Training		Studies regarding training, were researches that tried to define how primary care providers could be trained into using IT.
Development of guidelines		Studies that provided guidelines on how IT could be developed for primary care.
Development/design of IT		Studies that developed or designed information systems for primary care.

Table 6 Goal of research (Brainstorm)

The same process of creation was used for this classification, as for the classification of types of IT. A preliminary classification was created and during the charting categories were added (or removed/changed).

This classification of the research goals, in combination with the type of IT researched, will give us an answer on our sub question: "What research has already been done about IT within a General Practice?". It will show exactly the type of IT that was researched and what part of the IT was researched (implementation, development, effect etc.).

Absent categories

Categories that were thought to be in the classification (from the brainstorm) but were eventually removed.

Quality of Life
These studies had the goal of researching the effect on the quality of life of the patient.

Effectiveness
These studies looked at the effectiveness of IT in the process of Primary Care. In both positive and negative effect.

Both of these were removed during classification, because they bore to much resemblance to other categories. Quality of Life was an effect of IT on the patient, therefore having both categories, would be redundant. Effectiveness also described an effect of IT, usually the effect on the primary care process. Leaving this category in would also create redundancy.

Charting the goal of research

When putting the papers into the classification, the following results are found:

Goal of research	Number of papers
Implementation	48
Effect of IT on process	35
Effect of IT on patient	28
Prevalence of use	24
User acceptance	22
Effect of IT on provider	20
Effect of IT on finances	13
Development/design of IT	11
Usability	7
Data quality	5
IT safety & security	5
Development (of guidelines)	3
IT growth	2
Training	2
IT access	1

Self efficacy	1
Total	**227**

Table 7 Goal of research found

Combining type of IT and goal of research

In order to find a proper answer to the question "What research has already been done about IT within a General Practice?" the two findings above need to be combined. A visualization of the IT that has been researched (type of IT) and what part of this IT (goal of IT) was created. A pivot table was created combining the goals of the research with the types of research. This is shown below in Table 9.

In the first column, the type of IT is shown, the first row shows the goal of the research. The types and goals that have been researched the most are shown at the left/top, the types and goals that have been researched the least are on the bottom/right.

As can be seen from this visualization, a few topics have been mostly saturated. Especially the topic of *EMR* and *IT in General*. The fact that IT in General is researched as one of the most, is not strange because when looking at IT within primary care, one almost always looks at everything (or at least the most important). What does stand out, is that the subject of EMR is so popular. This is not suprising however, many governments are stimulating EMR adoption. For example the Obama administration in the USA rolled out a five-plan in 2010, where they want to have digital health records implemented throughout the USA in 2015 (USA Today, 2010). Another example is Denmark, where the government required that patient registers and fee-for-service claims be submitted electronically in order to receive subsidies (Protti, Bowden & Johansen, 2008).

Another reason is that EMR already has a wide-spread adoption. As shown in the research done by Dobrev, Haesner, Hüsing, Korte, Meyer (2008) for Emperica, of 27 member states of the European Union, Norway and Iceland, 79.7% of all general practices were electronically recording and storing individual administrative patient data. The fact that this adoption is so high, explains why a lot of research has been done into this subject.

The goal of the studies has a better spread, with *implementation* being the subject of most research. The *effect of IT on process* is a close second. When we combine the researches on *effect of IT* however, we see that most research has been done on this subject (110 studies). This is not strange, because before implementing and using IT systems, there has to be known whether the effect is actually beneficial. Finally a lot of studies look into the prevalence of use and the user acceptance. If the effect is clear and the implementation successful, is it actually being used?

The fact that these four topics are researched the most does not come as a surprise. IT is a relatively new subject, which means that the actual effect needs to be researched. After this, implementation has to be completed successfully, and if all goes well, do users accept and use it?

One major component seems to be missing in these studies: the development of IT. This may strike as odd, because before anything can be researched, it has to be developed first. However only twelve of the found studies talk about the *development and design of IT*, while four talk about the *development of*

guidelines. An explanation for its (relative) absence is that our search query focuses on existing IT, we assume that it has already been developed, the actual development is not relevant to answer our research questions. This explains why only few results were found on this topic.

Something else that can be concluded from this table, is that there are still a few blind spots within the literature regarding IT, Primary Care and it's maturity. The following subjects are described in under 5% of the studies found:

Type:

- Intervention Program
- Patient Emancipation
- eCoach
- Exchange of information (D2D, P2P and P2D2D)
- E-learning
- Internet
- Telemonitoring
- Education
- PDA
- Research

Goal of research:

- IT safety & security
- Development of guidelines
- Adoption
- Effectiveness
- IT Growth
- IT implementation
- Training
- IT Access
- Self-Efficacy

It appears that these subjects still have a lot that is not known about them and research into them might be worthwhile.

The table also shows that even large topics, such as EMR, still have opportunities to be researched. For example a study looking into access to an EMR was not found. When directly querying this subject, chances are that results are found, however this table does give a nice indication on where to start.

Not every empty cell in this table however, points to lack of research. For example implementation of the internet, might not be a subject worthy of research, it might be to basic.

Type of research

Finally the opportunity was taken to classify the research done in this field *on type of research*. Would most researches be performed by a survey, literature reviews or another type of study? In this classification was checked how the research was performed. These categories were all extracted from the papers during the scoping literature review.

Finally the last classification we made on the papers: Type of research. Below the results can be seen.

Type of research	Number of papers
Survey	34
Literature study	30
Interviews	15
Pilot study	14
Descriptive study	12
Case study	10
Randomized controlled trial	10
Comparative study	5
Focus group study	4
Observational study	4
Literature study & survey	2
Feasibility study	2
Retrospective review	2
Audit trail	1
Clinical Trial	1
Longitudinal Pre-Post Study	1
Qualitative process evaluation.	1
Review	1
Statistical analysis	1
Think aloud	1
Total	151

Table 8 Type of research

The survey and the literature study are by far the most common used research techniques for the studies. This can be explained, because these two quantitative research methods would provide a lot of data for the researchers and are relatively low-cost.

Qualitative studies are performed less within the studies that were found, but are still present. Interviews and pilot studies seem to be most favored here.

On itself, these figures are, however interesting, of no use. When they are combined with the type of IT that was researched, a clearer image is created. This is seen in Table 10. Here a clear overview of what type of research was performed with what goals and shows that some subjects are researched mostly in

a similar way is created. For example *implementation* is researched largely through surveys and the same is true for *prevalence of use*.

Combined with the previous table this provides interesting results. Let's take the example of Medication Safety. From the first table was seen that *medication* has been researched, looking mostly at the effect. However no research was found that looked at the prevalence of use of information technology for medication safety. Apparently prevalence of use is researched mostly through surveys, so a survey regarding the prevalence of use of medication safety could provide an addition to the scientific field.

This does not mean that there are *no* researches performed on this topic. Chances are our data-set is not complete. Yet, our data set is large enough to say, with a certain probability, that it is representative.

	Implementation	Process	Effect of IT on Patient	Effect of IT on Provider	Prevalence of use	Effect of IT on finances	User Acceptance	Effect of IT on Design of IT	Development/	Data Quality	Usability	IT safety & security	Development (of guidelines)	Adoption	IT Growth	Training	IT Access	Self Efficacy	Totaal
EMR	30	11	3	6	4	6	3	3	3	4	3	1	2	1					80
IT in General	13	10	7	17	9	10	4	3		2	2	2			1				80
Exchange of information (P2D)	2	7	3	1	4	4	3	2		1						1			28
Medication Safety	3	7	4		2		2												18
DSS	4	5	5					1											15
Registries	1	2		1	1	2			3						1				11
Intervention program	1	1	2					2											6
Patient emancipation		1	4				1												6
eCoach			2															1	3
Exchange of Information (D2D)	2							1											3
Exchange of information (P2D2D)			1		1		1												3
E-learning					1											1			2
Internet				1									1						2
Telemonitoring				1		1													2
Exchange of information (P2P)		1		1															2
Education					1														1
PDA	1																		1
Research										1									1
Totaal	**57**	**45**	**31**	**28**	**23**	**23**	**14**	**12**	**7**	**7**	**5**	**4**	**2**	**2**	**2**	**1**	**1**	**264**

Table 9 Overview of goal of research per type of IT

	Implementation	Effect of IT on Process	Effect of IT on Patient	Prevalence of use	User Acceptance	Effect of IT on Provider	Effect of IT on finances	Development/Design of IT	Usability	Data Quality	IT safety & security	Development (of guidelines)	Adoption	Effectiveness	IT Growth	IT Implementation	Training	IT Access		Self Efficacy
Survey	12	2	2	14	8	4	2	1	2	1	2	1	1	1		1		1		55
Literature study	5	10	7		2	4	5	3		2	1	1	1				1			42
Interviews	5	2	2	4	5	2	1	1			1	1								24
Pilot study	4	3	1	1	3	3	1	3	2					1						22
Randomized controlled trial	1	4	9				3												1	18
Descriptive study	4	4	1	1	1	2	1			2						1				17
Case study	7	1	2	1		1		3			1									16
Focus group study	1	2				1			1								1			6
Observational study	1	1		1	2										1					6
Comparitive study	5																			5
Interviews/Literature study	1	1				1														3
Literature study/survey	1	1				1														3
Longitudinal Pre-Post Study		1	1			1														3
Think aloud		1							2											3
Feasibility study		1													1					2
Retrospective review			2																	2
Statistical analysis				1	1															2
Audit trail				1																1
Clinical Trial			1																	1
Qualitative process evaluation.	1																			1
Review		1																		1
Totaal	48	35	28	24	22	20	13	11	7	5	5	3	2	2	2	2	2	1	1	233

Table 10 The type of research for each goal of research

2.2. Extracting the IT from papers

To this point, all the papers have been classified into categories. This was done three times, for type of IT, goal of the research and type of the research. The next thing that has to be extracted from the paper are actual IT applications. For example an EMR is a type of IT, but what is the actual software or hardware that provides the General Practice with this IT capability? The same can be asked for a DSS. A DSS is a type of IT, but what kind of decision support systems exist?

This extraction has been performed and can be seen in the tables that follows this section. A table was created for every "type of IT" that was found (EMR, medication safety etc.) and include the information technology that was found that provided that specific functionality. For example the first is the exchange of information between doctors. The papers showed that this communication could be done through e-mail. For every system or software capability found in the papers it was written down including a description and ordered into the appropriete classification of IT type. This can be found in the tables below. The description for every system or software capability, can be found in the Appendix A.

Exchange of information (D2D)
E-mail
Clinical data/imaging exchange
Electronic discussion groups
Electronic ordering and access of laboratory tests and results
Electronic Primary Care Research Network (ePCRN)
ePrescribing (transfer of prescription to pharmacies)
Interorganizational ICT
Ordering drugs
NHSnet
Interfacing with other information systems
Store and forward technology
Electronic transfer of patient data
Results & Results management
Intra-clinic communication
Inter-clinic coordination
Healthlink
E-commerce

Table 11 IT aimed at Exchange of information (D2D)

Exchange of information (P2D)
E-mail
Secure Personal Web Pages
Computer mediated consultations
Patient portals
Phone interactive voice response unit for refill requests
Pathology Messaging
Real time video communication
Text messaging
Text-based consultations through a Health Service Site
Sending reminders to patients that are overdue for mammography.
Virtual consultation
Electronic Booking

Table 12 IT aimed at Exchange of information (P2D)

Exchange of information (P2P)
Virtual support groups
Blogs

Table 13 IT aimed at Exchange of information (P2P)

Exchange of information (P2D2D)
Health Exchange System
HIE infrastructure
New networking service (N3)
Regional Health Information System and the exchange of its information
Video-conferencing

Table 14 IT aimed at Exchange of information (P2D2D)

DSS
(Realtime) DSS
Automated Telemanagement System
Clinical Decision support system for Anticoagulation (INRStar)
Clinical DSS
DSS for hypertension (Athena DSS)
DSS + EMR Linkage
Mentor, PRODIGY and GPnotebook)
Expert system
National Clinical DSS infrastructure
Order entry with decision support for chronic disease care

Table 15 IT aimed at Decision Support

Registries
(Chronic) Disease registries
Electronic Registries (Cancer Care)
E-library
National Cancer Database
Patient Management System Software
Web-based patient registry system

Table 16 IT aimed at registries

EMR
Smart Card
Automated data collecting (GENIE)
Computerized patient records system (CPRS)
E-health card system/ Patient Smart card
Electronic Record Linkage
Electronic storage of individual patient data
Personal Health Records
Web-based personal health record (HealthVault, Dossia, Google Health)

Table 17 IT aimed at electronic medical records

Patient emancipation
Home-based biometric measurement devices
Computer Delivered Cognitive Behavioural Therapy
Home automated telemanagement
Information technology–supported adherence and blood pressure monitoring system
SCI-DC (Integrated clinical management system)
Interactive websites
Multilingual automated telephone self-management support program
Secure personal websites
E-health services
Patient education and outreach
Interactive Websites

Table 18 IT aimed at patient emancipation

E-learning
Learning management system web course tools
Learning Programs

Table 19 IT aimed at e-learning

eCoach
Computerized Cognitive Behavioural Therapy ("Breaking the Blues")
Intervention website
Comparator Website

Table 20 IT aimed at eCoaching

Telemonitoring
Online monitoring system

Table 21IT aimed at telemonitoring

Medication Safety
British National Formulary (BNF)
Computerized physician order entry
Computerized prescribing of medication
Electronic prescribing
Drug-drug interaction (DDI) alerts
Drug–Renal Monitoring program
Electronic alarm/Prescribing alerts
eMIMS

Table 22 IT aimed at medication safety

IT in General
Billing
Care management for specific diseases
Computer/laptop
DVD/CD drive
Electronic Alerts (View Alert)
Choose And Book (Electronic booking)
File management
ICT Support
Keyboard
Library
Mouse
Notes
Pharmacy Information Technology (PIT) Service
Recall system
Templates /NSF
Scanning of Letters
Printer/fax
Reminders
Scheduling
Spreadsheets
Voice/Handwriting recognition
Word processing
Scanner
Web-based clinical information system
Web-based Generic Disease Management System (GDMS)
Web-based services (appointment booking, repeat prescriptions)
governance framework for IT security
Healthconnect (change management
strategy)
Service-Oriented Architecture (SOA)
Tools that provide interoperability among information systems

Table 23 General IT

Internet
Internet
Internet access to professional journals/ Literature searching
E-mail
RCN
Website with health care information about diabetes
Wikis
Podcasts
RSS
Specialized websites
Information for clients

Table 24 IT dealing with internet

PDA
E-prescribing
Mobile freestanding quality assurance
Use of a PDA
Smartphones
Data mining and information discovery

Table 25 IT aimed at PDAs

Education
Continuing medical education
Educational Programs
IT Training ()
Virtual Breakthrough Series (education for primary care)
Provider education and feedback through online material

Table 26 IT aimed at education

Intervention program
Critical Drug Interactions program
Data driven quality improvement in primary care (DQIP) intervention
EMR Based intervention program
Intervention system for HIV/STI testing
Intervention website

Table 27 IT aimed at intervention programs

Unknown
Clinical care process prompts
Electronic documentation
family practice-based research networks
IT can facilitate Care planning
IT can facilitate Communication
IT can monitor change
IT can facilitate Registry functionality and population management
Learning Health Care Systems
Knowledge Base
Chronic disease management
Web-based Chronic-disease management (CDM Toolkit)

Table 28 IT that can't be placed under other categories

2.3. Influence of IT

Influence of IT	Number of papers
Positive	56
Makes no judgment	47
Potential	33
Mostly positive	3
Negative	3
Both	2
Depends on implementation	2
No effect	2
Depends on development	1
Implementation difficulties	1
Not enough	1

Table 29 Influence of IT on general practices

Now that the IT that is available has been defined, can there be said that they are a "good" influence on primary care? Do they help the care process? This influence was documented as it was described in the papers reviewed. As can be seen from the table above, almost all papers notice a positive result for IT (56 of the 104 that judge the influence of IT). However, 33 of the papers did not find an actual positive influence of IT, however díd see the potential. Only a few see a negative influence for IT and one says that the good does not outweigh the bad. These influences will be discussed below.

2.3.1. Positive Influence

Overall most studies were positive about the influence that IT had on primary care. This influence was found on different aspects of primary such as the care process. Devine, Williams, Martin, Sittig, Tary-Hornoch, Payne & Sullivan (2010) for example describe an e-prescribing system and conclude that ". Collectively, participants embraced the change, were favorably impressed with the results, and did not wish to return to the world of paper-based prescribing.". Another example was a system described by Avery, Rodgers, Cantrill, Armstrong, Cresswell, Eden, Elliot, Howard, Kendrick, Morris, Prescott, Swanwick, Franklin, Putman, Boyd & Sheikh (2012), that was a pharmacist-led information technology intervention for medication errors proved to be "more effective than simple feedback for reduction of the number of patients at risk from hazardous prescribing and inadequate blood-test monitoring of medicines in general practice." A research by Weinfeld, Davidson & Mohan (2012) finds that "There is evidence that EHRs improve overall documentation, process outcomes, and assist in guideline adherence in underserved settings." IT can also help in identifying patients that are at risk for a specific disease. For example Klein Woolthuis, de Grauw, van Gerwen, van den Hoogen, van de Lisdonk,

Metsemakers & van Weel found that “EMR was valuable in identifying patients at risk for undiagnosed type 2 diabetes”.

These are examples of a few of the papers that find a positive influence of IT within General practice in multiple ways. Still a lot of these papers pose that there are still improvements to be made. They see potential. Below, this will be elaborated upon further.

2.3.2. Potential

Many of the papers describing the influence of IT, state many potential benefits. However most of the time these benefits are not yet realized and they provide reasons as to why this potential is not accomplished. For example, Meyer et al. (2009) say that “many of the benefits that could be reaped from applications such as ePrescribing, telemonitoring as well as medical data exchange between health professionals and across national borders remain untapped“and that "eHealth must be viewed as part of a larger context and measures on different levels are needed to realize the benefits". Another paper describing the benefits also states “the potential is not yet fully used. To increase the adoption of technical features like electronic alarm functions for medication or electronic prescribing, these should be technically improved and more adapted to physicians’ needs” (Urban, Ose, Joos, Szecsenyi & Miksch, 2012). But not only the technology seems to be to blame. Menachemi, Perkins, Durme & Brooks (2006) found low levels of adoption to be the reason why IT is not yet beneficial and propose that this needs to be stimulated.

Some papers take a step further and try to get IT to reach its potential by providing solutions to the found problems. Odukaya & Chui (2012) propose “integrating concepts from the field of HFE to identify safety hazards and recommendations for improving e-prescribing in pharmacies and other ambulatory settings” and Mäenpaa, Asikainen, Gissler, Siponen, Maass, Saranto & Suominen (2011) say about regional health information systems (RHIS) that “outcome assessment of HIE through an RHIS is essential for the success of health information technology (HIT) and as evidence to use in the decision making process.” Another study performed by Baier, Gardner, Buechner, Harris, Viner-Brown & Gifford (2011) discusses the states (in this case Rhode Island) process for developing HIT adoption measures.

All these papers do not currently see benefits in IT realized, however provide reasons why the possible benefits have not been seen. This confirms our belief that IT within primary care is still a very immature subject and raises our faith in the use of a maturity model for IT within primary care.

2.3.3. Negative

There were three papers that were outspokenly negative about IT. Compared to the positive papers, this seems a negligible amount, however we want to address the concerns these papers have.

Implementing the NHS information technology programme: qualitative study of progress in acute trusts (Hendy, Fulop, Reeves, Hutchings & Collin, 2007)

Hendy, Fulop, Reeves, Hutchings & Colin describe progress and perceived challenges in implementing the NHS information and technology (IT) programme in England. They looked at the progress of this

implementation through interviews with the seniour trust managers and clinicians. The first interviews were held at the beginning of this implementation and another round of interviews was held after eighteen months.

They found that the interviewees supported the goals of the programme, but had several serious concerns. “Local managers cannot prioritize implementing the programme because of competing financial priorities and uncertainties about the programme. They perceive a growing risk to patients’ safety associated with delays and a loss of integration of components of the programme, and are discontented with Choose and Book (electronic booking for referrals from primary care).”

Most problems however seem to stem from implementation issues, mostly due to uncertainty. For example they state that “It has been difficult for trusts to prioritize the programme and engage staff when implementation timetables keep shifting.” Due to this uncertainty, it makes managerial key decisions more difficult. Finally they state that in order to make the implementation successful, trust managers need “concrete information about implementation timetables, long term goals of the programme, and value for money.”

