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Improving Medication Management with MediScan

An empirical design study

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Executive summary

In Dutch healthcare, current patient compliance with medication plans is low and many mistakes are made when medication is administered in the home environment (e.g. by the patients themselves or by home care employees). This increases costs and decreases quality of healthcare. A low identifiability of medication (1), a low level of information on medication (2), a low level of user self-control on medication (3), and sub optimal relations between stakeholders (4) are defined as the main causes for the current situation. To advance the current situation, a novel solution concept, named MediScan, is developed to improve the state of the four causes. To detail the problem situation, the views of important stakeholders are taken into account: patients, home care providers, domiciliary care providers, and pharmacists. Their needs are identified and categorized into customer requirement groups. Existing solution alternatives are evaluated against the customer requirements to demonstrate the necessity for MediScan. MediScan is a flexible personal medication management system. The system allows the user to manage and view (information on) medication in an online web-based system. The user is automatically directed to the system when the user scans a tag (RFID tag or QR code) on the provided medication using a scanning device (e.g. a mobile phone). A pharmacist or home care organization owns the web-based system, and can query it to monitor patient compliance and possible medication mistakes. A prototype of MediScan is presented and evaluated with a group of selected patients and home care employees. The evaluation results show that the state of the four causes are improved, which positively influences patient compliance and the number of mistakes made with medication.

1 Problem Statement

1.1 Motivation

Many medication errors are made, by both patients themselves and by the prescribers/providers of medication. Many of these errors lead to medical interventions or hospital admissions that could have been prevented. The central problem is that this leads to unnecessary increase of costs and decrease of quality of healthcare, caused by the current level of medication safety that is characterized by low patient compliance and a high number of medication mistakes. The difference between patient compliance and patient mistakes with regard to medication is that with the former the patient does have information on medication (i.e. in the form of a medication plan) and with the latter the patient does not. Medication safety is concerned with activities to avoid, prevent, or correct adverse drug events, which may result from the use of medication. Up till now, the improvement of medication safety has focused primarily at care settings away from the patient's home environment (e.g. hospital care or ambulatory care), where the effects of errors are most visible in terms of quality and costs. In these environments, knowledge already exists that can help to prevent medication errors and thus increase medication safety. However, in the home environment there is no clear view on medication errors, especially when it does not lead to hospitalization. The goal of this report is to investigate the relevant issues related to the central problem in primary care settings. The investigation does not center on a specific organization but targets Dutch home/primary care settings in general. The focus is on patient compliance and medication errors made by patients since this area is relatively new and challenging.

1.2 Problem Analysis

First, the stakeholders involved in the problem area are identified. Figure 1 shows the different levels and corresponding stakeholders involved in a medication supply chain. On the creation and distribution level, the medication and information is produced and distributed to the other (lower) levels. The lower levels provide information to this level to improve medication and information. On the prescriber and provider level, the depicted stakeholders provide/prescribe medication to the user level for usage at home. On the user level, the medication (and information) is consumed directly by the patient, or indirectly by a nurse (home care) or relative/friend/acquaintance (domiciliary care). To repeat, this report focuses on mistakes made with regard to medication on the user level, not on mistakes made by prescribers and/or providers.

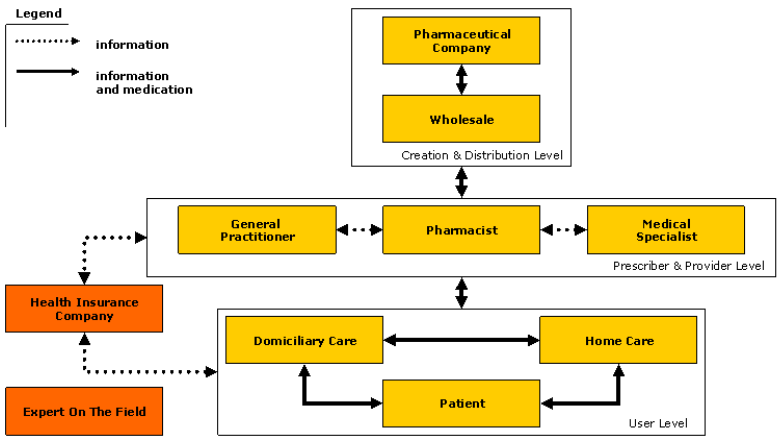

Figure 1. Levels and Stakeholders in a Medication Supply Chain.