A systematic review of economic analyses of telehealth services using real time video communication (Wade, Karnon, Elshaug & Hiller, 2010).

The study of Wade, Karnon, Elshaug & Hiller (2010) looked into telehealth services and its cost-effectiveness. Overall this study found that in health care, telehealth was more cost effective than alternative methods, however in primary care it was a different story. They found it was not cost effective “from the health services perspective, for local delivery of service between hospital specialists and primary care, particularly due to additional health care staffing.” They also state that this would not change “unless the other factors such as health workforce and facility space are also addressed”.

The authors did see the potential of telehealth being beneficial for primary care, however in its current state this was not yet achievable, unless other factors were changed.

Understanding the management of electronic test result notifications in the outpatient setting (Hysong, Sawhney, Wilson, Sittig, Esquivel, Singh & Sing, 2011)

In this study, Hysong et al. (2011) looked at the EHR-based “alert” notifications. They found that “Currently, EHR-based test result notification systems do not offer an effective way to safely and effectively present critical information such as that related to abnormal test results” and they saw “concerns about the current inability to save, track, and retrieve alerts”. They conclude that “providers perceive several challenges for fail-safe electronic communication and tracking of abnormal test results in a state-of-the-art HER”.

However in this paper they also do see the potential and try to provide a solution for the found problems: “A multidimensional socio-technical approach that includes addressing organizational, personnel, and workflow-related factors in addition to improving technology, is essential to design interventions that help reduce missed test results in EHRs and increase their meaningful use”.

2.3.4. Influence

Above tried to examine the different viewpoints studies had on the influence of IT on primary care were examined. Most of the papers saw a positive influence of IT and even if they did not, they did see the potential and delivered solutions. From this we can conclude that IT does have a positive influence on IT, despite the findings of Black et al. (2011). Most of the negative effects of IT were to blame on other factors, such as the implementation. This means that in order for IT to be implemented, steps need to be taken to assure a successful implementation.

2.4. Information Technology within primary care

In this chapter we have completed the scoping literature review. A query was created that would provide the necessary literature results on which an analysis could be performed. With this analysis, a classification was created for the types of IT that can be found within primary care and the goals that were researched by these studies. By doing this a clear overview of the performed research on this topic was created and some blind spots that would be benefited by more research were defined. Finally all the Information Technology that was found in this research was put within the created classification, providing an overview of the information technology that is available and is used within primary care.

This leads to the questions we posed at the start of this study. The following questions were asked:

1. What is the Information Technology that is used within primary care.
2. What research has already been done about IT within a General Practice?

An answer to both questions was provided. The first question, is answered through the classification that was made in this chapter. This was then extended by providing examples of these categories, which can be seen in chapter 2.2. IT encompasses more than just óne system, it is present in multiple ways within the practices. IT has a positive influence on primary care overall, which leads to the belief that it is an actual indicator of maturity.

This also provides a solid basis on which this research can be built. After defining the IT that is available for general practices, GPISs can be put to the test and see whether they can provide these functionalities.

The second question has also been answered in this chapter. The research that has been done into this topic was mapped and is shown in Table 10. This showed what kind of research was performed on the topic (survey, interview etc.) and was combined with the goal of the research. This provides an overview that shows what research has been performed and which research still needs to be performed. This is of high value to the scientific community, because it shows blind spots in the field.

Table 10 provides the opportunity to perform an unique reserach. Most of the studies performed in the area of general practices has been done through survey, literare study and interviews. This research takes a different approach. First, a meta-analysis of the literature that was performed. The next step of this study a different approach will be taken as well. Instead of interviews or surveys we will create our

model and test it through a comparative study by applying it to different GPISs. From our findings, this is a unique types of research.

3. Developing a maturity model

Now that the IT within primary care has been defined and classified, it is time to put this into a maturity model. In order to create this maturity model, a few questions need to be answered.

The previous chapter answered the first two sub questions of this research. This chapter aims at answering the following:

3. What functionalities does a general practice information system provide?
4. How can a maturity model for general practice information systems be developed?
5. How can a maturity model be validated?

3.1. Method

There are multiple maturity models available. The first decision that has to be made is which of these models is going to be used. Much has been written about developing a maturity model for IT within organizations. A general practice is also an organization,which means this literature can assist in the creation of our own maturity model. A very comprehensive overview for maturity models is made by Wendler (2012). His aim was to “structure and analyze the available literature of the field of maturity model research to identify the state-of-the-art research as well as research gaps.” His assessment delivered the first systematic summary of maturity model research and should support researchers categorizing their own projects. He also claims that “practitioners planning to use a maturity model may use the study as starting point to identify which maturity models are suitable for their domain and where limitations exist”.

This overview is a great asset to this research, seeing as it creates “the first comprehensive representation of the maturity model research field and builds a reference basis for further research activities”. This framework Wendler ensures a systematic approach guiding research in the field of maturity models. Besides this framework, it helps the research, because it provides us studies that explain how a maturity model (for IT management) can be developed. Out of the 237 papers reviewed by Wendler, he mentions six papers that describe this development, and of these six, two developed process models and criteria for developing maturity models. One of these papers provided just a theory, but the other provided an actual application of their procedure model through a case study. For this reason, the second paper was chosen. The study of Wendler (2012) also points out that a lot of maturity models “suffer a lack of validation” and provides information on how to validate a maturity model.

This paper described by Wendler, is the paper of Becker, Knackstedt & Pöppelbuß (2009). They saw the large amount of maturity models, however “the procedures and methods that led to these models have only been documented very sketchily”. Becker, Knackstedt & Pöppelbuß wanted to develop criteria for the development of maturity models using a scientific approach. The results from their study “have been generalized and consolidated into a generally applicable model.” This resulted in a step-by-step procedure for the development of maturity models. They base this model on the seven guidelines for design science, defined by Hevner et al. (2004). These seven guidelines where transformed into the following requirements by Becker, Knackstedt & Pöppelbuß:

R1. Comparison with existing maturity models
R2. Iterative procedure
R3. Evaluation
R4. Multi-methodological procedure
R5. Identification of problem relevance
R6. Problem definition
R7. Targeted presentation of results
R8. Scientific documentation

Becker, Knackstedt & Pöppelbuß have integrated these into a procedure model for developing maturity models. This is shown in the figure below.

The procedure exists out of a number of phases:

1. Problem definition
2. Comparison of existing maturity models
3. Determination of development strategy
4. Iterative maturity model development
5. Conception of transfer and evaluation
6. Implementation of transfer media
7. Evaluation
8. Rejection of maturity model.

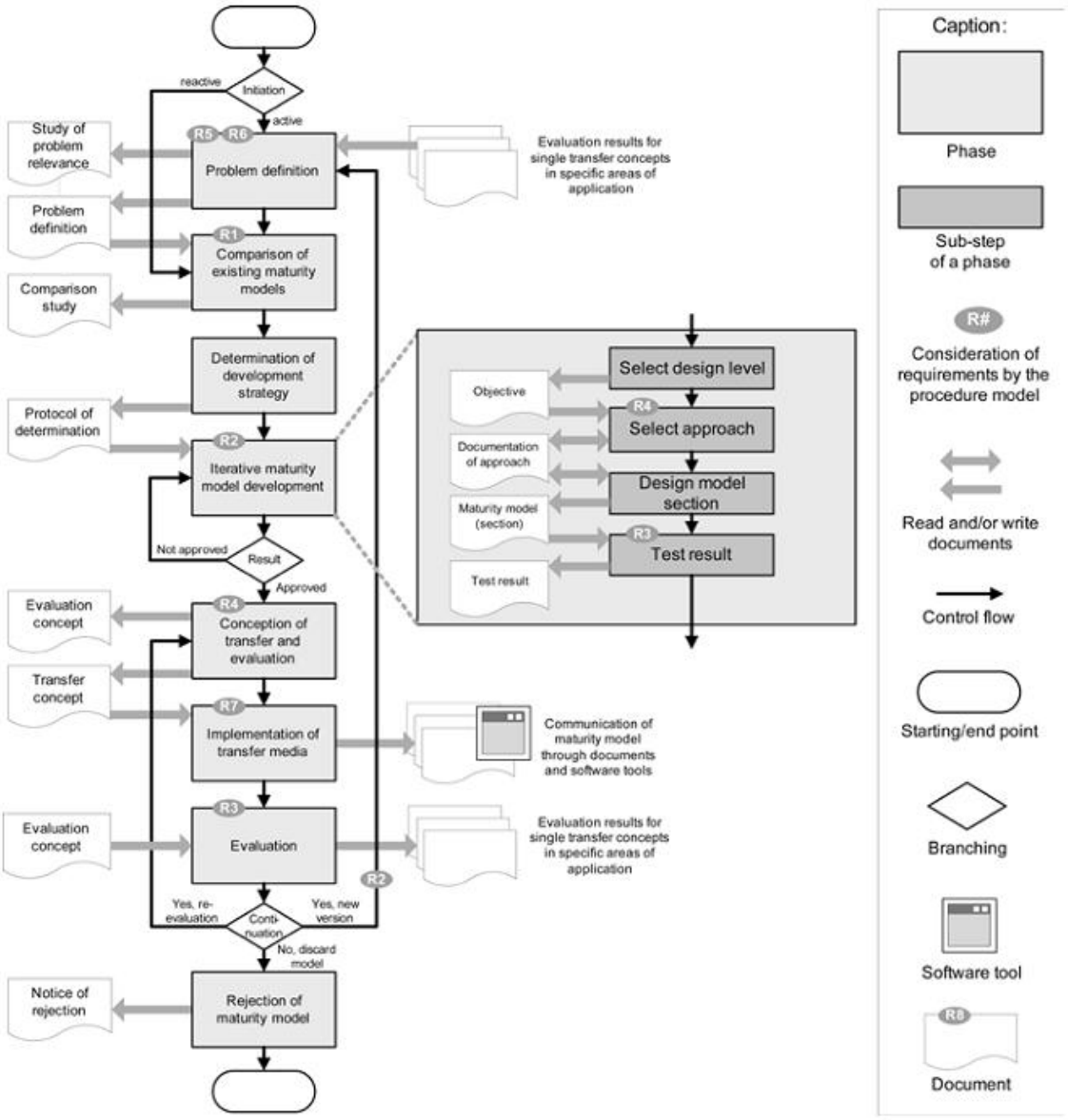

Figure 2 Procedure model for developing maturity models (Becker, Knackstedt & Poppelbuß, 2009)

3.2. Problem definition

According to Becker, Knackstedt & Pöppelbuß every to-be developed maturity model needs to start with a problem definitions. These are portrayed in requirements R5 and R6:

R5. Identification of problem relevance
R6. Problem definition

First the problem and the relevance of the problem have to be identified.

Within this study this step has already been performed in the introduction. First the problem/opportunity was stated and following this problem, its relevance to the scientific field, but also to the society was stated.

3.3. Comparison of existing models

Before a maturity model is developed, it needs to be known whether something usefull to the field is being added. It might be the case that a maturity model already exists. As Becker, Knackstedt & Pöppelbuß state: “The need for the development of a new maturity model must be substantiated by a comparison with existing models. The new model may also just be an improvement of an already existing one.“

In our introduction it was shown that there were no real maturity models available yet for the IT within General Practices. It was concluded that no model yet exists that looks at the IT maturity at General Practice level, encompassing all the IT available within a General Practice and that provides means to improve maturity.

There are however maturity models available for IT within other types of organizations. For this the paper of Becker, Knackstedt & Pöppelbuß can be used. They found 51 different maturity models, however most of these had incomplete documentation. Becker, Knackstedt & Pöppelbuß filtered the models on the basis of the Scientific Documentation (R8). After all, without proper documentation, it would be impossible to check, whether the maturity models were created in a valid way.

They divided the requirement for scientific documentation into three parts:

8-I: Documentation includes reference to existing models

8-II: Documentation indicates steps of design and evaluation processes

8-III: Detailed documentation of the design process

Below are the maturity models that were approved by Becker, Knackstedt & Pöppelbuß. In addition to these, a more recent maturity model was defined by van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010). The Focus area maturity model, which is based on the same requirements stated by Becker, Knackstedt & Poppelbuß.

1. **Analysis capability maturity model (ACMM)**

This researchers that developed the ACMM tried to provide a maturity model for the processes used by analysis organizations. They hoped “to facilitate an independent appraisal of analysis within a government program” (Covey & Hixon, 2005). With the model they wanted to provide “A process framework for the body of knowledge related to analysis and operations research”. The model can be used for “guidance for improving an analysis organization's processes and its ability to manage the

development, acquisition, and maintenance of analysis products and services. " The ACMM identifies five levels of maturity:

1. The initial level, characterized by ad hoc processes, which can be chaotic.
2. The managed level, characterized by managed analysis processes, work products, and services for individual studies.
3. The defined level, characterized by standard analysis processes, work products, and services for the analysis organization.
4. The quantitative level, characterized by analysis tasks being managed quantitatively.
5. The optimizing level, with continuous improvement of analytic processes.

2. Business Process Management Maturity (BPMM)

This model "provides a framework for the detailed evaluation of BPM capabilities and achievements." (Rosemann, de Bruin & Hueffner, 2004) and has as goal to evaluate and assess the business process management maturity of an organization. Business process management is "a holistic organizational management practice, which is focused on the identification, definition, analysis, continuous improvement, execution, measurement, monitoring and analysis of intra- and inter-organizational business processes."

Below the model is shown.

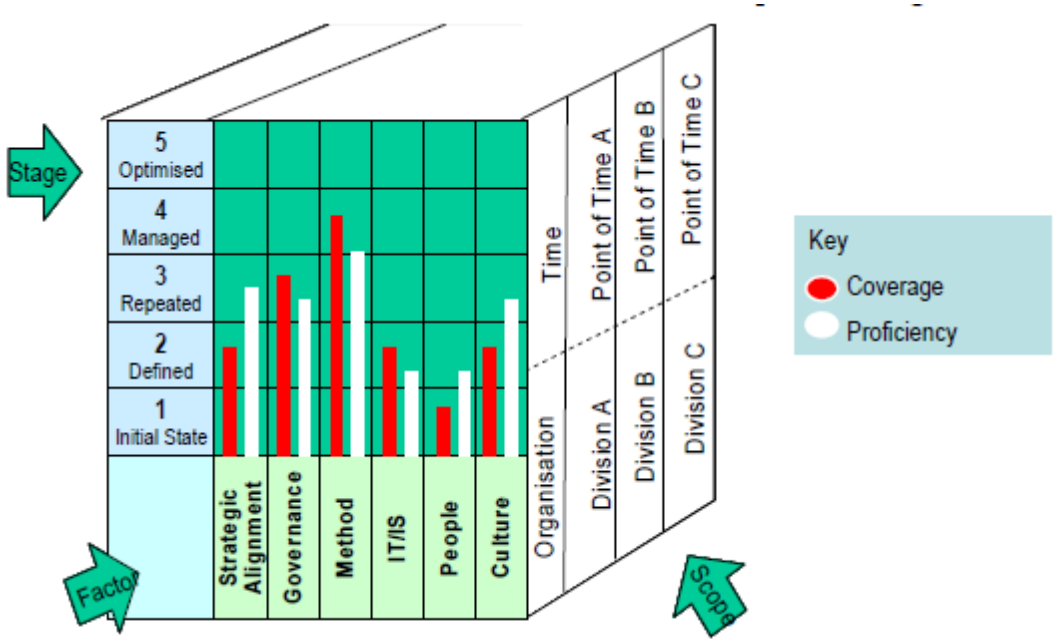

Figure 3 Business Process Management Maturity (Rosemann, de Bruin & Hueffner, 2004)

As can be seen, this model also uses five stages to define the maturity. Besides these stages, it takes into account Factors and Scope. Factor(s) "A specific, measurable and independent element which reflects a fundamental and distinct characteristic of BPM. Each factor is further broken down in a 1-m hierarchy." Scope has two parts, the organizational part and time. The organizational scope "defines the unit of

analysis and to which the model is being applied, e.g. a division, a business unit, a subsidiary." The time scope points to "the point in time at which the model is applied."

3. Capability Maturity Model Integration (CMMI)

CMMI is "a process improvement maturity model for the development of products and services." (CMMI Product Team, 2006). The purpose of the maturity model is to "help organizations improve their development and maintenance processes for both products and services." This model makes use of capability levels. These are:

0. Incomplete
1. Performed
2. Managed
3. Defined
4. Quantitatively Managed
5. Optimizing

This is used in combination with five maturity levels:

1. Initial
2. Managed
3. Defined
4. Quantitatively Managed
5. Optimizing

In order for an organization to increase in maturity level, all the capabilities belonging the that maturity level must be achieved.

4. Documentation Process Maturity Model (DPMM)

The DPMM was developed in order to "help organizations improve their development and maintenance processes for both products and services." (Visconti & Cook, 2000). The model looks at the documentation within an organization and whether the policies are adhered too. It is aimed at organizations that develop software. It is a "description of process maturity capability and practices that characterize an organization that generates high quality documentation." Below the overall structure is presented as can be seen, this maturity model deals with 4 maturity levels.

	Level 1 Ad-hoc	Level 2 Inconsistent	Level 3 Defined	Level 4 Controlled
Keywords	Chaos, Variability	Standards Check-off list Inconsistency	Product assessment Process definition	Process assessment Measurement Control Feedback Improvement
Succinct Description	Documentation not a high priority	Documentation recognized as important and must be done.	Documentation recognized as important and must be done well.	Documentation recognized as important and must be done well consistently
Key Practices	Ad-hoc process Not important	Inconsistent application of standards	Documentation quality assessment Documentation usefulness assurance Process definition	Process quality assessment and measures
Key Indicators	Documentation missing or out of date	Standards established and use of check-off list	SQA-like practices	Data analysis and improvement mechanisms
Key Challenges	Establish documentation standards	Exercise quality control over content Assess documentation usefulness Specify process	Establish process measurement Incorporate control over process	Automate data collection and analysis Continually striving for optimization

Figure 4 Documentation Process Maturity Model (Cook & Visconti, 2000)

5. E-Learning Maturity model (eMM)

The eMM " provides a means by which institutions can assess and compare their capability to sustainably develop, deploy and support e-learning. " (Marshall, 2007). This model also deals with 5 dimensions.

1. Delivery: "concerned with the creation and delivery of process outcomes."
2. Planning: "assesses the use of predefined objectives and plans in conducting the work of the process."
3. Definition: "covers the use of institutionally defined and documented standards, guidelines, templates and policies during the process implementation."
4. Management: "concerned with how the institution manages the process implementation and ensures the quality of the outcomes."
5. Optimisation: "captures the extent an institution is using formal approaches to improve capability measured within the other dimensions of this process."

These are combined with 35 processes, divided into five process categories:

Process category	Brief description
Learning	Processes that directly impact on pedagogical aspects of e-learning
Development	Processes surrounding the creation and maintenance of e-learning resources
Support	Processes surrounding the oversight and management of e-learning
Evaluation	Processes surrounding the evaluation and quality control of e-learning through its entire lifecycle.
Organisation	Processes associated with institutional planning and management

Figure 5 eMM Process Categories (Marshall & Mitchell, 2003)

Every process is then assessed on the performance of the institution:

Figure 6 eMM Capability Assessments (Marshall & Mitchell, 2003)

This model can be used not only for assessment of the own institution, but also to easily compare with other (similar) institutions.

6. IS/ICT Capability maturity framework (IS/ICT CMF)

The IS/ICT CMF provides a "solid theoretical foundation for continued research in the field of strategic IS/ICT management and the maturity of an organization's capability to manage its IS/ICT processes." (Renken, 2004) The framework proposes seven indicators on which the maturity of an organization is tested. These indicators are:

1. IS/ICT Applications
2. Business-IT Relationship
3. IS/ICT Strategy Alignment
4. IS/ICT User Profile
5. IS/ICT Managerial Paradigm
6. IS/ICT Governance
7. IS/ICT Organization

These indicators are divided into three to five maturity levels. An example is shown below. Renken states that this tool might be a valuable tool for evaluating an organizations' overall IS/ICT management capability.