To specify the central problem in more detail, the viewpoints of the stakeholders with regard to medication safety were collected using interviews, observations, and desk study. For each viewpoint, relevant statements were collected and categorised (see Table 1). In Table 1, the identified statements are labelled as SX with X being a number. Moreover, for each statement, the stakeholder(s) is(are) mentioned between parentheses: General Practitioner (GP), Medical Specialist (MS), Pharmacist (PH), Health Insurance Company (HIC), Home Care Provider (HCP), Domiciliary Care Provider (DCP), Patient (PA), Expert (E). Experts are considered to consist of the government, governmental healthcare institutions, and scientists.

Table 1. Overview and Categorization of Identified Stakeholders Statements.

Identifiability Of Medication S18: Medication can be interchanged with other medication (HCP/DCP/PA). S19: Medication is hard to distinguish once it is out of its package (HCP/DCP/PA).	**Mistakes Made By Users** S17: Mistakes are made with distribution of medication, by not paying enough attention (HCP). S28: Medication is used wrongly (PA).
Problem Awareness S35: Stakeholders do not know how many mistakes are made with medication (E).	**Compliance** S32: The patient does not stop medication properly (PA).
Relations Between Stakeholders S20: Differences exist between medication lists home care organizations use (HCP). S21: It takes a long time before adaptations in medication are transferred to distribution lists (HCP). S22: Home care has to trust the patient on medication (HCP). S27: The patient does not trust the prescriber and/or provider (PA).	**Patient Self-Control** S29: Medication has side-effects (PA). S30: The patient does not like the way of administering medication (PA). S31: The patient does not like the large number of applications of medication (PA). S34: The patient treats himself in the wrong way (acts like he is a doctor) (PA).
Mistakes Made By P&P S1: The general practitioner does not conform to prescription regulations (GP). S2: The general practitioner sets wrong diagnosis (GP). S3: The general practitioner prescribes wrong medication (GP). S4: The medical specialist does not conform to prescription regulations (MS) S5: The medical specialist sets wrong diagnosis (MS). S6: The medical specialist prescribes wrong medication (MS). S10: The Pharmacist makes mistakes with prescriptions, due to handwritten prescriptions (PH).	**Information On Medication** S7: Level of informing by pharmacist is likely to decrease, due to new income regulations (PH). S8: Pharmacist does not inform properly about medication (PH). S9: Information is given only once by pharmacist, patient often forgets within 5 minutes (PH). S24: Too little knowledge about medication (DC). S25: Information leaflet is too complicated (DC). S26: Information leaflet does not provide enough information (DC). S33: Too little knowledge about medication (P).
Costs Of Medication S11: Stakeholders at P&P Level are influenced by pharmaceutical industry to buy expensive medication that could be replaced by cheaper alternatives (HIC). S12: General Practitioner and Medical Specialist write same prescriptions to increase income (repeated prescriptions) (HIC). S13: Health care costs increase by mistakes made with medication (HIC). S14: Health care costs increase and have to be paid by the patient (HIC).	**Time** S15: Number of employees decreases (HCP). S16: Distributing medication takes a relatively long time (HCP). S23: Domiciliary care is voluntarily and takes a lot of time (DC).

Based on the statements and their categories, a conceptual model (i.e. cause-problem-effect model) of the problem area has been created (see Figure 2). This model is used as the starting point to create a design solution to improve the current situation. As mentioned before, the current situation is a situation with low compliance and a high number of medication errors, which leads to increased costs and low quality of healthcare. To improve the current situation, effective design solutions should be able to influence the causes in Figure 2: improving the identifiability of medication, improving the level of

information on medication, improving the level of patient self-control over medication, improving the relations between stakeholders. The cause "Duration of Disease" cannot be influenced by the design solution.