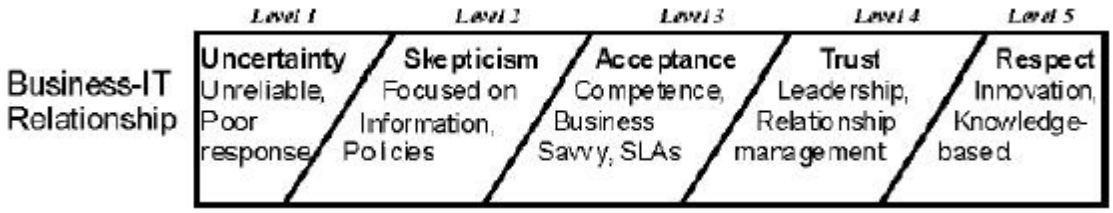

Figure 7 Business-IT Relationship capability maturity levels (Renken, 2004)

When every indicator has been filled in, a spider diagram can be made for the organization to benchmark with other the industry:

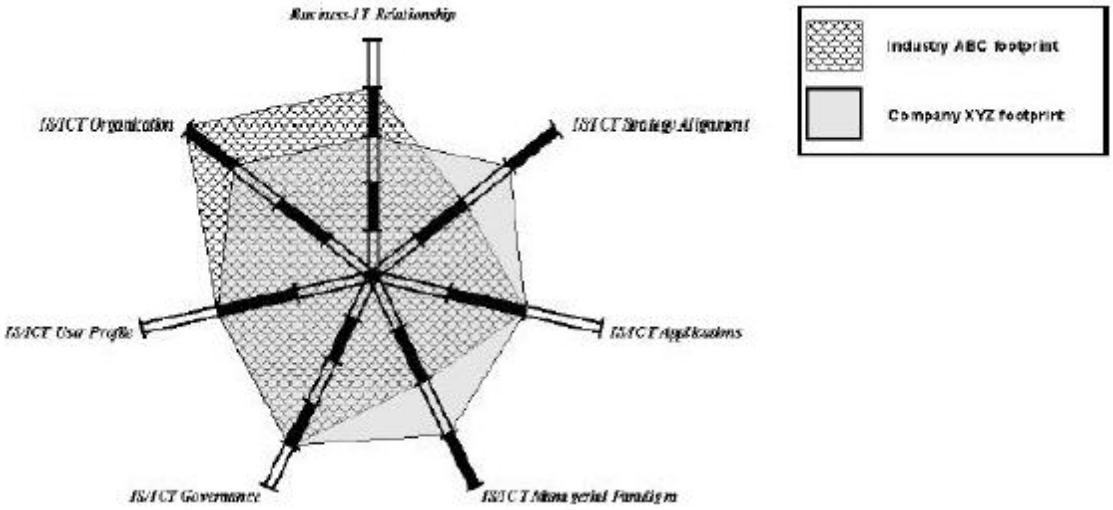

Figure 8 An example of how the IS/ICT management capability maturity framework can be presented in 'spider diagram' notation to illustrate the variations between the footprints of the average maturity levels for the industry and that of a particular organization. (Renken, 2004).

7. Focus Area Maturity Model (FAMM)

The focus area maturity model is different from the models described above. “A focus area maturity model defines for each of its focus areas a series of development steps in the form of progressively mature capabilities” (van Steenbergen, Bos, Brinkkemper & van de Weerd, 2010). The reason we decided to include this model was that this model was developed based on the requirements of Becker, Knackstedt & Pöppelbuß, and as such adheres to their demands for a maturity model. A focus area is defined as “an aspect that has to be implemented to a certain extent for a functional domain to be effective.” According to the authors focus area maturity models “show definite value in supporting organizations to incrementally improve their practices.” There was however no focus area maturity model found for the use of IT within an organization.

A basic design is shown below:

Maturity Scale / Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12
Requirements management													
Requirements gathering		A		B	C		D	E	F				
Requirements identification			A			B		C		D			E
Requirements organizing			A		B		C						
Release planning													
Requirements priorization				A		B	C	D		E			
Requirements selection			A						B	C	D		
Release definition				A	B	C		D		E			
Release validation				A			B			C		D	
Launch preparation		A				B		C			D		
Scope change management				A		B				C		D	
Product roadmapping													
Theme identification					A		B						
Core asset identification						A			B				C
Roadmap construction			A			B	C		D	E	F		
Portfolio management													
Market trend identification			A		B				C				
Partnering & contracting			A		B		C		D				
Product lifecycle management			A			B			C				
Product line identification							A			B			

Figure 9 The maturity matrix for Software Product Management

In the figure above, you can see the different focus areas, the maturity scale and the capabilities. As can be seen here, every focus area has a different scale for maturity. For example requirements gathering, has six different capabilities, ranging from 1 to 8 on the maturity scale. However requirements identification has five capabilities, however these range from 2 to 12 on the maturity scale.

3.3.1. Types of maturity models

This list can be complemented with a classification made by van Steenbergen, van den Berg & Brinkkemper (2007) . They identified three different types of maturity models. These are described below with the explanations they provide.

- Stage 5-level models
  "These models distinguish five levels of maturity. For each level a number of focus areas are defined specific to that level. These focus areas have to be implemented satisfactorily for the organization to achieve that particular level." The following models fall into this category: CMMI, DPMM, IS/ICT CMF.
- Continuous 5-level models
  "These models also distinguish five general maturity levels and a number of focus areas. The difference with the first kind of models is that the focus areas are not attributed to a level, but within each focus area the 5 levels are distinguished." These are: ACMM, BPMM, eMM.

- Focus area oriented models
  "These models depart from the idea that there are five generic maturity levels. Instead each focus area has its own number of specific maturity levels. The overall maturity of an organization is expressed as a combination of the maturity levels of these focus areas." The model in this category is the FAMM.

What kind of model could best be developed or adapted for our research?

- The **ACMM** is used to improve processes of an analysis organization and to manage the development, acquisition and maintenance of analysis products and services. The general practice information system is not an analysis organization, nor does it have analysis products or services.
- **BPMM** is focused upon the business process. It focuses on intra- and inter-organizational business processes. This sounds promising, however the focus is not on IT. It is seen as a small part of the entire business. It is of course true that IT is a part of a larger organizational, however our model we wants to put the focus on IT system of a general practice. A maturity model encompassing the entire family practice was already shown by Tapp et al. (2009)
- The **CMMI** model focuses on the development and improvement of products and services. The goal of a general practice information system is not to develop products and services, but to provide them to the customer. This is a substantial difference, which causes this model to be inapplicable. The same problem exists for the DPMM model.
- The **eMM** is also not applicable to general practices, because of the focus on E-Learning, which is not a goal of a general practice information system.
- The **IS/ICT CMF** however, does come close to what we wish to accomplish. It wants to evaluate an organizations' overall IS/ICT management capability and can provide a comparative model so that general practices can benchmark themselves.
- Finally the **FAMM** looks on a more detailed level. The maturity levels are not predefined nor are the focus areas, which make it a flexible model and can provide a comparative model. A FAMM also provides improvement actions with which maturity can be improved.

The next step of this research will consider these models and a model will be chosen.

3.4. Determination of development strategy

Looking at the models described above, only two are a possible fit for the purpose of our research. These models are the IS/ICT CMF and FAMM. A decision has to be made which of these we will use. According to van de Weerd, Bekkers & Brinkkemper (2007) continuous and staged 5-level models are "too heavy" or "too large" to use or even comprehend. IS/ICT CMF belongs to these categories. A focus area model however enables local analysis and incremental improvement possible. In the focus area maturity model the focus areas are not fixed on the standard of 5-levels, it makes the model more flexible in defining them and to define interdependencies between them. This also means that the focus areas are not set in stone, which is the case for all the other maturity models. With this model it is also possible to perform a comparitive analysis on general practice information systems.

Because a model that is flexible and easy to use, it can be used for a comparitive analysis and provides improvement actions, we will choose the FAMM.

van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers define the development method for the focus area maturity model in ten steps:

1. Identify and scope the functional domain
2. Determine focus areas
3. Determine capabilities
4. Determine dependencies
5. Position capabilities in matrix
6. Develop assessment instrument
7. Define improvement actions
8. Implement maturity model
9. Improve matrix iteratively
10. Communicate results

From this point we can continue developing our maturity model with these steps, since they are developed with the requirements of Becker, Knackstedt & Pöppelbuß (2009). These steps are shown in the following product deliverable diagram:

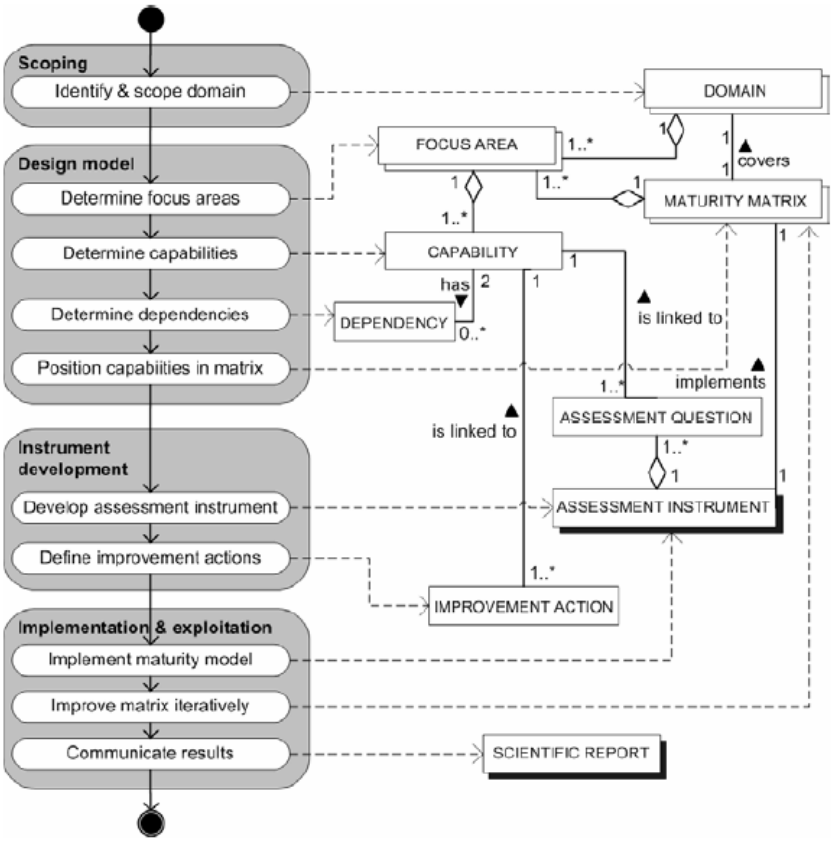

Figure 10 Development product-deliverable diagram for focus area maturity models van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010)

This is the answer for the sub-question we were asking ourselves:

- How can a maturity model for general practice information systems be developed?

In the previous part of this chapter the maturity models that are available were discussed and it was concluded to use the framework of the Focus Area Maturity model. The content for this model has to be developed. In the steps from the development method can be seen which information is required. Focus areas, capabilities with their positioning and dependencies have to be defined. In the next part of this chapter, this development method will be performed.

3.5. Development of the maturity model

The first step (Identify scope and functional domain) has already been performed, through the first chapters in this study.

3.5.1. Determine focus areas

Steenborgen, Bos, Brinkkemper, van de Weerd & Bekkers (2010) say that "focus area maturity models are based on the concept of a number of focus areas that have to be developed to achieve maturity in a

functional domain". The first step is to determine these focus areas. These can be derived from the main activities a general practice has. A research by the NIVEL (Dutch institute for research in health care) looks at the time general practioners spend on main activities (Nivel, 2013). They divide these activities into three categories:

1. Direct patient-related activities
   A predetermined set of activities that can called patient-related. This does not include activities such as training, organization and scientific research.
2. Indirect patient-related activities
   These are the activities that are not directly related to the patient, such as filing and other patient registration.
3. Non patient-related activites
   All activities that are not related to the patient, such as education, organization or scientific research.

In our scoping literature review the types of IT have been defined. These can now be divided in these categories. For example, EMR deals with patient records, but not with patient directly, which means it can be placed in the category “Indirect patient-related activities”. Exchange of information (P2D) however, deals with direct communication with the patient, which means it can be categorized as “Direct patient-related activities”. In the table below, the full division is shown:

Direct Patient-related	**Motivation**
Exchange of information (P2D)	These systems deal with communicating directly with the patient.
Exchange of information (P2P)	This is patient to patient interaction
Exchange of information (P2D2D)	This deals with patient to doctor ánd doctor to doctor communication.
Patient emancipation	These systems help the patient with independency.
eCoach	These assist the patient directly.
Telemonitoring	Monitoring the patient from a distance, which means it directly relates to the patient.
Medication safety	These systems deal with the medication a patient takes.
Intervention Program	Intervention programs are also directly related to the patient.
Indirect Patient-related	
Exchange of information (D2D)	This exchange of information is between doctor to doctor. This can be about a patient, for a patient, or about the medical field. Large parts of this communication is thus about the patient, however the patient is not directly involved.
DSS	These assist the general practice in the care of a patient.
Registries	Registries are about patients or diseases, but do not interact with the patient itself.
Electronic medical records	The medical records are *about* a patient.

Administrative	All the administrative systems a general practice has. These are about the patient.
PDA	The PDA is a system a general practice can use to access information about the patient, diseases or other information.
Not Patient-related	
E-learning	Deals with the learning of the general practice about IT. Does not have anything to do with the patients.
ICT Support	Support for the general practice with their IT.
Internet	Access to the internet of a general practice. No patient is involved.
Education	Medical education for the general practice.

Table 30 Focus Areas

3.5.2. Determine capabilities

According to van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010) each focus area consists of a number of different capabilities representing progressive maturity levels. A capability is defined by them as "an ability to achieve a predefined goal that is associated with a certain maturity level. For example the ability to *email* achieves a goal (communication between doctors). The capability to email is then associated to a maturity level. The definition of these capabilities “depends on the underlying rationale of how the focus area can be incrementally developed in an evolutionary way”. They state that these capabilities can be found from literature.

In order to answer our third subquestion "What functionalities does a general practice information system provide?" the IT capabilities of a general practice have to be defined. After this, there can be look at which of these capabilities a GPIS can perform.

For each focus area the capabilities of IT within a general practice have to be defined. Note that instead of using specific IT programs (such as Outlook) this is generalized further(such as e-mail), because it is out of scope to assess whether specific programs (for example specific e-mail programs) are more mature than others, however we can state whether having the capability (e-mailing) is more mature compared to other capabilities.

To determine the capabilities, there was looked at all the different types of IT that were found per IT/focus area through our scoping literature review and can be viewed from Table 11 to Table 28. These were filtered on similarities/lack of proper description and sorted into the focus areas.

Following table shows the focus areas and its capabilities:

	Exchange of information (P2D)
A1	Text messaging

A2	Phone interactive voice response unit
A3	Recall system
A4	Email
B	Electronic booking
C	Real time video
D	Patient Portals
	Exchange of information (P2P)
A	Blogs
B	Virtual support groups
	Exchange of information (P2D2D)
A	Video conferencing
B	Regional HIE
C	HIE
D	eMIMS
E	Health Exchange system
	Patient emancipation
A	Home-based biometric measurement devices
B	Computer delivered therapy (such as CDCBT)
C	Interactive websites
D	Home automated Telemanagement
E	Integrated clinical management system
F	Secure personal websites
	eCoach
A1	Comparator website
A2	Intervention website
B	Therapy in computerized form
	Telemonitoring
A	Online monitoring system
	Medication safety
A	Online medication information (such as BNF)

B	Computerized physician order entry
C	ePrescribing
D1	Drug-drug interaction alerts
D2	Electronic alarm
	Intervention Program
A	Intervention programs (such as HIV/STI testing)
B	EMR based intervention program
C	Intervention websites
	Exchange of information (D2D)
A	Electronic discussion groups
B	Email
C	Electronic ordering and access of laboratory results
D	ePrescribing
E	Inter Clinic coordination
F	Intra-clinic communication
G	Clinical data/image exchange
H	Support for chain digitization
	DSS
A	Automated telemanagement system
B	Expert System
C	Disease specific DSS
	Registries
A	E-library
B	Disease registries
C	Patient management system software
D	Web-based patient registry system
	Electronic medical records
A	Computerized patient records
B	Automated data collecting
C	Electronic record linkage

D	Web-based personal health record
E	Smart card
	Administrative
A	File management
B	Scheduling
C	Electronic Billing
	PDA
A	Access up-to-date evidence based data
B	Smartphones
C	ePrescribing
D	Mobile freestanding quality assurance
E	Data mining and information discovery
	E-learning
A	Learning programs
B	Learning management system web course tools
	ICT Support
A	ICT Support
B	IT Training
	Internet
A	Internet access
B1	Information for clients
B2	Internet acces to literature/journals
C	Email
D1	Wikis
D2	Podcasts
D3	RSS

	Education
A	Educational programs
B	Continuing medical education
C	Provider education and feedback through online material

Table 31 Focus Areas and Capabilities

3.5.3. Determine the capabilities for a GPIS

Now that the capabilities for a general practice in general are determined, it is time to apply them to general practice information systems. What capabilities could be supported by a GPIS? Note that in this part, it is checked whether an GPIS is able to support the capability, not whether an existing GPIS actually hás this capability.

Some of the capabilities that were found through the literature review and that were defined in 3.5.2 are not feasible for a GPIS. A GPIS has certain limits, for example a GPIS cannot talk face to face with patients. With these limitations in mind, the capabilites as defined in 3.5.2 will be adapted.

In order to maintain an overview, the focus areas or capabilities that are nót possible or useful in a GPIS will be described, included with an explanation.

	Exchange of information (P2D)	
A1	Text messaging	It is not necessary for the computer system to be able to text message to patients, there are other ways of communciation.
A2	Phone interactive voice response unit	A phone interactive voice response unit is not a capability that has to be supported by a GPIS. The phone is not part of the information systems that assist a general practice.
	Exchange of information (P2P)	The entire focus area Exchange of information (P2P) is not relevant to a GPIS. This is communication between patients, not between a

		general practice and another party. Therefore we believe this does not have to be facilitated by a GPIS.
	eCoach	An ecoach is a separate system, that operates outside of a general practice (however can be recommended/prescribed by a general practice).
	Electronic medical records keeping	
E	Smart card	A smart card is a card that is carried by a patient. Therefore it is not possible to insert this into a GPIS.
	Administrative	
A	File management	Not every file can be managed by the GPIS, some files need to be managed outside of the system. Of course electronic medical records should be managed by the GPIS, however other files do not have to be.
	ICT Support	
A	ICT Support	ICT support is not performed by the GPIS, but rather the companies that delivered the ICT to the General Practice (for example the GPIS supplier).
	Internet	Internet cannot be provided with a GPIS.
	Education	Education is out of the scope of a GPIS. Increasingly so because of the quickly changing subject matter.

Table 32 Removed capabilities and focuse areas for GPIS

3.5.4. GPIS functionalities

Previous part provides an answer to the third subquestion:

What functionalities does a general practice information system provide?

The capabilities gave a finalized list of capabilities that a general practice information system can perform and can't perform. Throughout this study however this list is still susceptible to change. For a final list of capabilities performed by a GPIS, see Appendix C.

3.5.5. Determine dependencies

The following step in the process is identifying dependencies between the capabilities, providing a partial ordering. These dependencies can exist outside of the borders of the capability. Email requires that the system has access to the internet. Therefore internet access is a dependency of email. Regional health information exchange program requires computerized patient records to be available and is therefore dependent on them. A complete overview of the dependencies can be found in appendix F.

3.5.6. Position capabilities in matrix

The next step is to position the capabilities within the matrix. There are a few rules that have to followed.

1. Capabilities that are dependent on other capabilities are always positioned further to the right.
2. Capabilities that are not dependent on each other may be put in the same scale.
3. If many capabilities are contained in one scale, they may be assigned to a number of scales to get a more balanced matrix.

This positioning is based on past experiences and preferences of implementation order.

The IT was sorted from immature to mature in our opinion. The most immature was categorized with “A” and every subsequent capability was granted a letter higher up the alphabetical order. This does not mean that a capability classified with “A” is very immature, it just means that it’s the least mature of all the other options within that category. For example virtual support groups are classified as B, however are still considered mature.

With the capabilities defined and their dependencies charted, we create a first iteration of the maturity model with the capabilities sorted on the maturity level they provide. For explanation of the letters, see the table below the matrix.

	1	2	3	4	5	6	7	8	9	10
Direct Patient-related										
Exchange of information (P2D)	A				B	C	D			
Exchange of information (P2D2D)			A		B	C		D	E	
Patient emancipation		A	B	C	D	E	F			
Telemonitoring		A								
Medication safety		A	B		C	D				
Intervention Program	A	B	C							
Indirect Patient-related										
Exchange of information (D2D)		A	B	C	D	E	F	G	H	
DSS		A	B	C						
Registries		A	B	C	D					
Electronic medical records	A	B	C	D						
Administrative	A	B	C							
PDA			A	B	C	D	E			
Not Patient-related										
E-learning		A	B							
ICT Support	A									

Table 33 First iteration Focus Area Maturity Model

3.5.7. Develop assessment instrument

In order to use this model to assess the current maturity of a general practice information system, measures must be defined for each of the capabilities. This can be done by formulating questions that are based on the descriptions of the capabilities. Below the capabilities and their questions are defined.

	Exchange of information (P2D)	
A1	Recall system	Are patients recalled by the system for routine and other planned episodes of care?
A2	Email	Can the system use e-mail as a consultation method? Is e-mail used to remind patients about refills, repeat prescribing or repeat prescription requests? Is e-mail used to provide lab results to patients? Can you transfer pathology results through email to the patients?
B	Electronic booking	Can the system allows you to make patient's appointments electronically? Does it allow you to make referrals?
C	Real time video	Can you communicate with the patient through real time video?
D	Patient Portals	Does the system provide online applications that allow patients to communicate with their health care providers?

Table 34 Exchange of information (P2D) capabilities and assessment questions

	Exchange of information (P2D2D)	
A	Video conferencing	Can the system be used to video consult with patients, but also other health care professionals?
B	Regional HIE	Can you access information and services in the region through the system? Does it enable you to provide health care through integrated services in the region? Do you have deals or contracts with other health providers in your regional area to share information? Is your the system compatible for this sharing?
C	HIE	Can you electronically transmit health information across boundaries of organizations and electronic information systems? Can you access information and services from any health provider? Can you provide health care through integrated services in other areas? Do you have deals or contracts with other health providers in outside of your region to share information? Is the system compatible for this sharing?
D	eMIMS	Can the system manage medical images? Does it allow users to express multi-criteria queries?

E	Health Exchange system	Can the system provide patients with a system that are a central point for medical/ambulance/diagnostic and referral facilities? If this is the case, does it also provide emergency health care services? Does the system have alliances with pharmaceutical companies, insurance providers, medical service providers and educational institutions?

Table 35 Exchange of information (P2D2D) capabilities and assessment questions

	Patient emancipation	
A	Home-based biometric measurement devices	Is the system compatible with home-based measurement devices? (For example to monitor and collect daily readings and symptom information?) Can the patient upload this data via telephone or the internet to care-the system, from which health care professionals can then access the patient data?
B	Computer delivered therapy (such as CDCBT)	Can the patient receive therapy through the system?
C	Interactive websites	Does the patient have access to a website, where they can access and perform some steps of treatment/diagnoses?
D	Home automated Telemanagement	Does the system give a patient access to a program that helps to implement patient self-care, clinical decision support and care coordination? Does this system provide enhanced patient-provider communication, disease education, control of patient adherence with their treatment plans, healthy lifestyle counseling and social support?
E	Integrated clinical management system	Can the patient access the system for detailed, patient- and practice-specific information? Is this information available over a secure connection to authenticated users? Can the system collect and link data? Does it provide data presentation, data security and confidentiality?
F	Secure personal websites	Does the system provide a webpage where patients can communicate with physicians? Does this provide an e-mail function? Can these webpages: - create lists of diagnoses, medication and allergies? - issue reminders on appointments and preventive services? - perform prescription refills? - provide links to reputable health information web sites?

Table 36 Patient emancipation capabilities and assessment questions

	Telemonitoring	
A	Online monitoring system	Can patients be monitored through the system from a distance, for example through an online diary?

Table 37 Telemonitoring capabilities and assessment questions

	Medication safety	
A	Online medication information (such as BNF)	Does the system provide a place where sound up-to-date information about the use of medicines is available?
B	Computerized physician order entry	Can you enter medication orders through the system. Can it communicate with the apothecary regarding orders?
C	ePrescribing	Is the way of prescribing medicine fully electronic? Does this require an electronic signature of the prescription. Is this electronically transferred to the pharmacy?
D1	Drug-drug interaction alerts	Does the system provide alerts for drug-drug interaction, that interrupt when medication orders are entered.
D2	Electronic alarm	Is there an alarm in place for incorrect drug dosage?

Table 38 Medication safety capabilities and assessment questions

	Intervention Program	
A	Intervention programs (such as HIV/STI testing)	Is there support for intervention programs present? Can the system itself provide an intervention program? How many of these do you have?
B	EMR based intervention program	Do the intervention programs make use of the information of an EMR? Are these systems offered access to the EMR?
C	Intervention websites	Can the system provide access to intervention websites?

Table 39 Intervention program capabilities and assessment questions

	Exchange of information (D2D)	
A	Electronic discussion Groups	Does the system provide access to platforms were health care providers can have discussions with each other or ask questions?
B	Email	Can the system use e-mail as a method for communicating with other health care providers? Is e-mail used to order lab results from laboratoria? Is e-mail used to provide medication orders to other health care providers? Can you transfer pathology results through email to other health care providers?
C	Electronic ordering and access of laboratory results	Can laboratory results be accessed or requested through the GPIS, not using e-mail?
D	ePrescribing	Can you communicate prescription orders to other health care providers through the system?
E	Inter Clinic coordination	Does the system provide automatically generated

		forms/care plans? Is clinical care managed between visits?
F	Intra-clinic communication	Can you assign clinical tasks with the system? Can you document imaging of paper notes? Does the system documentation in a structured analyzable format? Is this all used for clinical coordination with other health care providers?
G	Clinical data/image exchange	Can you use the information systems for the exchange of clinical data and imaging with other health care providers?
H	Support for chain digitization	Is there support for chain digitization and prevention?

Table 40 Exchange of information (D2D) capabilities and assessment questions

	DSS	
A	Automated telemanagement system	*Already answered in previous question.*
B	Expert System	Does the system provide some form of an expert system? Does this collate and analyze perspectives into tailored health promotion advice? Does it do this without adding to the workload of primary care practitioners? (Ilife, Kharlcha, Harari, Swift & Stuck, 2005)
C	Disease specific DSS	Do the system provide a decision support system? Is this decision support system focused on diagnostics? Is this decision support system focused on treatment? Does this system support in decision making regarding specific diseases? How many of these systems do you have?

Table 41 DSS capabilities and assessment questions

	Registries	
A	E-library	Does the system give access to an electronic library to browse online catalogues or e-journals?
B	Disease registries	Does the system provide access to disease registries? (These have functions such as printed patient reports, progress reports, registry-generated exception reports and stratified population reports.)
C	Patient management system software	Can the system with record patient details? Does this system also record clinical consultation details?
D	Web-based patient registry system	Is the system compatible with a web-based patient registry system?

Table 42 Registries capabilities and assessment questions

	Electronic medical records	
A	Computerized patient records	Does the system work with computerized patient records (EMR)?

B	Automated data collecting	Does the system automate the collection of clinical information? Can the system do this from multiple/different computer systems?
C	Electronic record linkage	Are you computerized patient records linked with other systems?
D	Web-based personal health record	Is there web-based access to the computerized patient records in the system? Can the patient access these?

Table 43 Electronic medical records capabilities and assessment questions

	Administrative	
A	Scheduling	Can the system schedule your patients electronically?
B	Electronic Billing	Can you bill your patients electronically? Can you bill your providers electronically?

Table 44 Administrative capabilities and assessment questions

	PDA	
A	Access up-to-date evidence based data	Can you store or electronically access directories of pharmacies and specialists for each managed care panel in the system through the PDA? Can you access reference texts through the PDA? Can you access practice guidelines through the PDA? Can you get evidence-based abstracts through the PDA? Can the system be used and can the data be accessed through a PDA?
B	Smartphones	Do you use smartphones in the care process? Do these smartphones have the all the same functions as described in A? Are these linked to the system?
C	ePrescribing	Can your mobile device produce or access lists of all products indicated for a particular diagnosis from the system? Does it also provide proper dosages? Does it flag drug interaction? Does it determine whether the drug is on the patients insurance formulary? Can it send the prescription to the patients pharmacy?
D	Mobile freestanding quality assurance	Do you use a mobile handheld device for freestanding quality assurance?
E	Data mining and information discovery	Can you use your mobile device for data mining?

Table 45 PDA capabilities and assessment questions

	E-learning	
A	Learning programs	Does the system provide learning programs aimed at using IT accessible through the computer?

B	Learning management system web course tools	Does it provide access to a web-based resource that can measure the medical knowledge competency? Can these be used for learning?

Table 46 E-learning capabilities and assessment questions

	ICT Support	
A	IT Training	Is there Do you have IT training on a weekly/monthly or yearly basis regarding the syustem? Do you receive trainings for the systemof the companies that provide you the IT systems. Do they provideIs there training with every (significant) update? Do Are thereyou have any Service Level Agreements regarding training? with the companies of which you have IT systems?

Table 47 ICT support capabilities and assessment questions

3.5.8. Define improvement actions

In the next step the improvement actions that can be done have to be defined, that will define how the GPIS can move to that capability. These improvement actions will be general, rather than specific. They are suggestions, the actual execution of these, have to be defined per general practice or GPIS developer.

	Exchange of information (P2D)	
A1	Recall system	Implement a functionality that can contact and recall patients for routine and other planned episodes of health care.
A2	Email	Implement or link with an emailing system with which you can communicate with the email of patients. Make sure this system that can transfer pathology results.
B	Electronic booking	Implement or expand the appointment system of the general practice information system, in such a way that you can make patients' appointments and referrals.
C	Real time video	Make the system able to work with a videoconferencing system. Communicate with your patients through this real time video.
D	Patient Portals	Provide an online portal (website) where patients can communicate with the general practice.

Table 48 Echange of information (P2D) improvement actions

	Exchange of information (P2D2D)	
A	Video conferencing	Implement videoconferencing to communicate with patients, but also other health care providers.
B	Regional HIE	Enable the system to work in co-operation with the other regional primary care providers, that gives access to information and services in the region and allows them to access yours. Make sure sure this can provide health care through integrated services in the region.
C	HIE	Enable the system from the previous step to cross regional boundaries.
D	eMIMS	Implement medical image management within the system that allows users to express multi-criteria queries.

E	Health Exchange system	Implement in co-operation with other health care providers, health kiosks that co-operates with the general practice information system which "become focal points for creating a business infrastructure of medical, ambulance, diagnostic, and referral facilities. They also provide emergency healthcare services, maternity services, pre-natal and post-natal services, epidemic response services, etc" but also has alliances with "pharmaceutical companies, insurance providers, medical service providers (e.g., hospitals and nursing homes), and educational institutions" (Saurabh, Bhowmick, Amrita & Biswas, 2012).

Table 49 Echange of information (P2D2D) improvement actions

	Patient emancipation	
A	Home-based biometric measurement devices	Provide the patient with home-based measurement devices, that enables them to upload this via telephone or internet to the system.
B	Computer delivered therapy (such as CDCBT)	Enable therapies to be delivered through the system from a computer at home.
C	Interactive websites	Provide a website for the patient, where he can access and perform some steps of treatment/diagnosis within the system.
D	Home automated Telemanagement	Implement a part in the system where the patient has access to a system that helps to implement patient self-care, clinical decision support and care coordination. It should provide enhanced patient-provider communication, disease education, control of patient adherence with their treatment plans, healthy lifestyle counseling and social support.
E	Integrated clinical management system	Provide a functionality in the system that can provide detailed, patient- and practice-specific information. It should provide data collection and linkage, data presentation, data security and confidentiality.
F	Secure personal websites	Provide the patients with a (secure) web page that can create lists of diagnoses, medications and allergies; issue reminders on appointments and preventive services such as flu shot; perform prescription refills and provide links to reputable health information websites.

Table 50 Patient emancipation improvement actions

	Telemonitoring	
A	Online monitoring system	Implement an online monitoring system, through which patients can be monitored from a distance through the general practice

		information system.

Table 51 Telemonitoring improvement actions

	Medication safety	
A	Online medication information (such as BNF)	Provide the system with access or link it to an online resource on which sound and up to date information about the use of medicines can be found.
B	Computerized physician order entry	Implement a functionality on which the general practice can enter order information for medication.
C	ePrescribing	Provide an electronic way to prescribe medicine for patients, with an electronic signature.
D1	Drug-drug interaction alerts	Enable the ePrescribing system to notify on drug-drug interactions.
D2	Electronic alarm	Enable the ePrescribing system to provide an alarm for dangerous medication interactions/dosages.

Table 52 Medication safety improvement actions

	Intervention Program	
A	Intervention programs (such as HIV/STI testing)	Implement assistance for intervention programs
B	EMR based intervention program	Enable the intervention program to make use of the information of the electronic medical records within the system?
C	Intervention websites	Provide a website that links with the system, where patients can follow an intervention program.

Table 53 Intervention program improvement actions

	Exchange of information (D2D)	
A	Electronic discussion groups	Provide access to a platform, within the system, or through a link, were health care providers can safely discuss with each other and ask questions.
B	Email	Implement or link with an emailing system with which you can communicate with the email of other health care providers. Make sure this system that can transfer pathology results.

C	Electronic ordering and access of laboratory results	Provide a system, that can communicate with laboratory systems, in order to give access to results of patients of the general practice (not e-mail). Provide a functionality with which laboratory results can be requested through the system (not using e-mail).
D	ePrescribing	Implement a functionality that is able to send prescription orders to other health care providers.
E	Inter Clinic coordination	Prodive the option to automatically generate forms/care plans and manages clinical care between visits.
F	Intra-clinic communication	Make tasks can be electronically assignable. Provide the functionality to document the paper notes in the system. This system has to be able to provide multidisciplinary documentation in structured analyzable formats.
G	Clinical data/image exchange	Enable the general practice system to exchange clinical data and imaging with other health care providers' systems.
H	Support for chain digitization	Provide support for chain digitization and prevention and make this accessible from the general practice information system.

Table 54 Exchange of information (D2D) improvement actions

	DSS	
A	Automated telemanagement	Give patients access to the system so that they can provide patient self-care, clinical decision support and care coordination. The system should provide enhanced patient-provider communication, disease education, control of patient adherence with their treatment plans, healthy lifestyle counseling and social support.
B	Expert System	Make the system collate and analyze perspectives into tailored health promotion advice without adding to the workload of primary care practitioners.
C	Disease specific DSS	Implement decision support for specific diseases.

Table 55 DSS improvement actions

	Registries	
A	E-library	Provide access to an e-library, that can access online catalogues.
B	Disease registries	Provide access or implement a disease registry that can support organized care management. It should include functions such as printed patient reports, progress reports, registry-generated exception reports and stratified population reports.
C	Patient management system software	Implement a system that assists with recording of patient and clinical consultation details and helps with the daily running of the general practice.
D	Web-based patient registry system	Provide a web-based patient registry system.

Table 56 Registries improvement actions

	Electronic medical records	
A	Computerized patient records	Implement computerized patient records within the general practice information system.
B	Automated data collecting	Make the system able to collect clinical information automatically from different other computer systems.
C	Electronic record linkage	Link with multiple systems to gain more information about the data.
D	Web-based personal health record	Provide online access to the computerized patient records.

Table 57 Electronic medical records improvement actions

	Administrative	
A	Scheduling	Make a scheduler within the system. This system should schedule the patients electronically.
B	Electronic Billing	Bill your providers/patients through the system.

Table 58 Administrative improvement actions

	PDA	
A	Access up-to-date evidence based data	Link with a mobile device that allows the general practice to instantly access up-to-date evidence based data from the system.

B	Smartphones	Convert the mobile device used, to a smartphone.
C	ePrescribing	Make your mobile device able to provide all the abilities of ePrescribing.
D	Mobile freestanding quality assurance	Use your mobile device, to provide mobile freestanding quality assurance.
E	Data mining and information discovery	Use your mobile device for data mining.

Table 59 PDA improvement actions

	E-learning	
A	Learning programs	Install computerized learning programs in the system.
B	Learning management system web course tools	Provide access to an online (web-based) source that can measure the medical knowledge company and can be used for learning.

Table 60 E-learning improvement actions

	ICT Support	
B	IT Training	Provide IT Training for the general practice information system.

Table 61 ICT support improvement actions

3.5.9. Implement maturity model

The next step as defined by Van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010) is "Implement maturity model". Implementation is regarded as applying the model to a real situation. A part of this step is to validate our model. They provide a few suggestions on how this can be performed and state that this can be done by discussion in workshops, or holding interviews. Van Steenbergen et al. validated their model through expert validation using surveys. Wendler (2012) also looks at the types of validation and found that 49% of maturity models were validated through case studies or action research, 33% of were validated through surveys, and the remaining 18% was done through interviews/discussion. Becker, Knackstedt & Pöppelbuß (2009) give an example of case studies and they themselves perform literature review, semi-structured interviews with IT managers and a group discussion, depending on the iteration of the model.

The most optimal situation for validation is the method by Becker, Knackstedt and Pöppelbuß, where they combine multiple validation methods per iteration of the model, is probably the most complete way. However due to time constraints we are restricted to choosing óne method. There was chosen for a case study during which a comparitive analysis will be performed. The model will be applied to multiple GPISs. After that, the results will be compared to create the next iteration of the maturity model.

From this the next sub-question can be answered:

- How can a maturity model be validated?

A maturity model can be validated through case studies, action research, surveys and interview/discussions.

In this research a case study will be used in order to validate the model. A case study gives valuable insight into the model and shows immediately shows whether the model is viable. This case study will be extended with a comparitive analysis in which multiple GPISs will be assessed and compared with each other. Before this case study is performed a meeting with an expert was planned to gain more insight into the subject and improve the model before it was put to the test.

Expert meeting

The expert meeting will give more in depth feedback on our model. The capabilities of the model were found through an extensive literature review and therefore we wanted the expert to shed his light on our focus areas.

The expert we interviewed was Tjeerd van Althuis. Tjeerd van Althuis is the Team leader ICT & Health at the NHG, the dutch general practitioners association.

In the meeting the goal was to validate whether the model that was created matched with reality. The expert had to judge the focus areas and check whether these described the actual situation for the information systems at a general practice. What focus areas are missing? Which areas are superfluous? Together with these focus areas expert had to look at the capabilities and possible change the order, remove them from our model or classify them into another focus are.

Results of the meeting

The expert had a significantly different view on the model than anticipated. Some terms that were used were not very familiar with the expert within the general practice (such as eCoach) and other terms were not applicable to the Netherlands. For example, registries were never used in the Netherlands.

Another different view was the one about electronic medical records. The expert regarded this focus area to be of a higher level. Some of the functionalities described by the focus areas, were part óf electronic medical records, and not a separate function within the information system. He commented that, that was how electronic medical records were looked at from his perspective (and that of his company). When the expert described what in his opinion was the focus area EMR, he started describing what was in the EMR and what it could do. Herein lies the difference of viewpoints. In this paper the EMR focus area looks more at the record keeping of the EMR within the GPIS. A decision has to be made whether electronic medical records need to be left out of the model, or rethink the name of the focus area, to avoid confusion.

The expert also saw no future in Telemonitoring. At the moment it's barely used by general practices, and the expert deemed that this was not an area that has a future in general practice or its information systems, so it would not be an indicator of maturity. This corresponds with the findings of Wade,

Karnon, Elshaug & Hiller (2010), who also saw no cost effectiveness in telemonitoring at primary care. Furthermore he also did not see Registries as a maturity indicator because these do not exist in the Netherlands. In his opinion, these two should be removed from the model.

For every focus area discussed, the expert said what capabilities he saw possible within the focus area and deemed as mature. This resulted in a small amount of new capabilities and ordering of some existing capabilities.

Focus Areas

Three focus areas were defined as obsolete / not appropriate for the model. These were Telemonitoring, Registries and EMR.There was agreed that the explanation of the expert that the first two focus areas were not an indicator of a general practices maturity with IT, so these were removed from the model.

However the EMR was a slightly different case. The explanation of the expert led to the belief that the focus area was misunderstood and could be interpreted in different ways. It was decided to change the name of this focus area, and rename it to "EMR Keeping" to point out that it deals with the keeping of EMR within the system and not EMR as a whole integral part of the system.

Capabilities

The capabalities that were added had to do with the exchange of information at doctors. The added capablities were: Teleconsultation and Referral Applications. These are important functions of the general practice, which were not found in our literature study.

Teleconsultation is the possibility to (electronically) ask treatment advice from a distance, for example from experts. Referral applications are applications that provide a bridge between general practitioners and for example the hospital, mental healthcare, independent treatment facilities and other health care institutions. This functionality could be integrated into general practice information systems.

It also led to the removal and replacement of some capabilities. *National linkage of electronic record* was included. Finally *Patient Management System Software"* was moved from "Registries" to "Administrative", because this was still an important part of the IT within general practices, however "Registries" was being removed.