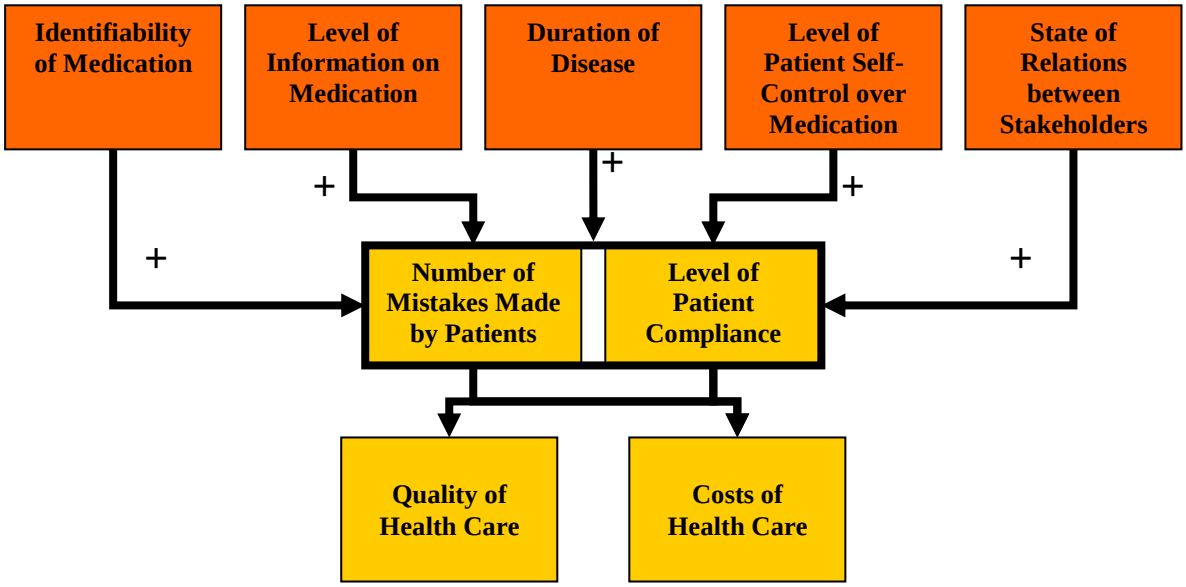

Figure 2: Conceptual Model.

Two approaches can be used to come up with effective design solutions. On the one hand, it is possible to improve existing design solutions. In this way, it may be possible to mitigate better the relevant causes. On the other hand, a new design solution can be developed. This report explores both options before selecting the best option. This is the subject of the next section.

2 Solution Alternatives

2.1 Customer Requirements

Every statement in Table 1 can be considered a problem to be addressed by the design solution. As indicated above, the focus of this report is on the user level. Therefore, the main customers of the design solution are patients, domiciliary care providers, and home care providers. Moreover, the pharmacist is a customer since many statements (i.e. problems) in Table 1 are concerned with the relation between the user level and the pharmacist. Interviews with five representatives of these four customer groups were performed to identify solution requirements. The result is a list of 55 categorized customer requirements (see Appendix A).

2.2 Existing Solutions

The following existing best practices for dealing with medication management and compliance exist.

Best Practice 1: Information Leaflet

The information leaflet is usually a small paper enclosed in each medication package on which important information about the medication is provided (see Figure 3). The information leaflet is primarily used by the patient, but other stakeholders may use it as well. Each pharmaceutical company is obliged by law to enclose such an information leaflet. The contents of information leaflets are regulated

by law as well and are checked by a governmental institution. Amongst others, topics like characteristics of medication, possible side-effects, interactions with other medication, and usage of medication belong to the contents of the information leaflet. In general, information leaflets are considered to be hard to understand by patients. Therefore, a price for best information leaflet is introduced by DGV[1]. By awarding pharmaceutical companies for simple and easy information leaflets, DGV tries to improve the quality of information leaflets.


SAMENSTELLING

FARMACEUTISCHE VORM EN VOORSTELLINGEN

FARMACOTHERAPEUTISCHE GROEP

REGISTRATIEHOUDER, FABRIKANT

AANGEWEZEN BIJ

OMSTANDIGHEDEN WAARBIJ HET GEBRUIK VAN HET GENEESMIDDEL MOET WORDEN VERMEDEN

BIJZONDERE VOORZORGEN

WISSELWERKINGEN MET ANDERE GENEESMIDDELEN EN VOEDING

Figure 3. Example of an Information Leaflet.

Best Practice 2: Baxter System

The Baxter system consists of a machine that is able to package medication automatically. The system is used by the pharmacist to distribute medication for chronically ill patients. This saves a lot of time and mistakes, as medication does not have to be packaged and distributed manually anymore. The medication is packaged in small plastic bags (see Figure 4). Each bag contains medication for one patient for one time period. This implies that a patient receiving medication for three times a day, receives three different bags for one day. Each bag is labeled with the patient's name, day, time of intake, and a description of the physical properties of the medication.

Figure 4. The Baxter System.