The new focus areas and capabilites now looked as such:

	Exchange of information (P2D)
A1	Recall system
A2	Email
B	Electronic booking
C	Real time video
D	Patient Portals
	Exchange of information (P2D2D)

A	Video conferencing
B	Regional HIE
C	HIE
D	eMIMS
E	Health Exchange system
	Patient emancipation
A	Home-based biometric measurement devices
B	Computer delivered therapy (such as CDCBT)
C	Interactive websites
D	Home automated Telemanagement
E	Integrated clinical management system
F	Secure personal websites
	Medication safety
A	Online medication information (such as BNF)
B	Computerized physician order entry
C	ePrescribing
D1	Drug-drug interaction alerts
D2	Electronic alarm
	Intervention Program
A	Intervention programs (such as HIV/STI testing)
B	EMR based intervention program
C	Intervention websites
	Exchange of information (D2D)
A	Electronic discussion groups
B	Email
C	Teleconsultation
D	Electronic ordering and access of laboratory results
E	ePrescribing
F	Inter Clinic coordination
G	Intra-clinic communication
H	Referral application
I	Clinical data/image exchange
J	Support for chain digitization

	DSS
A	Automated telemanagement system
B	Expert System
C	Disease specific DSS
	Electronic medical records keeping
A	Computerized patient records
B	Automated data collecting
C	Electronic record linkage
D	Web-based personal health record
E	National linkage of electronic record
	Administrative
A	Scheduling
B	Electronic Billing
C	Patient management system software
	PDA
A	Access up-to-date evidence based data
B	Smartphones
C	ePrescribing
D	Mobile freestanding quality assurance
E	Data mining and information discovery
	E-learning
A	Learning programs
B	Learning management system web course tools
	ICT Support
A	IT Training

Table 62 Second iteration focus areas and capabilities

3.5.10. Case study

After these changes were applied, the final step towards validation could be taken through the case study. This validation was performed with a few major general practice information systems that are being used in Dutch general practices. It will show which capabilites are encompassed by the model, if the model is missing capabilities or whether the GPIS is missing capabilities that could be implemented.

These GPISs were made available through us by the NIVEL, as they gave us access to demo versions of five of the biggest GPISs in the Netherlands (with full functionality). They provided us with a controlled environment and access to an inhouse expert of these systems.

With this case study, a comparative analysis between these different GPISs is made, creating an overview with which general practices can make a more informed decision regarding their GPIS. It will also provide a benchmark for GPIS developers, because it shows them how their system compares to other GPISs and provides them with improvement possibilities. From the results of these case study, we make a large step towards reaching our research objective.

The table below provides extra details on these GPISs.

	Developer	Accessed through	Aimed at	Satisfaction rate*	LSP-connection**	Product Goal	GBZ	Website
MIRA	Compugroup Medical	Browser	General practices	6,7	Yes	Complete general practice information system that provides all functions necessary in the general practice.	Yes	Link
MicroHIS X	Healthcare Group of CSC	Application	Primary Care	5,9	Yes	Efficient consulting and practice management.	Yes	Link
OmniHIS Scipio	OmniHis B.V.	Application	General practices	6,7	Yes	Platform independent, user friendly software, that is continuously keeping up with changes in care and can communicate with other care providers.	Yes	Link
Promedico ASP	Promedico ICT B.V.	Browser	General Practice	6,4	Yes	A general practice information system that matches the wishes of a general practice and is ready for the future. It has to be able to be accessed from anywhere. Links with care providers, flexibility and service are a central focus.	Yes	Link
Promedico VDF	Promedico ICT B.V.	Application	General practice with apothecary	6,5	Yes	Easy to use, intuitive system that has full integration of a apothecary system, especially designed for the general practice with an apothecary that is easy to connect with other care providers.	Yes	Link

Table 63 Overview of the general practice information systems used in the case study

*The satisfaction rate among general practitioners as researched by the LHV (Dutch national general practitioner association) (Peek, 2010)

**LSP is a national system that handles the (secure) exchange of patiëntinformation between care institutes in the Netherands.

All these systems are aimed at providing functionality for the general practice, such as patient management, electronic medical record management and medicine.

Comparative analysis of the general practice information systems

In the Netherlands almost all the general practice information systems meet requirements set by the the NICTIZ (the Dutch National ICT Institute in care). A system that meets these requirements is called a "Goed beheerd zorgsysteem" or translated: a well managed care system. They have to meet these requirements if they want to be connected to the LSP ("Landelijk schakelpunt"). The LSP is national system that handles the (secure) exchange of patiëntinformation between care institutes in the Netherands. However there is no contractual obligation for a general practice to be connected to the LSP, which is why not every GPIS meets the requirements, even though most dó. In this case study however, all of the GPISs meet these requirements.

Starting the test

In order to properly test all these information systems, the systems had to be familiarized. With the help of an expert at the NIVEL, a proper understanding of each of the systems was gained. Once the sysmtes could be used properly, the testing of the systems could begin.

"Testing" the model

To test these GPISs, the questions that have been created in chapter 3.5.7 were answered. This provides the capabilities the GPIS can perform. For every question, it was checked whether the information system provided the functionality. For example the question "Does the system provide alerts for drug-drug interaction, that interrupt when medication orders are entered."

In order to test that question, a prescription was made within the system, with multiple drugs which knew interacted. The results of this action were checked. In this case, every system provided a warning, (which could however be ignored by the physician). All these questions were answered with yes or no, there is no room for ambiguity in the model.

What was missing?

Finally after the "questionnaire" was completed, the information systems were looked into further. Every part of the system was examined. The was done so it could be extracted which functionalities are present in the GPIS, but were not present in the model. If the systems supported functionalities that were not yet defined by the capabilities, these could be defined. For example almost every system had the ability to log changes within documents/patient records etc. This was not yet incorporated in our model. This is very helpful because we can make our model more complete. However, because these would be discovered dúring testing, we could not incorporate them in the model, the testing had to be done with the exact same questions in order to prevent other influences that could change the outcome.

General Practice information systems maturity

These tests were very helpful in the development and testing of our model. It was possible to validate that all the functions that were described actually are of importance within a general practice and it

showed what the model was missing. Below the results of each information system can be seen with the results entered into the model.

The following tables show the results of the case study. For every GPIS the maturity model was completed. When a capability is present, it has been given a green color, if it was not present, it was not colored in. The maturity "can be depicted by coloring the cells up until the next capability that has not been implemented yet" (van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers, 2010). This means that per focus area, the highest implemented capability defines the maturity for the focus area. If capability D (Patient Portals) for "Exchange of information (P2D)" is present it means that the focus area "Exchange of information (P2D)" has a maturity level of 7. However the total maturity is defined by the lowest denominator. If every focus area would be at maturity level 10, except for óne focus area that is at maturity level 4, the entire system would be regarded as a system with a maturity of 4.

For a reference of the capabilities view table Table 62.

MicroHIS X

	1	2	3	4	5	6	7	8	9	10	11
Direct Patient-related											
Exchange of information (P2D)	A				B	C	D				
Exchange of information (P2D2D)			A			B	C		D	E	
Patient emancipation		A	B	C	D	E	F				
Medication safety		A	B		C	D					
Intervention Program	A	B	C								
Indirect Patient-related											
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J
DSS		A	B	C							
Electronic medical records keeping	A	B	C	D	E						
Administrative	A	B	C		B	C					
PDA			A	B	C	D	E				
Not Patient-related											
E-learning		A	B								
ICT Support	A										

Table 64 Maturity model MicroHIS X

MIRA

	1	2	3	4	5	6	7	8	9	10	11
Direct Patient-related											
Exchange of information (P2D)	A				B	C	D				
Exchange of information (P2D2D)			A			B	C		D	E	
Patient emancipation		A	B	C	D	E	F				
Medication safety		A	B		C	D					
Intervention Program	A	B	C								
Indirect Patient-related											
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J
DSS		A	B	C							
Electronic medical records keeping	A	B	C	D	E						
Administrative	A	B	C								
PDA			A	B	C	D	E				
Not Patient-related											
E-learning		A	B								
ICT Support	A										

Table 65 Maturity model MIRA

Promedico ASP

	1	2	3	4	5	6	7	8	9	10	11
Direct Patient-related											
Exchange of information (P2D)	A				B	C	D				
Exchange of information (P2D2D)			A			B	C		D	E	
Patient emancipation		A	B	C	D	E	F				
Medication safety		A	B		C	D					
Intervention Program	A	B	C								
Indirect Patient-related											
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J
DSS		A	B	C							
Electronic medical records keeping	A	B	C	D	E						
Administrative	A	B	C								
PDA			A	B	C	D	E				
Not Patient-related											
E-learning		A	B								
ICT Support	A										

Table 66 Maturity model Promedico ASP

Promedico VDF

	1	2	3	4	5	6	7	8	9	10	11
Direct Patient-related											
Exchange of information (P2D)	A				B	C	D				
Exchange of information (P2D2D)			A			B	C		D	E	
Patient emancipation		A	B	C	D	E	F				
Medication safety		A	B		C	D					
Intervention Program	A	B	C								
Indirect Patient-related											
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J
DSS		A	B	C							
Electronic medical records keeping	A	B	C	D	E						
Administrative	A	B	C								
PDA			A	B	C	D	E				
Not Patient-related											
E-learning		A	B								
ICT Support	A										

Table 67 Maturity model Promedico VDF

OmniHIS

	1	2	3	4	5	6	7	8	9	10	11
Direct Patient-related											
Exchange of information (P2D)	A				B	C	D				
Exchange of information (P2D2D)			A			B	C		D	E	
Patient emancipation		A	B	C	D	E	F				
Medication safety		A	B		C	D					
Intervention Program	A	B	C								
Indirect Patient-related											
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J
DSS		A	B	C							
Electronic medical records keeping	A	B	C	D	E						
Administrative	A	B	C								
PDA			A	B	C	D	E				
Not Patient-related											
E-learning		A	B								
ICT Support	A										

Table 68 Maturity model OmniHIS

3.5.11. Comparing GPISs

Through this case study proof is found that the maturity model can be applied to general practice information systems. Our model has been succesfully applied to the GPISs. From these results can be seen that these information systems are very similar in their capabilities. When the maturity models of each information system are compared, they mostly support the same capabilities and only differ on a few. An example for this can be seen at *Exchange of Information (D2D)*. Within this focus area almost every capability is present, except for *E-mail* which is only present in MIRA and OmniHIS. This is not strange, recalling that in order to be connected to the national healthcare infrastructure (LSP) in the Netherlands, they have to comply to certain requirements. These requirements are created by Nictiz (the national IT institute for healthcare in the Netherlands). These requirements make the information systems similar in their capabilities. It can be said that the Nictiz has a high influence on the maturity of the GPISs in the Netherlands. This adds another beneficiary of our model, the Nictiz. With help of our model they can be advized on the creation or changing of guidelines.

The capabilities that are supported by the GPISs are very scattered throughout the maturity model. Exchange of information (D2D), medication safety and electronic medical records keeping have good support within any of the GPISs. They might miss a few capabilities, but the majority of these capabilities are present. Some of the focus areas however get little attention. For example none of the GPISs support PDA or E-learning capabilities. Patient emancipation also rarely available.

The scattering of capabilities makes it difficult to assess which GPIS is the most mature. Looking at the GPISs that support the most capabilities, MicroHIS X and Promedico ASP support the most capabilities (27). However when we look at the classification by van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010), all models have the same maturity. Because *PDA* and *E-learning* and *Intervention Program* capabilities are not supported, they are all classified as GPISs with a maturity level of 0. With assistance of the improvement actions of this model, these missing capabilities can be implemented, resulting in a more mature GPIS.

3.5.12. Improve matrix iteratively

This first application of the maturity model shows an interesting effect of the model. According to van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010), a capability can not be implemented unless the previous capability has been implemented. For example in three GPISs, the capability "electronic ordering and access of laboratory results (Capability D of *Echange of information (D2D)*) is implemented, while all the previous capabilities were not (such as teleconsultation).

This seems to be a pattern. More immature capabilities seem to be absent, while more mature capabilities are present. Before we can complete our comparitive analysis, this has to be adressed. Could it be the possible that the focus area maturity model does not have to adhere to this rule made by van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010)? Or have the capabilities been put in the model incorrectly? The first possibility requires further research and is a very interesting topic. For

the scope of this review however we will contemplate our model again to see whether changes can be made in order to adhere to the rules of the focus area maturity model.

In order to do this, we have to re-examine all the capabilities and analyze whether they were correctly place. Are there capabilities included that are not of importance within a general practice information system? Are their functions being replaced by other capabilities. Have capabilities been placed in the wrong order or in the wrong focus area?

This analysis was performed and the results of this analysis can be found below. It shows the capabilities that were subject to change, what was changed and an explanation for this change.

Exchange of information (P2D)

A1 Recall system
An automatic recall system, is something you would expect from an information system in a general practice. However after carefull consideration we think this capability belongs in another focus area: "Administrative".

A2 Email
The information systems we tested rarely provided an e-mail application. From our conversation with the expert however, we know that every general practice in the Netherlands should have e-mail capabilities. That this is not found in the information systems is therefore not surprising. Therefore it was considered as obsolete. However for future purposes, for example looking at other parts of primary care, it was kept in the model, but greyed out.

C Real time video
The first question we ask ourselves is whether this is a capability that would be expected in a General Practice Information System, or should this be in a separate system? Also, *Real time video* and *Patient Portals* do not seem to have an either/or relationship. Both, none or only one of them could be present. This begs the question how we want to implement this in the model. The ideal situation would be that this is a dynamic capability. If óne of both is available, you maturity reaches the letter "C", of both are available, your maturity reaches "D". This would however require a new type of maturity model, which might be interesting to look further into. For the time being however, it seems that Real time video is of a higher maturity then patient portals. This means they will be switched around.

Patient emancipation

B Computer delivered therapy (such as CDCBT)
Computer delivered therapy is not thought of as an capability that would be expected of an general practice information system. However we also believe that this might have been wrongly estimated how mature this is, so it will move up in the order.

C Interactive websites
Like al web-based capabilities, we seem to have considered them too "immature" and appear to lower on the maturity scale.

E Integrated clinical management system

F Secured personal websites
We will consider these capabilities together. After reconsidering, they were placed in the wrong focus area. These are both ways to communicate with the general practitioner, therefore it should have been placed in the focus area "Exchange of information (P2D)". Because they fit in both categories, they were first placed in "Patient emancipation".

Exchange of information (D2D)

A *Electronic discussion groups*
Electronic discussion groups may not be the responsibility of an general practice information system. This is something a general practitioner can do outside of these systems.

B *Email*
The information system does provide a way to communicate with other health care professionals, however this happens through a nationwide application, not through e-mail. E-mail is therefore not necessary. However, the same goes here for *email* in the "Exchange of information (P2D)": it is greyed out, and not removed for future purposes.

C *Teleconsultation*
There are two ways of teleconsultation: synchronous and asynchronous. Depending on which type of teleconsultation is meant, the maturity differs. Asynchronous teleconsultation is on the right spot in our maturity model, however synchronous is not yet present. This will be added on the scale. Asynchronous teleconsultation is supported by all general practice information systems.

I *Clinical data/image exchange*
Clinical data/image exchange usually appears in hospitals and not general practices. Because this is not necessary for a general practice, we can consider it to be of a higher maturity. Therefore we will switch this with Support for chain digitization.

DSS

A *Automated telemanagement system*
This already exists in the model, for redundancy reasons it is removed.

Electronic medical records

D *Web-based personal health record*
This capability, like *secure personal websites* also deals with the fact it could be placed under multiple focus areas. For one, it has to do with electronic medical records, however it also deals with patient emancipation. When we look at it from our new perspective, we might have placed it in the wrong category. Therefore it will be placed in the focus area "Patient emancipation", because it deals with patients having access to their medical record.

These adaptations resulted in a second iteration of the maturity model with the following new focus areas, capabilities and their ordering:

	Focus areas and capabilities
	Exchange of information (P2D)
A	Email
B	Electronic booking
C	Integrated clinical management system
D	Secure personal websites
E	Patient Portals

F	Real time video
	Exchange of information (P2D2D)
A	Regional HIE
B	HIE
C	Video conferencing
D	eMIMS
E	Health Exchange system
	Patient emancipation
A	Home automated Telemanagement
B	Home-based biometric measurement devices
C	Computer delivered therapy (such as CDCBT)
D	Interactive websites
E	Web-based personal health record
	Medication safety
A	Online medication information (such as BNF)
B	Computerized physician order entry
C	ePrescribing
D1	Drug-drug interaction alerts
D2	Electronic alarm
	Intervention Program
A	Intervention programs (such as HIV/STI testing)
B	EMR based intervention program
C	Intervention websites
	Exchange of information (D2D)
A	Email
B	Asynchronous teleconsultation
C	Electronic ordering and access of laboratory results
D	ePrescribing
E	Inter Clinic coordination
F	Intra-clinic communication
G	Referral application
H	Support for chain digitization
I	Clinical data/image exchange

J	Electronic discussion groups
K	Synchronous teleconsultation
	DSS
A	Expert System
B	Disease specific DSS
	Electronic medical records keeping
A	Computerized patient records
B	Automated data collecting
C	Electronic record linkage
E	National linkage of electronic record
	Administrative
A	Scheduling
B	Electronic Billing
C	Patient management system software
D	Recall system
	PDA
A	Access up-to-date evidence based data
B	Smartphones
C	ePrescribing
D	Mobile freestanding quality assurance
E	Data mining and information discovery
	E-learning
A	Learning programs
B	Learning management system web course tools
	ICT Support
B	IT Training

Table 69 Third iteration focus areas and capabilities

When entering the general practice information systems into the new version of the model, the following results appear:

MicroHIS X

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records keeping	A	B	C	D								
Administrative	A	B	C	D								
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 70 Revised maturity model MicroHIS X

MIRA

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records keeping	A	B	C	D								
Administrative	A	B	C	D								
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 71 Revised maturity model MIRA

Promedico ASP

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records keeping	A	B	C	D								
Administrative	A	B	C	D								
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 72 Revised maturity model Promedico ASP

Promedico VDF

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records keeping	A	B	C	D								
Administrative	A	B	C	D								
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 73 Revised maturity model Promedico VDF

OmniHIS

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records keeping	A	B	C	D								
Administrative	A	B	C	D								
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 74 Revised model OmniHIS

Analysis of the new model

With the improvements made to the model, it now adheres to the rules of van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010). It is now easier to see, what the general practice can do, in order to increase their maturity. For example Promedico VDF and OmniHIS could increase their exchange of information between patient and doctor maturity by providing secure personal websites. On these secure personal websites patients can communicate with the general practice; an e-mail function is available; provide lists of diagnosis, medication, allergies of the patient; reminders of appointments, repeat prescriptions etc.

Comparative analysis general practice information systems

In the table below, the differences in capabilites are shown. On left side, you can see the focus areas and their capabilities and on top the GPISs.

	MicroHIS X	MIRA	Promedico ASP	OmniHIS Scipio	Promedico VDF
Exchange of information (P2D)					
Secure personal websites	**Yes**	**Yes**	**Yes**	**No**	**No**
Patient portals	**Yes**	**Yes**	**Yes**	**No**	**No**
Patient emancipation					
Home-based biometric measurement devices	**No**	**No**	**Yes**	**No**	**No**
Exchange of information (D2D)					
Clinical data/image exchange	**No**	**No**	**No**	**Yes**	**No**

Table 75 Differences in capabilities GPISs

There are only a few differences between the GPISs, which makes it difficult to assess which system provides the most maturity to a general practice. However, because every GPIS is missing an i*ntervention program*, *e-learning* and *PDA* capability, they are all considered to be at 0 maturity according to the rules of van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010). This raises the question wether *intervention prgoram*, e-*learning* and *PDA* are functionalities that are required of a GPIS. Without these however, the maturity level of each application still do not differ much. It depends on which capabilities would be viewed as more mature. Mira, MicroHIS X and Promedico ASP all provide the capabilities *Secure personal websites* and *Patient portals*. However they do not provide *Clinical data / image exchange* which is provided by OmniHIS.

If a decision has to be made regarding the most mature information system, priorities would have to be considerd. These priorities might be different for each general practice. Are secure personal websites and patient portals more mature than clinical data and image exchange? Depending on this choice, a different GPIS is the most mature.

Keep in mind that our model does not make any judgment regarding to ease of use, ease of learning etc. For a more definitive conclusion, a more comprehensive review of these systems is required.

3.5.13. Communicate Results

Through the test of the maturity model it can be concluded that the model can be used to assess information systems in the general practice. This gives cause for future tests in an actual general practice setting. An general practice information system is a very important part of the current general practice. From our findings that most capabilities were applicable to the information system shows that the model is on the right track.

The results from the information systems test also provides a valuable insight into the importance of certain capabilities and improved our model greatly. The results of this brings us a big step towards validation.