Best Practice 3: Electronic Medication File

The electronic medication file (EMF, EMD in Dutch) is created by a stakeholder (i.e. a care provider) in healthcare. Development of this file started only a few years ago. In the file, prescribed and provided medication is registered for each patient. In this way, a historical overview of used medication is available. This information stays at its source, in the information system of a hospital, pharmacist or

[1] DGV: Dutch Institute for Appropriate Medication Usage (translated from Dutch).

general practitioner, for example. It is only available for prescribers and providers of medication, and thus for pharmacists. This file only slightly deals with patient compliance towards treatment plans. Based on the information in the file, some assumptions can be made about the patient's compliance.

Best Practice 4: Electronic Health Record
The electronic health record (EPD in Dutch) succeeds the electronic medication file. In fact, the EPD consists of the electronic medication file and a lot other files as well. Only recently, the EPD was introduced to Dutch society. Eventually, every single aspect related to the health of a single patient is to be stored in the EPD. Besides the stakeholders in healthcare being able to view information, the patient is able to check the information in the EPD as well, which is different compared to the EMF.

Best Practice 5: Digital Medication File
The digital medication file is a variant of the EMF. However, this file is used by one single organization of pharmacists only (Kring Pharmacists). It is different from the EMF due to the patient being able to access the information in it.

Best Practice 6: (Electronic) Medication Consultation or Review
A medication consult or review is "a structured, critical evaluation of the medication usage by the patient in order to get an agreement between patient and pharmacist about the treatment, for optimizing the effects of medication, for minimizing problems related to medication and reducing waste of medication by increasing patient compliance" (as defined by the KNMP[2]). For a medication consult, a patient has to visit the pharmacist and bring all used medication. In that way, the pharmacist can update its administration and post questions about medication. The patient is able to ask for information as well.

Best Practice 7: Daybox or Weekbox
The daybox or weekbox can store medication that a patient has to use during a day or during a week. The box can be filled by the patient, a home care employee, or a filled box can be delivered by the pharmacist. Normally, the box consists of a few predefined small compartments in which medication can be stored (see Figure 5). Medication that has to be used on the same time is put together in the same compartment. Boxes exist that are easy to use, easy to take around, or have large texts. When the box is empty, it can be refilled by the patient or home care employee. Refilling takes about 5 to 15 minutes, depending on the complexity of the treatment plan the patient has.

Figure 5. A Medication Weekbox.

[2] KNMP: Koninklijke Nederlandse Maatschappij ter bevordering der Pharmacie.

Best Practice 8: Medication Alarm Clock

The medication alarm clock (see Figure 6) is used by the patient. The patient has to fill the alarm clock with medication and enter the times on which an alarm needs to go off. Only a few different times can be programmed and only a few types of medication can be entered in the box. Some medication alarm clocks have other functionalities as well, like facilities to measure the heartbeat of a patient.

Figure 6. A Medication Alarm Clock.

Best Practice 9: Simpill

Simpill is used by both the pharmacist and the patient to determine and improve compliance. The concept consists of a small box in which medication is stored (see Figure 7). The box uses mobile phone technology to remind the patient to take his/her medication on time. The SIMpill system is programmed with the patient's medication schedule. By opening the medication box, a signal is sent to the Simpill supporting system. If the patient does not open the medication box on the prescribed time, a message is sent immediately to the patient's mobile phone, reminding him/her to take the medication. If the patient opens the medication box on time, no message is sent. The times on which the medication box is opened are registered. Afterwards, compliance can be determined by checking the registered times with the prescribed times. This can be done by both the patient and the pharmacist. New medication needs to be put into the box by the patient.

Figure 7. The Simpill box.

Best Practice 10: Medication Pattern

The medication pattern is used by the pharmacist to determine patient compliance. It only works for long-term treatment plans. The patient picks up the required medication at the pharmacist, which is registered. By checking the treatment plan and the amount of medication given to the patient (see Figure 8), the pharmacist knows when the patient should return approximately for a refill. In case the patient is (days) too late, the pharmacist knows the patient is not entirely compliant with the defined treatment plan.