As mentioned before, a few capabilities were found in the GPISs that were missing from our model. For example inventory management, how much of each medicine is present at the general practice (or the associated apothecary) and ordering of additional/new medicine to (re)fill supplies.

Another capability found was change logging of the electronic medical record. This shows who accessed the electronic medical record of the patient, what was changed by this person, when this occured etc.

The question is whether these should be included, or are these capabilities not necessarily applicable to indicate maturity in the general practice. Future research may have to provide a definitive answer for this.

The last part of this chapter provides the answers to the last sub-questions.

- How can a maturity model for general practice information systems be developed?

The finalized maturity model has now been defined. The model itself can be seen in the appendix B with the contents explained in appendix D. In order to apply it, general practices have to answer the questions provided in appendix E.

- How can we the maturity be used model to advise a general practice on the choice or use of a general practice information system?
- How can the maturity model be used to improve the maturity of a general practice information ystem within general practices?

As can be seen by the case study, this maturity model can advise general practices on the choice of a general practice information system and improve the use of general practice information systems within the general practice. The model advises them about their current situation and define actions that could improve their care process.

Besides the benefit our model has towards general practices, it also benefits the developers and/or software vendors of GPISs. With our model, their GPIS can be benchmarked with other GPIS applications. The model shows them what capabilities are currently missing from their software and system and provides opportunities for them to improve it.

Another organisation that was found that could benefit from our model is the Nictiz, whom create guidelines for GPISs in the Netherlands. Through their guidelines they have a large influence on the future development of GPISs. With our model they can see what the following steps in GPIS development could be and they can create new guidelines accordingly.

The actions that need to be performed to reach a higher maturity level are shown in Appendix E.

4. Conclusion & Discussion

In this chapter, the conclusions of this research will be discussed. It will provide an overview of the performed research and link the results of the research to the research questions. The research also was subject to some limitations, which will be explained and recommendations for future research will be made.

4.1. Research overview

In this study the goal was to improve the clinical IT capability of primary care because much ground was still to be made in this area. In order to achieve this, a maturity model was developed that can assist in achieving this improvement. The development of this model was focused on general practice information systems, due to the availability of literature on the subject of general practices and their IT, with the intention of creating a precedent for other parts of primary care.

The development started with a literature review looking at papers that focus on general practice information technology and the changes it made to the general practice. From this research the types of IT that were available for general practices and what software/hardware provides this type of IT were found. Alongside the goals IT in the general practice were identified. Besides these results the types of research done in these fields were charted, to identify gaps in the scientific research on these subjects.

After the literature research it was specified what kind of maturity model would be best suitable for the goal of improving the clinical IT capability of general practice information systems. It was found that the Focus Area Maturity Model would be best suited for our goals. The results of the literature research on general practice information technology were used in order to create the model. This model was then improved through inquiring extra information by an expert and through a case study and comparative analysis.

This validation resulted in a finalized maturity model. This maturity model has the ability and potential to assess the IT maturity ofa general practice information system and define improvement actions for the general practice and the software developer.

4.2. Research questions

In the beginning of this research, a research question and subquestions were formulated. Below these will be discussed.

How can an IT maturity model for Dutch general practices be developed with regard to the information systems they use and how can this help general practices to improve their IT maturity?
In this research a maturity model for IT maturity of an information system in a general practice has been developed. More specifically, a focus area maturity model. Through the answering of questions as defined in chapter 3.5.7 the maturity model can be applied. Through this an assessment can be made on how mature a general practice information system is. For every capability in the model, an improvement action has been defined through which the capability can be reached. This can be viewed in chapter 3.5.8.

With this focus area maturity model a general practice *can* assess their information system and improve their IT maturity.

To be able to reach this answer to the main research question, a few sub questions had to be answered:

What is the Information Technology that is used within primary care.
The information technology that is being used in primary care, was found through a scoping literature review. This resulted in a large number of IT applications. These IT applications can be found in chapter 2.2 and appendix A.

What research has already been done about IT within a General Practice?
With the scoping literature review, we charted what research has been done on the topic of IT and general practices. This resulted in tables Table 9 and Table 10. Table 9 provides an overview of the types of IT that were researched and the goal that the research had, for example the effect on the patient of an EMR. Table 10 looked at what type research was done on this subject and what it tried to research, for example what kind of research was done on implementation and if this was mostly done through surveys or interviews.

What functionalities does a general practice information system provide?
In chapter 1.1.5 and 3.5.3 was researched what IT functions a general practice information system could support within a general practice. We discovered that most IT functions could be performed by these general practice information systems. We specified which functions could not be supported and explained why this was the case.

How can a maturity model for general practice information systems be developed?

In chapter 3 the best approach for the development of the maturity model was defined. After following steps defined by Becker, Knackstedt & Pöppelbuß (2009), multiple maturity model types were found. After a comparison of these models in chapter 3.3, it was decided that the Focus Area Maturity Model would fit the purpose of this research the most. A new focus area maturity model had to be created from scratch, because there was no suitable maturity model already available. Van Steenbergen, Bos, Brinkkemper, van de Weerd & Bekkers (2010) defined what steps must be followed in order to create this focus area maturity model. This development can be seen in chapter 3.5.

How can a maturity model be validated?

There are many ways in which a maturity model could be validated. Wendler (2012) provided information on the validation of the maturity model. The possibilities were (expert) interviews, case studies or surveys. In this research we chose for a a case study, comparative analysis and complemented that with a expert meeting. Thanks to the NIVEL we could perform a case study on general practice information systems, for which we are thankful. The validation can be found in chapter 3.5.9, 3.5.11 and 3.5.13.

After the validation was completed, a final model was created. This is shown in Appendix B and C. It could then be applied by means of the questions created in chapter 3.5.7. After completing these questions, improvement actions could then be defined, as shown in in chapter 3.5.8.

How can the maturity model be used to advise a general practice on the choice or use of a general practice information system?

The case study performed in chapter 3.5.11 proved that the model could be applied to a general practice information system.

From the results of this application, a general practice can compare GPISs and decide which capabilities they value the most. Through this comparison they can make a more informed choice on a GPIS and they can see what the GPIS can and can't perform.

How can the maturity model be used to improve the maturity of a general practice information system within general practices?

With the questionnaire, the general practice information systems can be assessed on their maturity. After this assessment, the actions that should be taken to increase their maturity are defined. By increasing the maturity of the general practice, the general practice overall improves.

An important clarification has to be made about the model. Most of the improvement actions can not be made by the general practices themselves. These should be performed by the developers of the information system or on a larger scale (regional/national etc.). A general practitioner can not program extra functions into the software, nor can he force other care providers to use a compatible system. General practices are even limited further due to the difficulties of switching between these systems and possible regional agreements on the choice of a general practice information system. In order to reach full maturity and co-operation between these two parties is required, because without this co-operation, limites general practices in their development.

4.3. Limitations

There are however a few limitations that should be considered when viewing these research results.

Firstly, the scoping literature review in this study was limited through its search query. In order to make the scoping literature review manageable, a search query was constructed. This search query has a direct influence on the results due to the literature that was found. This has an impact on the final maturity model, which was built upon this literature review. A broader search query might have found

additional IT within a general practice and altered the final model. A more extensive literature review on this subject can build upon the current model and improve it further.

The case study of the GPISs was performed by one person. This influences the reliability of this case study. In order to reach a more trustworthy result, the case study should be performed by multiple evaluators in order to create more valuable results.

A choice was made to apply the model in a safe environment, testing the GPISs through versions that were not implemented at a general practice. This was done in order to gain confidence in the maturity model, before applying it to real life situations. This decision was made because through this testing the model becomes more valuable when applying them to operating general practices, instead of the first iteration. The downside to the choice of testing in a safe environment is that the real life situation and a testing enviroment are different, which has an impact on the development of the model.

A final limitation was the scope of this subject. It was decided to focus on general practice information systems in the Netherlands, however most literature that was found focused on the general practices outside of the Netherlands. This caused some discrepancy in information technology that was found and information technology that is available in the Netherlands.

4.4. Future research

During this study, some interesting topics that could be researched further were found. First we will discuss possible research on what was have researched in this study and then add some comments about opportunities that were found.

The next step for the development of this maturity model would be to take it into the field and test it on more GPISs besides the five tested in this study. The next step would be applying this maturity model on information systems within general practices so that a new iteration of this model can be created. This would also be a great test case to see whether what was found in this research is of actual value in the general practice. This would have to be done in two ways. First, talk with general practices and GPIS providers about the model and see whether they agree with the models capabilities/focus areas and the questions that would be asked about GPISs in order to assess their maturity and the improvement actions. This should create a new iteration of the model and the questions to be asked. Next the model could undergo a new case study at general practices, to assess their maturity and define the actions that could improve the maturity of their GPIS.

Another research that could look further into our model, should look at the generalizability of our model. Can it be applied to other forms of primary care, or are changes required? If so, what changes should there be made to the model. This would require an extensive study on the other forms of primary care because, as found in this research, there is very little literature available.

A final topic of further research regarding the model would be a study that assesses whether the model would be applicable to other countries. Can it be applied in its current form or do there need to be any changes. Or would this model not be applicable at all?

Another interesting topic that was noted in this study was the literature. It was discussed what future research could be done to improve or extend the maturity model, however in this study missing literature was charted. There was looked which IT in general practices was researched and how this research took place. With these results "gaps" in the current literature on IT and primary care were identified. Some of these gaps might not be noteworthy, however other gaps provide interesting possibilities for future research. For example, one of those gaps is the research into exchange of information between patients. This is a valuable subject to research with the popularity of the internet. It is very easy for patients with similar diseases to contact each other and speak to each other. This could potentially have an influence not only on them, but also on their coping or healing process.

In chapter 3.5.12 we considered that more mature capabilities could be implemented within an organization, while more immature capabilities in the same focus area are not. Through further examination of our model it was found that this was not the case for our model, however it is an interesting notion to consider and can be worth researching further.

Lastly, this model looked at IT functions within a general practice that could be supported by a single general practice information system. However this means we did not yet look at IT capabilities outside of these systems, which provides an opportunity for further research.

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6. Appendix

6.1. Appendix A: IT extracted from the scoping literature review.

Exchange of information (D2D)	Description
E-mail	E-mail is used to communicate between health care providers
Clinical data/imaging exchange	Information systems use for the exchange of clinical data and imaging.
Electronic discussion groups	Online groups where health care providers can hold discussions
Electronic ordering and access of laboratory tests and results	The ability of a health care provider to order and access laboratory results electronically
Electronic Primary Care Research Network (ePCRN)	The ePCRN is an ”electronic infrastructure that facilitates the conduct of randomized controlled trials (RCTs) in primary care and promotes the translation of research findings into practice. It provides a highly secure, Internet-based electronic infrastructure that will enable primary care practices anywhere in the United States to link with researchers in academic centers or the National Institutes of Health (NIH) to facilitate recruitment, entry, and follow-up of participants in multidisciplinary RCTs.” (Peterson, Fontaine & Speedie, 2005)
ePrescribing (transfer of prescription to pharmacies)	Communicating prescription orders to other health care providers.
Interorganizational ICT	Interorganizational systems are defined as “automated information systems connecting two or more parties, allowing them to share data and resources of a digital format” (Morrell, Ezingeard, 2002).
Ordering drugs	The electronic ordering of drugs by the providers of health care.
NHSnet	National health service network in Great Brittain
Interfacing with other information systems	“Gives medical office pharmacy staff access to patient height and weight information, laboratory information, and disease information.” (Helling, Nelson, Ramirez & Humphries, 2006)
Store and forward technology	“Storing and forwarding of results from various diagnostic services, such as pathology and imaging services” (Robinson, 2003).
Electronic transfer of patient data	Transfer of administrative patient data to reimbursers or other care providers (Meyer.

	Hüsing, Dobrev, Korte, Artmann & Stroetmann, 2009).
Results & Results management	Online order sets, online results for clinicians of ordered tests Tools track and follow up preventive care needs, results, and outcomes (Leu, Cheung, Webster, Curry, Bradley, Fifield, Burstin, 2007).
Intra-clinic communication	Clinical tasks assigned electronically, document imaging of paper notes (a.k.a., "Go paperless"). Multidisciplinary coordinated care; documentation in structured, analyzable format (Leu, Cheung, Webster, Curry, Bradley, Fifield, Burstin, 2007).
Inter-clinic coordination	Automatically generated forms/care plans (e.g., asthma action plan). Clinical care managed between visits (includes goal-setting and tracking) (Leu, Cheung, Webster, Curry, Bradley, Fifield, Burstin, 2007).
Healthlink	web-based network for downloading and transferring health information between providers (Didham, Martin, Wood & Harrison, 2004)
E-commerce	For example, purchasing medications (Clauser, Wagner, Bowles, Tuzzio & Greene, 2011).

Table 76 IT aimed at Exchange of information (D2D)

Exchange of information (P2D)	Description
E-mail	E-mail could be used as a non-face-to-face consultation or for repeat prescribing/repeat prescription requests. (Hanna, May & Fairhurst, 2012).
Secure Personal Web Pages	"Secure personal web pages represent a more comprehensive form of electronic communication between patients and physicians. In addition to their e-mail function, Web pages can create lists of diagnoses, medications and allergies; issue reminders on appointments and preventive services such as flu shots; perform prescription refills; and provide links to reputable health information Web sites." (Bodenheimer & Grumbach, 2003)
Computer mediated consultations	These are consultations that are face-to-face, however a computer is used during these consultations by the care provider.
Patient portals	"Online applications that allow patients to communicate with their health care providers" (Bitton, Schwartz, Stweart, Henderson, Keohane, Bates & Schiff, 2012).
Phone interactive voice response unit for refill requests	Voice recognition technology, that responds on patients voice for refill requests. (Helling, Nelson, Ramirez & Humphries, 2006)
Pathology Messaging	The electronic transfer of pathology results (Keddie & Jones, 2005)
Real time video communication	Communication between the patient and the health care provider through real-time video

	applications.
Text messaging	Text messaging could be used for interaction with the patient. Hanna, May & Fairhurst (2012) describe that it could be used to send reminders for appointments and getting results back to patient.
Text-based consultations through a Health Service Site	A patient could send a question with this website and one of the doctors would respond with an answer. This was used as a complement to physical meetings. (Umefjord, Malker, Olofsson, Hensjo & Petersson, 2004)
Sending reminders to patients that are overdue for mammography.	Electronically sending reminders to patients. For example to patients that are overdue for a mammography (Lester, Ashburner, Grant, Chueh, Barry, Atlas, 2009).
Virtual consultation	"Virtual consultations were available to providers as an order placed in the medical record just as one would order a face-to-face consult. The family medicine desk verifies that the electronic note outlining that the clinical question is available, and the request is sent to the specialty department, in which a subset of providers who are willing to respond to the request has been identified." (Angstman, Adamson, Furst, Houston & Rohrer, 2005).
Electronic Booking	"a system that allows general practitioners to make patients' appointments and referrals into acute trusts electronically" (Hendy, Fulop, Reeves, Hutchins & Collin, 2007). An example of this is Choose & Book.

Table 77 IT aimed at Exchange of information (P2D)

Exchange of information (P2P)	
Virtual support groups	These are "a way for patients to find coping strategies and share experiences" (Clauser et al., 2011).
Blogs	Blogs can be used in place of a "listserv" so that a topic can be dicussed and replied to on the same Website, they can function as journals or diaries where people dicuss their opinions on topic They can serve as locations to review medical cases with comments from any users and it can also be a site where patients discuss their health care. (Lozeau & Potter, 2009)

Table 78 IT aimed at Exchange of information (P2P)

Exchange of information (P2D2D)	**Description**
Health Exchange System	This system provides health kiosks, which "become focal points for creating a business infrastructure of medical, ambulance, diagnostic, and referral facilities. They also provide

	emergency healthcare services, maternity services, pre-natal and post-natal services, epidemic response services, etc" but also has alliances with "pharmaceutical companies, insurance providers, medical service providers (e.g., hospitals and nursing homes), and educational institutions" (Saurabh, Bhowmick, Amrita & Biswas, 2012).
HIE infrastructure	"This will support electronic transmission of health information across boundaries of organizations and electronic information systems"(Downing, Zuckerman, Coon & Puryear, 2010)
New networking service (N3)	"N3 is the National Network for the NHS. It provides a robust and reliable broadband network, supporting IT infrastructure, world-class networking services and sufficient, secure connectivity and capacity to meet current and future NHS IT needs." (NHS, 2013)
Regional Health Information System and the exchange of its information	These "enable accessibility to information and services in the region without visible organizational boundaries, and provide health care through integrated services for seamless care and personalized, individual patientcentered care and information delivery" Mäenpää, Asikainen, Gissler, Siponen, Maass, Saranto, Suominen (2011)
Video-conferencing	Used for consultations with patient, but also with other health care professionals. (Robinson, 2003).

Table 79 IT aimed at Exchange of information (P2D2D)

DSS	Description
(Realtime) DSS	Patient-linked automated decision support (Grant, Campbell, Gruen, Ferris & Blumenthal, 2006)
Automated Telemanagement System	"helps to implement patient self-care, clinical decision support and care coordination, enhanced patient-provider communication, disease education, control of patient adherence with their individualized treatment plans, healthy lifestyle counseling, and social support." (Finkelstein & Cha, 2009)
Clinical Decision support system for Anticoagulation (INRStar)	INRStar included: Maintenance of a register of patients on warfarin; Supported call and recall on the anticoagulation register; includes all necessary information to prepare an individual management plan for each patient; maintains records of the performance and outcomes and includes a comprehensive set of audit reports of any software in its market. (Jones, Sullivan & Barret, 2005).
Clinical DSS	A clinical decision support system can provide "realtime electronic notification of abnormal test results via the EHR may facilitate timely follow-up" or "drug-drug interaction alerts, which interrupt users when they are entering medication orders" (Hysong, Sawhney, Wilson, Sittig, Esquivel, Singh & Singh, 2011).

DSS for hypertension (Athena DSS)	"Automates evidence-based guidelines for management of primary hypertension." (Goldstein, Coleman, Tu, Shankar, O'connor, Musen, Martins, Lavori, Shlipak, Oddone, Advani, Gholami & Hoffman, 2004). The system would give advice and recommendations at the moment of clinical decision making
DSS + EMR Linkage	In a study performed by Holbrook, Pullenayegum, Thabane, Troyan, Foster, Keshjavee, Chan, Dolovich, Gerstein, Demers & Curnew (2011), they combined the information about a patient in an EMR, with a clinical DSS that was an individualized vascular tracking, advice and support program, hoping it would improve vascular care and outcomes.
Mentor, PRODIGY and GPnotebook)	Mentor is a diagnostic decision support tool in the UK primary healthcare market. PRODIGY was a guideline model for support of chronic disease management. (does not exist anymore) and GPNotebook is an online encyclopaedia of medicine that provides a trusted immediate reference resource for clinicians in the UK and internationally.
Expert system	Allows "the perspectives of older people on their health and health risk behaviours to be collated, analysed and converted into tailored health promotion advice without adding to the workload of primary care practitioners." (Iliffe, Kharicha, Harari, Swift, Stuck, 2005).
National Clinical DSS infrastructure	"Enables authoritative, centrally-curated knowledge on genomic medicine to be consistently leveraged in clinical practices across the nation" (Kawamoto, Lobach, Willard & Ginsburg, 2009). They claim it is required in order to guide the appropriate use and interpretation of new genomic assays. It will provide "clinicians, patients, and other healthcare stakeholders with pertinent knowledge and/or person-specific information, intelligently filtered or presented at appropriate times, to enhance health and healthcare"
Order entry with decision support for chronic disease care	"Order entry with embedded decision support for asthma, diabetes and congestive heart failure" (Simon, Rundall & Shortell, 2007).

Table 80 IT aimed at Decision Support

Registries	Description
(Chronic) Disease registries	"A chronic disease registry is an information system that is designed to support organized care management." "The main purpose of a registry is to assist physicians in taking care of their patients with chronic diseases." Functions include printed patient reports, progress reports, registry-generated exception reports and stratisfied population reports. (HRSA, 2013)
Electronic Registries (Cancer Care)	The CDC (2013) in the United States comment on cancer registries: "Data collected by local cancer registries enable public health professionals to understand and address the cancer burden more effectively."

E-library	An E-library would provide access to online catalogues or e-journals (Gibson, Jack & Rennie, 2006).
National Cancer Database	The national cancer database is in the USA " a nationwide oncology outcomes database for more than 1,500 Commission-accredited cancer programs in the United States and Puerto Rico. Some 70 percent of all newly diagnosed cases of cancer in the United States are captured at the institutional level and reported to the NCDB." (ACS, 2013)
Patient Management System Software	Assists with "recording of patient and clinical consultation details and to help with the daily running of their business" (Didham, Martin, Wood & Harrison, 2004). Examples are Healthtech Medtech 32, Houston GP, Intrahealth Profile for Mac, Intrahealth Profile for PC, 'Taylor Made Software' Medcen, Next Generation, Mana Systems GPDAT, Houston VIP, Alumni 32, Healthtech Medtech 16, Advanced Clinical Records, Other (independently developed), Intrahealth MMAS3, Medata Good Practice II, Yield Systems.
Web-based patient registry system	This was a probabilistic register: "When physicians registered to use the CDM toolkit, they found in their user space a list of their patients who had been identified as having a moderate to high probability of having diabetes, congestive heart failure (CHF) or depression." (Green, Fortin, Maclure, Macgregor & Robinson, 2006).

Table 81 IT aimed at registries

EMR	Description
Smart Card	A smart card is "a credit card-sized plastic card with an embedded computer chip that can store a patient's demographic and medical data" (Bodenheimer & Grumbach, 2003)
Automated data collecting (GENIE)	"The GENIE automated the collection of clinical information from different computer systems by exploiting the fact that most can export data as text." and it was used "to transmit data from the General Practice Administration System for Scotland (GPASS)." (Cunningham, McAlpine, Leese, Brennan, Sullivan, Connacher, Waller, Boyle, Greene, Wilson, Emslie-Smith & Morris, 2011)
Computerized patient records system (CPRS)	CPRS "enables clinicians to review and analyze patient clinical data, order laboratory tests and medications, document care, review radiology and other data and support clinical decision-making." (Doebbeling, Vaughn, McCoy & Glassman, 2006)
E-health card system/ Patient Smart card	"The objective of the nationwide implementation of the e-health card system is to facilitate and standardize the communication between the institutions of the German healthcare system " (Ernstmann, Ommen, Neumann, Hammer, Voltz & Pfaff, 2008). Ernstman et. Al. provide some properties of the E-Health card, these include: storage of administrative data, electronic prescriptions, storage of medication records, emergency

	data, additional health information, electronic discharge letters and personal data supplied by the patients. Bodenheimer & Grumbach (2003) also describe a similar technique called the patient smartcard which is a "credit cardsized plastic card with an embedded computer chip that can store a patient's demographic and medical data. Protected by a personal identification number, smart cards can be swiped through a card reader to access the information".
Electronic Record Linkage	This describes the linking of multiple system, to gain more information about the data. For example Cunningham et al. (2011) describe a linkage of multiple data sources that could identify all patients with diabetes mellitus in Tayside (a region of Scotland).
Electronic storage of individual patient data	The electronic storage either for administrative or for medical purposes. (Meyer, Husing, Dobrev, Korte, Artmann & Stroetmann, 2009).
Personal Health Records	Personal health records "allow patients to consult and manage their own health information, and sometimes even to communicate electronically with their health care providers" (Bélanger, Bartlett, Dawes, Rodríguez & Hasson-Gidoni, 2012).
Web-based personal health record (HealthVault, Dossia, Google Health)	Online access to the personal health records as described above (Clauser, Wagner, Bowles, Tuzzio & Greene, 2011).

Table 82 IT aimed at electronic medical records

Patient emancipation	Description
Home-based biometric measurement devices	"Home-based measurement devices used to monitor and collect daily readings and symptom information (e.g. blood glucose and blood pressure readings). Once collected, this information is uploaded via telephone or Internet to care-givers who can then access patient data through a standard browser or desktop computer." (Nobel, 2006)
Computer Delivered Cognitive Behavioural Therapy	Cognitive Behavioural Therapy delivered to the patient in a computerized form. (McCrone, Knapp, Proudfoot, Ryden, Cavanagh, Shapire, Ilson, Gray, Goldberg, Mann, Marks, Everitt & Tylee, 2004)
Home automated telemanagement	"The HAT system was designed to facilitate the Chronic Care Model by supporting an informed, activated patient interactign with a prepared, proactive practice team." It also "Helps to implement patient self-care, clinical decision support and care coordination, enhanced patient-provider communication, disease education, control of patient adherence with their individuzalized treatment plans, healthy lifestyle counseling and social support." (Finkelstein & Cha, 2009)
Information technology–supported adherence and blood pressure monitoring system	A blood pressure monitor for patients that provides nurses, pharmacists, and physicians with monthly reports. (Rinfret, Lussier, Peirce, Duhamel, Cossette, Lalonde, Tremblay,

	Guertin, LeLorier, Turgeon & Hamet, 2009)
SCI-DC (Integrated clinical management system)	"The system provides detailed, patient- and practice-specific information and is only available over a secure NHS connection to authenticated users. The key components of the system are data collection and linkage, data presentation, and data security and confidentiality." (Cunningham et. al., 2011)
Interactive websites	An interactive website (for patient emancipation), is a website to which patients have access and can perform some steps of treatment/diagnoses etc. For example Bodenheimer and Grumbach (2003) describe a system for diabetes patients, on which they can enter home glucose levels and a website concerned with depression can complete one of the formal depression screening tools.
Multilingual automated telephone self-management support program	Automated telephone self-management support (ATSM) "employs phone technology to provide surveillance and education and to prioritize further care management efforts for those most in need". It can also provide "individualized assessment, skills enhancement, live follow-up and support from health educators or coaches, access to community resources, and continuity of clinical care" (Ratanawongs, Handley, Quan, Sarkar, Pfeifer, Soria & Schillinger, 2012).
Secure personal websites	This is "a more comprehensive form of electronic communication between patients and physicians. In addition to their e-mail function, Web pages can create lists of diagnoses, medications and allergies; issue reminders on appointments and preventive services such as flu shots; perform prescription refills; and provide links to reputable health information Web sites" (Bodenheimer & Grumbach, 2003)
E-health services	Could "provide support for patients with conditions such as diabetes or chronic heart disease"(Flynn, Gregory, Makki & Gabbay, 2009)
Patient education and outreach	This is described by Leu, Cheung, Webster, Curry, Bradley, Fifield & Burstin (2008) as telephone calls or mailings for medication recalls, appointment reminders, or to discuss abnormal lab results
Interactive Websites	"Create a community information platform to share and disseminate information between providers and patients and to deliver disease-specific educational material to target populations". (Nobel, 2006)

Table 83 IT aimed at patient emancipation

E-learning	Description
Learning management system web course tools	"A web-based resource that can measure the medical knowledge competency required by the Accreditation Council for Graduate Medical Education (ACGME)." (Johnson, Hurtubise,

	Castrop, French, Groner, Ladinsky, McLaughlin, Plachta & Mahan, 2004)
Learning Programs	Learning programs for health care providers that are accessed through the computer. Gibson, Jack & Rennie (2006) for example, tested these on dentists.

Table 84 IT aimed at e-learning

eCoach	Description
Computerized Cognitive Behavioural Therapy ("Breaking the Blues")	Cognitive Behavioural Therapy delivered to the patient in a computerized form. (McCrone, Knapp, Proudfoot, Ryden, Cavanagh, Shapire, Ilson, Gray, Goldberg, Mann, Marks, Everitt & Tylee, 2004)
Intervention website	A website in which patients can follow an intervention program. Wallace, Murray, McCambridge, Khadjesari, White, Thompson, Kalaitzaki, Godfrey & Linke (2011) developed an intervention website for an intervention program about alcohol abuse, which was based on brief intervention and psychological treatment principles.
Comparator Website	A website where patients can compare their symptoms/disease with actual symptoms/diseases. Wallace et al. (2011) used a comparator website with a "graphical design and style to present simple, text-based information about the harms caused by excess alcohol consumption."

Table 85 IT aimed at eCoaching

Telemonitoring	
Online monitoring system	An online monitoring system (for telemonitoring) is a system through which patients can be monitored from a distance. For example the asthma monitoring system described by Langstrup (2008): The system provided impartial information and debate options for its user in addition to the data that was entered by the patient. This diary we accessible through a web portal. It would also provide an advice about the regulation of the drug treatment. The professional also had access to a decision support tool providing a control status, which was a calculation of asthma severity on basis of the accumulated data in daily status and would suggest an appropriate level of pharmaceutical treatment.

Table 86IT aimed at telemonitoring

Medication Safety	**Description**
British National Formulary (BNF)	The BNF is an online website which "aims to provide prescribers, pharmacists and other healthcare professionals with sound up-to-date information about the use of medicines." (British National Formulary, 2013)

Computerized physician order entry	Helps the physician with “the management of prescriptions or diagnostic tests” (Bélanger, Bartlett, Dawes, Rodríguez & Hasson-Gidoni, 2012).
Computerized prescribing of medication	"Computer-based generation of the prescription form, electronic fill-in by the physician, printing, validation by manual signature of the physician" (Urban, Ose, Joos, Szecsenyi, Miksch, 2012)
Electronic prescribing	“Fully electronic way of prescribing with electronic signature of the prescription and electronic transfer to the pharmacy” (Urban, Ose, Joos, Szecseny & Miksch, 2012)
Drug-drug interaction (DDI) alerts	These alerts interrupt users, as they are entering medication orders. (Hysong, Sawhney, Wilson, Sittig, Esquivel, Singh & Singh, 2011).
Drug–Renal Monitoring program	This is created with a specific function. If a patient with decreased renal function is being prescribed an inappropriate medical dose, this system alerts the pharmacist (Helling, Nelson, Ramirez & Humphries, 2006).
Electronic alarm/Prescribing alerts	An alarm for drug dosage and drug interaction (Urban, Ose, Joos, Szecseny & Miksch, 2012).
eMIMS	"EMIMS is designed to merge several facets of medical image management requirements with a generic repository model to offer new content-based operaters that allow users to express multi-criteria queries." (Coquil, Atnafu & Brunie, 2003)

Table 87 IT aimed at medication safety

IT in General	Description
Billing	Electronic billing of patients/providers
Care management for specific diseases	Chronic care management
Computer/laptop	Usage of a computer/laptop by the care provider
DVD/CD drive	Possession of a DVD/CD drive by the care provider
Electronic Alerts (View Alert)	“Notify providers about abnormal test results directly on their desktops” (Hysong, Sawhney, Wilson, Sittig, Espadas, Davis, Singh, 2010)
Choose And Book (Electronic booking)	“A system that allows general practitioners to make patients’ appointments and referrals into acute trusts electronically.” (Hendy, Fulop, Reeves, Hutchings & Collin, 2007)
File management	The electronic managing of files
ICT Support	Support for the use of ICT within practices. (Ridgway, Mitchell, Sheean, 2011)
Keyboard	Usage of a keyboard by the care provider
Library	Electronic access to a library

Mouse	Usage of a mouse by the care provider
Notes	Usage of notation program by the care provider
Pharmacy Information Technology (PIT) Service	"Consists of 2 pharmacy managers, 2 pharmacy supervisors, 6 pharmacy system pharmacists, and 10 pharmacy system analysts, supports technological innovation" (Helling et al., 2006)
Recall system	The department of health in Australia describes a recall system as a system to recall patients for routine and other planned episodes of health care (http://remotehealthatlas.nt.gov.au/client_recall_systems.pdf)
Templates /NSF	"Templates for chronic disease management" (Keddie & Jones, 2005)
Scanning of Letters	"Referral and other correspondence was scanned into the computer system" (Keddie & Jones, 2005)
Printer/fax	Possession of a printer/fax by the care provider
Reminders	There are a multitude of reminders technology could provide health care providers. For example it could generate reminders for preventive services (Elder, Wiltshire, Rooks, BeLue & Gary, 2010)
Scheduling	The scheduling of patients (Condon & Smith, 2002).
Spreadsheets	Usage of spreadsheets by the care provider
Voice/Handwriting recognition	Voice recognition "Allows physicians to dictate into the EMR system without typing or paying a transcriptionist" (Bodenheimer & Grunbach, 2003). Handwriting would make it easier to enter information into the computer.
Word processing	Usage of a word processing program by the care provider
Scanner	Possession of a scanner by the care provider
Web-based clinical information system	"Incorporates shared electronic health records across sectoral and professional boundaries within the NHS intranet (with appropriate security), as well as evidence-based medicine sources (e.g. electronic guidelines), patient leaflets and contact information for patients and professionals." (Evans, Guthrie, Pagliari,. Green, Morris, Cunningham & Donnan, 2008).
Web-based Generic Disease Management System (GDMS)	The GDMS is a Web-based application that uses General Electric Web Services and a MSQweb.net platform to retrieve patient vital statistics such as blood pressure, weight, body mass index, age, demographic information, prior diagnoses, allergies, prior radiology diagnostic tests and previous preventive services (e.g. immunizations, cancer and metabolic screenings, laboratory test results pertaining to diabetes, coronary artery disease, asthma and depression) from different clinical information systems. The GDMS

	includes a rules-based application coded with guidelines for age-specific, sex-specific preventive services and for process and outcome measures for diabetes and coronary artery disease. On the basis of the data from Web services, the rules provide point-of-care decision support regarding the services that the patient needs at their visit and in the next 90 days. (Chaudhry, Tulledge-Scheitel, Parks, Angstman, Decker & Stroebel, 2011).
Web-based services (appointment booking, repeat prescriptions)	Online appointment book and prescribing of repeat prescriptions for patients.
governance framework for IT security	"A guide to a general practice and a resource enabling a general practice to review its information security practices. It will also define its legal obligations no matter what their current level of compliance is and if necessary, provide guidance to move to a higher level of compliance" (McDermid, Mahncke & Williams, 2010).
Healthconnect (change management strategy)	"HealthConnect implementations leveraged existing eHealth projects and infrastructure, and progressed towards compliance with National E-Health Transition Authority and other nationally agreed standards to improve the availability of information in the health sector. " (Australian Government, 2013)
Service-Oriented Architecture (SOA)	“The use of service-oriented architecture (SOA) or Web services is an important strategy for sending patient data to a Web service that reviews the data and returns assessments and advice.” And can also be used “as a strategy to extract specific data elements from a practice information system through queries that select patients and return only the information needed for quality measurement or improvement, thus protecting patient privacy by excluding data not needed for the current analysis.” (Zuckerman, 2009)
Tools that provide interoperability among information systems	These address the task of aggregating and assembling data for quality care decisions (Zuckerman, 2009)

Table 88 General IT

Internet	Description
Internet	Whether or not practices have access to the internet (Gibson, Jack & Rennie, 2006)
Internet access to professional journals/ Literature searching	The use of internet for access to professional journals (Grant, Campbell, Gruen, Ferris & Blumenthal, 2006)
E-mail	E-mail is a communication tool. It was used to communicate with fellow health care professionals, used for some committee work and for contact with patients. (Robinson, 2003).
RCN	Website of “The royal college of nursing”, which represents nurses and nursing, promotes excellence in practice and shapes health policies. (RCN, 2013)

Website with health care information about diabetes	This was called the "Tayside Regional Diabetes Network Website". It contained "information contributed by patients, health professionals, and researchers and includes details of network team members, regional diabetes clinics, retinopathy screening, children's diabetes services, latest news in collaboration with local Diabetes U.K. branches, regional research projects, and links to other relevant Web sites." (Cunningham et al., 2011).
Wikis	"In medicine, wikis offer a way for people in many different locations to collaborate on a topic. Wikis can serve as sites to find medical information, ways to collaborate on a specific topic, and places for patients to focus on a specific topic." (Lozeau & Potter, 2009)
Podcasts	"Podcasts allow information to be shared with anyone at any time." (Lozeau & Potter, 2009) They "have become very popular teaching tools in medical schools and resident training."
RSS	RSS is a method for ""pushing" new Web content to users or allowing for continuous instant "alerting" of users to new Web content " and "with the use of RSS technology, physicians can subscribe to table of contents for electronic journals, news headlines, blog postings, and podcasts. "(Lozeau & Potter, 2009)
Specialized websites	Use of sites such as the Cochrane Database, which is the "leading resource for systematic reviews in health care" according to their website (The Cochrane Library, 2013); British Medical Journal, which "advances healthcare worldwide by sharing knowledge and expertise to improve experiences, outcomes and value." according to their website. (BMJ, 2013) ; and more websites such as: Royal Australian College of General Practicioners, Medscape, Canadian Journal of Family Practice. (Robinson, 2003)
Information for clients	Using the internet to find information for clients (Ridgway, Mitchell & Sheean, 2011).

Table 89 IT dealing with internet

PDA	Description
E-prescribing	"a PDA with software that produces lists of all products indicated for a particular diagnosis, provides proper dosages, flags drug interaction, determines whether the prescribed drug is on the patient's insurance formulary, and sends the prescription to the patient's pharmacy" (Bodenheimer & Grumbach, 2003).
Mobile freestanding quality assurance	The use of mobile handheld devices for freestanding quality assurance (Zuckerman, 2009).
Use of a PDA	"To instantly access up-to-date evidence based data" (Bodenheimer & Grumbach, 2003).
Smartphones	The use of smartphones by the health care providers. "For clinicians, the smartphone

	offers an alternative to many health IT formats that have been cumbersome and costly to adopt, and that may interrupt their workflow." (Sarashon-Kahn, 2010)
Data mining and information discovery	Tools such as a mobile internet browser "are merging the two technologies of handheld applications and Web access in a single device." (Zuckerman, 2009)

Table 90 IT aimed at PDAs

Education	Description
Continuing medical education	Online access to continuing medical education. (Grant et al. 2006)
Educational Programs	Usages of information technology during education: Word processing, Internet searches, Problem-based learning, audit with use of a spreadsheet for statistical and charting function, literature research, presentations, communications between students and medical school staff, support of problem-based learning and evidence-based medicine, access internet for teaching activities and usefull medical sites, provide self-assessment and selfstudy and the distribution of lecture notes, handouts and timetables. (Hagdrup, Edwards, Carter, Falshaw, Gray & Sheldon, 1999)
IT Training ()	Basic IT training for the medical staff, ranging for basic tasks such as turning on the computer to the specific systems being used such as EMIS and Meditel. This training could be received through: Colleagues, in-house trainer, external trainer or a user manual and on-screen help. (Alpay & Russel, 2002).
Virtual Breakthrough Series (education for primary care)	An exclusively Internet- and phone-based system of adult learning dedicated to improving access in primary care. (Boushon, Provost, Gagnon & Carver, 2006).
Provider education and feedback through online material	Provider education is possible in several ways: "Some practices make their clinic- and region-specific guidelines and protocols available online, whereas others make web-based informational resources available at the point-of-care (UpToDate™ was mentioned most frequently). Physicians may also use other informational resources such as journals, audio tapes, podcasts, or handheld reference materials. Finally, health IT can be used to verify that specific resources have been accessed, to assess proficiency, and to support continuing medical education efforts." Feedback to "support preventive care and chronic disease management. Every office visit presents an opportunity to reinforce clinical guidelines to the health care team, by providing patient-specific recommendations at the point of care. However, participants suggested that point-of-care reminders in the form of pop-ups or alerts have well-documented problems, including provider alert fatigue." (Leu et al., 2008).

Table 91 IT aimed at education

Intervention program	Description
Critical Drug Interactions program	"A team of outpatient and clinical pharmacy staff identified critical drug interactions and flagged them in the pharmacy computer system. They also developed an intervention guide to aid pharmacists in dealing with such problems. When the system encounters a critical drug interaction, the dispensing process is completely shut down. Instead of a prescription label being generated, a label signaling the critical interaction is printed so the medication cannot be inadvertently dispensed."
Data driven quality improvement in primary care (DQIP) intervention	"an example of a potentially sustainable safety improvement intervention that builds on the existing National Health Service IT-infrastructure to facilitate systematic management of high-risk prescribing by existing practice staff." (Dreischulte, Grant, Donnan, McCowan, Davey, Petrie, Treweek & Guthrie, 2012)
EMR Based intervention program	"Several key components of the intervention were implemented in the CHC's EHR system, including alerts of high blood pressure readings, and templates, order sets, and clinical reminder algorithms for hypertension management." (Millery, Shelley, Wu, Ferrari, Tseng & Kopal, 2011)
Intervention system for HIV/STI testing	"Program adaptable to multiple clinic systems which aims to increase clinic efficiency and enhance sexual health testing." (Drummond, Lewis, Bourna, Ramanathan, Hocking, Wand, Donovan, Kaldor & Guy, 2011)
Intervention website	A website in which patients can follow an intervention program. Wallace, Murray, McCambridge, Khadjesari, White, Thompson, Kalaitzaki, Godfrey & Linke (2011) developed an intervention website for an intervention program about alcohol abuse, which was based on brief intervention and psychological treatment principles.

Table 92 IT aimed at intervention programs

Unknown	Description
Clinical care process prompts	Automatic prompts to improve the clinical care process (Delaney, 2010).
Electronic documentation	"Electronic documentation of results and diseases" (Urban, Ose, Joos, Szecsenyi & Miksch, 2012).
family practice-based research networks	The networks "collect and analyze primary care data for research and development" (van Weel, de Grauw, 2006).
IT can facilitate Care planning	"Populating and sharing the content of care plans efficiently." (Homer & Baron, 2010)

IT can facilitate Communication	"Effective health IT can facilitate primary care/specialty communication, patient-doctor communication, and in-office team communication."
IT can monitor change	“Monitoring and tracking change and improvement.” (Homer & Baron, 2010)
IT can facilitate Registry functionality and population management	"Identifying and managing the population of patients within a practice as a population" (Homer & Baron, 2010)
Learning Health Care Systems	A health care system that collects data from routine care for research and facilitates the use of evidence to improve care has been defined as a learning health care system. (Delaney, Peterson, Speedie, Taweel, Arvanitis & Hobbs, 2012)
Knowledge Base	Access to knowledge bases such as MEDLINE (Bodenheimer & Grumbach, 2003)
Chronic disease management	“IT specialists collated billing and clinical data, which was formatted into useful chronic disease performance reports and fed back to the practice each day.” (Bitton et al., 2012)
Web-based Chronic-disease management (CDM Toolkit)	“First of all, the doctors on the system now know who their patients are and how well the disease is being managed. Active recall reports help to ensure planned and preventive care according to practice guidelines. Measurement data is both individualized per patient as well as aggregated for the practice population and for the CDM collaborative as a whole. Aggregated data in run charts provide the information necessary for tracking progress and setting the stretch goals.” (Green, Fortin, Maclure, Macgregor & Robinson, 2006)

Table 93 IT that can't be placed under other categorie

6.2. Appendix B: Maturity Model

	1	2	3	4	5	6	7	8	9	10	11	12
Direct Patient-related												
Exchange of information (P2D)	A				B	C	D	E	F			
Exchange of information (P2D2D)						A	B	C	D	E		
Patient emancipation		A	B	C	D	E						
Medication safety		A	B			C	D					
Intervention Program	A	B	C									
Indirect Patient-related												
Exchange of information (D2D)		A	B	C	D	E	F	G	H	I	J	K
DSS		A	B									
Electronic medical records	A	B	C	D								
Administrative	A	B	C									
PDA			A	B	C	D	E					
Not Patient-related												
E-learning		A	B									
ICT Support	A											

Table 94 Final focus area maturity model to assess IT maturity in general practices

6.3. Appendix C: Focus areas and Capabilities

	Focus areas and capabilities
	Exchange of information (P2D)
A	Email
B	Electronic booking
C	Integrated clinical management system
D	Secure personal websites
E	Patient Portals
F	Real time video
	Exchange of information (P2D2D)
A	Regional HIE
B	HIE
C	Video conferencing
D	eMIMS
E	Health Exchange system
	Patient emancipation
A	Home automated Telemanagement
B	Home-based biometric measurement devices
C	Computer delivered therapy (such as CDCBT)
D	Interactive websites
E	Web-based personal health record
	Medication safety
A	Online medication information (such as BNF)
B	Computerized physician order entry
C	ePrescribing
D1	Drug-drug interaction alerts
D2	Electronic alarm
	Intervention Program
A	Intervention programs (such as HIV/STI testing)
B	EMR based intervention program
C	Intervention websites
	Exchange of information (D2D)

A	Email
B	Asynchronous teleconsultation
C	Electronic ordering and access of laboratory results
D	ePrescribing
E	Inter Clinic coordination
F	Intra-clinic communication
G	Referral application
H	Support for chain digitization
I	Clinical data/image exchange
J	Electronic discussion groups
K	Synchronous teleconsultation
	DSS
A	Expert System
B	Disease specific DSS
	Electronic medical records keeping
A	Computerized patient records
B	Automated data collecting
C	Electronic record linkage
D	National linkage of electronic record
	Administrative
A	Scheduling
B	Electronic Billing
C	Patient management system software
D	Recall system
	PDA
A	Access up-to-date evidence based data
B	Smartphones
C	ePrescribing
D	Mobile freestanding quality assurance
E	Data mining and information discovery
	E-learning
A	Learning programs
B	Learning management system web course tools

	ICT Support
B	IT Training

Table 95 Final focus areas and capabilities

6.4. Appendix D: Assessment questions

	Exchange of information (P2D)	
A	Email	Can the system use e-mail as a consultation method? Is e-mail used to remind patients about refills, repeat prescribing or repeat prescription requests? Is e-mail used to provide lab results to patients? Can you transfer pathology results through email to the patients?
B	Electronic booking	Can the system allows you to make patient's appointments electronically? Does it allow you to make referrals?
C	Integrated clinical management system	Can the patient access the system for detailed, patient- and practice-specific information? Is this information available over a secure connection to authenticated users? Can the system collect and link data? Does it provide data presentation, data security and confidentiality?
D	Secure personal websites	Does the system provide a webpage where patients can communicate with physicians? Does this provide an e-mail function? Can these webpages: - create lists of diagnoses, medication and allergies? - issue reminders on appointments and preventive services? - perform prescription refills? - provide links to reputable health information web sites?
E	Patient Portals	Does the system provide online applications that allow patients to communicate with their health care providers?
F	Real time video	Can you communicate with the patient through real time video?
	Exchange of information (P2D2D)	
A	Regional HIE	Can you access information and services in the region through the system? Does it enable you to provide health care through integrated services in the region? Do you have deals or contracts with other health providers in your regional area to share information? Is your the system compatible for this sharing?
B	HIE	Can you electronically transmit health information across boundaries of organizations and electronic information systems? Can you access information and services from any health provider? Can you provide health care through integrated services in other areas?

		Do you have deals or contracts with other health providers in outside of your region to share information? Is the system compatible for this sharing?
C	Video conferencing	Can the system be used to video consult with patients, but also other health care professionals?
D	eMIMS	Can the system manage medical images? Does it allow users to express multi-criteria queries?
E	Health Exchange system	Can the system provide patients with a system that are a central point for medical/ambulance/diagnostic and referral facilities? If this is the case, does it also provide emergency health care services? Does the system have alliances with pharmaceutical companies, insurance providers, medical service providers and educational institutions?
	Patient emancipation	
A	Home automated Telemanagement	Does the system give a patient access to a program that helps to implement patient self-care, clinical decision support and care coordination? Does this system provide enhanced patient-provider communication, disease education, control of patient adherence with their treatment plans, healthy lifestyle counseling and social support?
B	Home-based biometric measurement devices	Is the system compatible with home-based measurement devices? (For example to monitor and collect daily readings and symptom information?) Can the patient upload this data via telephone or the internet to care-the system, from which health care professionals can then access the patient data?
C	Computer delivered therapy (such as CDCBT)	Can the patient receive therapy through the system?
D	Interactive websites	Does the patient have access to a website, where they can access and perform some steps of treatment/diagnoses?
E	Web-based personal health record	Is there web-based access to the computerized patient records in the system? Can the patient access these?

	Medication safety	
A	Online medication information (such as BNF)	Does the system provide a place where sound up-to-date information about the use of medicines is available?
B	Computerized physician order entry	Can you enter medication orders through the system. Can it communicate with the apothecary regarding orders?
C	ePrescribing	Is the way of prescribing medicine fully electronic? Does this require an electronic signature of the prescription. Is this electronically transferred to the pharmacy?
D1	Drug-drug interaction alerts	Does the system provide alerts for drug-drug interaction, that interrupt when medication orders are entered.
D2	Electronic alarm	Is there an alarm in place for incorrect drug dosage?
	Intervention Program	
A	Intervention programs (such as HIV/STI testing)	Is there support for intervention programs present? Can the system itself provide an intervention program? How many of these do you have?
B	EMR based intervention program	Do the intervention programs make use of the information of an EMR? Are these systems offered access to the EMR?
C	Intervention websites	Can the system provide access to intervention websites?
	Exchange of information (D2D)	
A	Email	Can the system use e-mail as a method for communicating with other health care providers? Is e-mail used to order lab results from laboratoria? Is e-mail used to provide medication orders to other health care providers? Can you transfer pathology results through email to other health care providers?
B	Asynchronous Teleconsultation	Is it possible to ask treatment advice with a specialist on distance, not in real time?
C	Electronic ordering and access of laboratory results	Can laboratory results be accessed or requested through the GPIS, not using e-mail?
D	ePrescribing	Can you communicate prescription orders to other health care providers through the system?
E	Inter Clinic coordination	Does the system provide automatically generated forms/care plans? Is clinical care managed between visits?
F	Intra-clinic communication	Can you assign clinical tasks with the system? Can you document imaging of paper notes? Does the system documentation in a structured analyzable format?

		Is this all used for clinical coordination with other health care providers?
G	Referral application	Is there a bridge between general practice and hospitals, mental healthcare, independent treatment facilities and other health care providers.
H	Support for chain digitization	Is there support for chain digitization and prevention?
I	Clinical data/image exchange	Can you use the information systems for the exchange of clinical data and imaging with other health care providers?
J	Electronic discussion Groups	Does the system provide access to platforms were health care providers can have discussions with each other or ask questions?
K	Synchronous teleconsultation	Is it possible to ask treatment advice with a specialist on distance, in real time?
	DSS	
B	Expert System	Does the system provide some form of an expert system? Does this collate and analyze perspectives into tailored health promotion advice? Does it do this without adding to the workload of primary care practitioners? (Ilife, Kharlcha, Harari, Swift & Stuck, 2005)
C	Disease specific DSS	Do the system provide a decision support system? Is this decision support system focused on diagnostics? Is this decision support system focused on treatment? Does this system support in decision making regarding specific diseases? How many of these systems do you have?
	Electronic medical records keeping	
A	Computerized patient records	Does the system work with computerized patient records (EMR)?
B	Automated data collecting	Does the system automate the collection of clinical information? Can the system do this from multiple/different computer systems?
C	Electronic record linkage	Are you computerized patient records linked with other systems?
D	National linkage of electronic record	Is your electronic medical record connect to the national electronic medical record?
	Administrative	
A	Scheduling	Can the system schedule your patients electronically?
B	Electronic Billing	Can you bill your patients electronically? Can you bill your providers electronically?
C	Patient management system	Can the system with record patient details?

	software	Does this system also record clinical consultation details?
D	Recall system	Are your patients recalled by a system for routine and other planned episodes of care?
	PDA	
A	Access up-to-date evidence based data	Can you store or electronically access directories of pharmacies and specialists for each managed care panel in the system through the PDA? Can you access reference texts through the PDA? Can you access practice guidelines through the PDA? Can you get evidence-based abstracts through the PDA? Can the system be used and can the data be accessed through a PDA?
B	Smartphones	Do you use smartphones in the care process? Do these smartphones have the all the same functions as described in A? Are these linked to the system?
C	ePrescribing	Can your mobile device produce or access lists of all products indicated for a particular diagnosis from the system? Does it also provide proper dosages? Does it flag drug interaction? Does it determine whether the drug is on the patients insurance formulary? Can it send the prescription to the patients pharmacy?
D	Mobile freestanding quality assurance	Do you use a mobile handheld device for freestanding quality assurance?
E	Data mining and information discovery	Can you use your mobile device for data mining?
	E-learning	
A	Learning programs	Does the system provide learning programs aimed at using IT accessible through the computer?
B	Learning management system web course tools	Does it provide access to a web-based resource that can measure the medical knowledge competency? Can these be used for learning?
	ICT Support	
A	IT Training	Is there Do you have IT training on a weekly/monthly or yearly basis regarding the syustem? Do you receive trainings for the systemof the companies that provide you the IT systems. Do they provideIs there training with every (significant) update? Do Are thereyou have any Service Level Agreements

		regarding training? with the companies of which you have IT systems?

Table 96 Final assessment questions

6.5. Appendix E: Improvement actions

	Exchange of information (P2D)	
A	Email	Implement or link with an emailing system with which you can communicate with the email of patients. Make sure this system that can transfer pathology results.
B	Electronic booking	Implement or expand the appointment system of the general practice information system, in such a way that you can make patients' appointments and referrals.
C	Integrated clinical management system	Provide a functionality in the system that can provide detailed, patient- and practice-specific information. It should provide data collection and linkage, data presentation, data security and confidentiality.
D	Secure personal websites	Provide the patients with a (secure) web page that can create lists of diagnoses, medications and allergies; issue reminders on appointments and preventive services such as flu shot; perform prescription refills and provide links to reputable health information websites.
E	Patient Portals	Provide an online portal (website) where patients can communicate with the general practice.
F	Real time video	Make the system able to work with a videoconferencing system. Communicate with your patients through this real time video.
	Exchange of information (P2D2D)	
A	Regional HIE	Enable the system to work in co-operation with the other regional primary care providers, that gives access to information and services in the region and allows them to access yours. Make sure sure this can provide health care through integrated services in the region.
B	HIE	Enable the system from the previous step to cross regional boundaries.
C	Video conferencing	Implement videoconferencing to communicate with patients, but also other health care providers.
D	eMIMS	Implement medical image management within the system that allows users to express multi-criteria queries.
E	Health Exchange system	Implement in co-operation with other health care providers, health kiosks that co-operates with the general practice information system which "become focal points for creating a business infrastructure of medical, ambulance, diagnostic, and referral facilities. They also provide emergency healthcare services, maternity services, pre-natal and post-natal services, epidemic response services, etc" but also has alliances with "pharmaceutical companies, insurance providers, medical service providers (e.g., hospitals and nursing homes), and educational institutions" (Saurabh, Bhowmick, Amrita & Biswas, 2012).

	Patient emancipation	
A	Home automated Telemanagement	Implement a part in the system where the patient has access to a system that helps to implement patient self-care, clinical decision support and care coordination. It should provide enhanced patient-provider communication, disease education, control of patient adherence with their treatment plans, healthy lifestyle counseling and social support.
B	Home-based biometric measurement devices	Provide the patient with home-based measurement devices, that enables them to upload this via telephone or internet to the system.
C	Computer delivered therapy (such as CDCBT)	Enable therapies to be delivered through the system from a computer at home.
D	Interactive websites	Provide a website for the patient, where he can access and perform some steps of treatment/diagnosis within the system.
E	Web-based personal health record	Provide online access to the computerized patient records.
	Medication safety	
A	Online medication information (such as BNF)	Provide the system with access or link it to an online resource on which sound and up to date information about the use of medicines can be found.
B	Computerized physician order entry	Implement a functionality on which the general practice can enter order information for medication.
C	ePrescribing	Provide an electronic way to prescribe medicine for patients, with an electronic signature.
D1	Drug-drug interaction alerts	Enable the ePrescribing system to notify on drug-drug interactions.
D2	Electronic alarm	Enable the ePrescribing system to provide an alarm for dangerous medication interactions/dosages.
	Intervention Program	
A	Intervention programs (such as HIV/STI testing)	Implement assistance for intervention programs

B	EMR based intervention program	Enable the intervention program to make use of the information of the electronic medical records within the system?
C	Intervention websites	Provide a website that links with the system, where patients can follow an intervention program.
	Exchange of information (D2D)	
A	Email	Implement or link with an emailing system with which you can communicate with the email of other health care providers. Make sure this system that can transfer pathology results.
B	Asynchronous teleconsultation	Implement a system with which you can communicate with other experts. This system has to be capable of asynchronous communication.
C	Electronic ordering and access of laboratory results	Provide a system, that can communicate with laboratory systems, in order to give access to results of patients of the general practice (not e-mail). Provide a functionality with which laboratory results can be requested through the system (not using e-mail).
D	ePrescribing	Implement a functionality that is able to send prescription orders to other health care providers.
E	Inter Clinic coordination	Prodive the option to automatically generate forms/care plans and manages clinical care between visits.
F	Intra-clinic communication	Make tasks can be electronically assignable. Provide the functionality to document the paper notes in the system. This system has to be able to provide multidisciplinary documentation in structured analyzable formats.
G	Referral application	Implement a system with which you can refer patients to other healthcare professionals.
H	Support for chain digitization	Provide support for chain digitization and prevention and make this accessible from the general practice information system.
I	Clinical data/image exchange	Enable the general practice system to exchange clinical data and imaging with other health care providers' systems.
J	Electronic discussion groups	Provide access to a platform, within the system, or through a link, were health care providers can safely discuss with each other and ask questions.
K	Synchronous teleconsultation	Implement a system with which you can communicate with other experts. This system has to be capable of asynchronous communication.
	DSS	

A	Expert System	Make the system collate and analyze perspectives into tailored health promotion advice without adding to the workload of primary care practitioners.
B	Disease specific DSS	Implement decision support for specific diseases.
	Electronic medical records	
A	Computerized patient records	Implement computerized patient records within the general practice information system.
B	Automated data collecting	Make the system able to collect clinical information automatically from different other computer systems.
C	Electronic record linkage	Link with multiple systems to gain more information about the data.
D	National linkage of electronic record	Link with the national eletronic record database.
	Administrative	
A	Scheduling	Make a scheduler within the system. This system should schedule the patients electronically.
B	Electronic Billing	Bill your providers/patients through the system.
C	Patient management system software	Implement a system that assists with recording of patient and clinical consultation details and helps with the daily running of the general practice.
D	Recall system	Implement a functionality that can contact and recall patients for routine and other planned episodes of health care.
	PDA	
A	Access up-to-date evidence based data	Link with a mobile device that allows the general practice to instantly access up-to-date evidence based data from the system.
B	Smartphones	Convert the mobile device used, to a smartphone.
C	ePrescribing	Make your mobile device able to provide all the abilities of ePrescribing.
D	Mobile freestanding quality assurance	Use your mobile device, to provide mobile freestanding quality assurance.
E	Data mining and information discovery	Use your mobile device for data mining.

	E-learning	
A	Learning programs	Install computerized learning programs in the system.
B	Learning management system web course tools	Provide access to an online (web-based) source that can measure the medical knowledge company and can be used for learning.
	ICT Support	
B	IT Training	Provide IT Training for the general practice information system.

Table 97 Final list of improvement actions

6.6. Appendix F: Dependencies of the capabilities

	Exchange of information (P2D)	**Dependencies**
A	Email	Internet access
B	Electronic booking	Internet access, Scheduling
C	Integrated clinical management system	Internet access
D	Secure personal websites	Internet access
E	Patient Portals	Internet access
F	Real time video	Internet access
	Exchange of information (P2D2D)	
A	Regional HIE	Internet access, Computerized patient records, Electronic ordering and access of laboratory resutls
B	HIE	Internet access, Regional HIE
C	Video conferencing	Internet access
D	eMIMS	Internet access
E	Health Exchange system	Internet access, HIE
	Patient emancipation	
A	Home automated Telemanagement	Internet access
B	Home-based biometric measurement devices	Internet access
C	Computer delivered therapy (such as CDCBT)	Internet access
D	Interactive websites	Internet access
E	Web-based personal health record	Internet access
	Medication safety	
A	Online medication information (such as BNF)	Internet access
B	Computerized physician order entry	Internet access
C	ePrescribing	Internet access, computerized physician order entry
D1	Drug-drug interaction alerts	Internet access, ePrescribing
D2	Electronic alarm	Internet access, ePrescribing
	Intervention Program	
A	Intervention programs (such as HIV/STI testing)	

B	EMR based intervention program	
C	Intervention websites	Internet access
	Exchange of information (D2D)	
A	Email	Internet access
B	Asynchronous teleconsultation	Internet access
C	Electronic ordering and access of laboratory results	Internet access
D	ePrescribing	Internet access
E	Inter Clinic coordination	Internet access
F	Intra-clinic communication	Internet access
G	Referral application	Internet access
H	Support for chain digitization	Internet access
I	Clinical data/image exchange	Internet access
J	Electronic discussion groups	Internet access
K	Synchronous teleconsultation	Internet access
	DSS	
A	Expert System	
B	Disease specific DSS	
	Electronic medical records keeping	
A	Computerized patient records	
B	Automated data collecting	Internet access, Computerized patient records
C	Electronic record linkage	Internet access, Computerized patient records
D	National linkage of electronic record	Internet access, Computerized patient records
	Administrative	
A	Scheduling	
B	Electronic Billing	Internet access
C	Patient management system software	Internet access
D	Recall system	Internet access
	PDA	
A	Access up-to-date evidence based data	Internet access
B	Smartphones	Internet access
C	ePrescribing	Internet access
D	Mobile freestanding quality assurance	Internet access
E	Data mining and information discovery	Internet access

	E-learning	
A	Learning programs	Internet access
B	Learning management system web course tools	Internet access
	ICT Support	
A	ICT Support	

Table 98 Dependencies capabilities