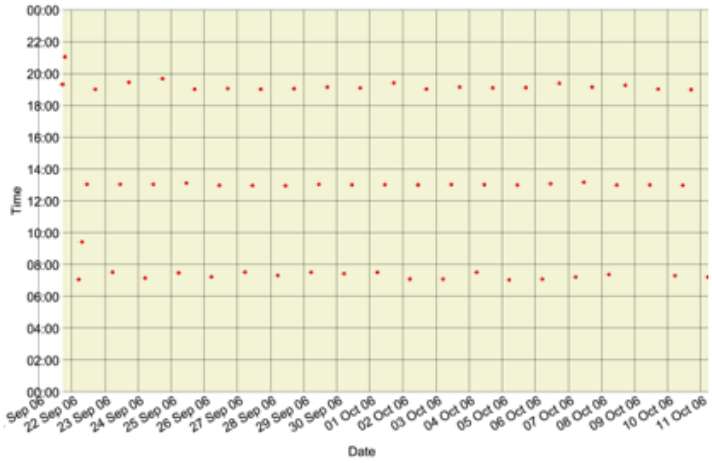

Figure 8. Medication Pattern.

2.3 Solution Analysis

In Table 2, each best practice receives a score for each defined customer requirements group from Appendix A. A group receives a positive score ("+") when the customer requirement is being fulfilled. It receives a neutral score ("+/-") in case the customer requirement is partly being fulfilled. Finally, the negative score ("-") is given when the customer requirement is not being fulfilled at all. For each best practice, the total score is calculated by multiplying the positive (+1), neutral (0) or negative (-1) score with a group importance factor, given by the interviewed customers, and by adding up those weighted scores. In the last row, the target customer group for which the best practice has been developed is given: U means that the best practice is mainly developed for the user, P means that the best practice is mainly developed for the pharmacist. The lower case u and p indicate that the user or pharmacist is a secondary target customer group of the best practice.

Table 2. Scoring of Best Practices based on Customer Requirements.

Best Practice / Requirements group (importance factor)	1	2	3	4	5	6	7	8	9	10
1. Time (4)	-	+	-	-	-	-	+	+	+	-
2. Packaging (5)	-	+/-	-	-	-	+/-	-	-	-	-
3. Relation (4)	+/-	-	+/-	+	+/-	+	-	-	+	+/-
4. Reliability (5)	-	+/-	-	-	-	-	+/-	+/-	+/-	-
5. Safety (5)	-	+	-	-	-	+/-	-	-	+/-	-
6. Identifiability (5)	+/-	+/-	-	-	-	-	-	-	-	-
7. Supporting (5)	-	-	-	-	-	-	+/-	+	+	+/-
8. Remembering (5)	-	-	-	-	-	-	+/-	+	+	-
9. Communicating (5)	-	-	+/-	+/-	+/-	+/-	-	-	-	-
10. Information (5)	+	-	+/-	+/-	+	+/-	-	-	-	-
11. Overview (5)	-	-	+	+	+	+	-	-	+/-	+/-
12. Compliance (5)	-	+/-	-	-	-	+/-	+/-	+/-	+/-	+/-
# of +'s	1	2	1	2	2	2	2	3	4	0
# of + / -'s	2	4	3	2	2	5	2	2	4	4
# of –'s	9	6	8	8	8	5	8	7	4	8
Cum.	**-39**	**-20**	**-34**	**-30**	**-29**	**-15**	**-30**	**-20**	**-2**	**-39**
Used by	U / p	U / P	P / u	P / u	U / p	U / P	U	U	U / P	P

Table 2 reveals that the existing design solutions do not fully address the customer requirements, especially with regard to the customer requirements groups packaging, reliability, safety, identifiability, communication, and compliance. In general, a more interactive system is required which allows for personal medication management with functionality to communicate with the pharmacist, to improve reliability and safety through directing user behavior, to provide easily understandable information, to identify medication, and to monitor patient compliance. A possible direction would be to improve one or more of the existing design solutions to meet most or all of the customer requirements. For instance, the Simpill system, which has the best score in Table 2, could be improved. The direction chosen in this research is to develop a novel design solution. In this way, the solution can be completely designed for personal medication management.

3 Solution Design: MediScan

3.1 MediScan Concept

A new concept, called MediScan, has been realized based on brainstorm sessions with experts, interviews with the stakeholders, and literature searches. The concept works as follows. Medication is labeled with a RFID tag for unique identification. A mobile phone (or another scanner) is used to scan the tag. The tag contains information that connects the user to an information source. This information source is likely to be situated somewhere external, most likely online, but information can be put on the tag or scanning device as well, depending on the type of tag and device. The scanner may also be used to display information to the user. Alternatively, another display may be used (e.g. a television) in the home environment. By scanning the medication, it can be added to or deleted from the patients' medication overview, which is stored in the information source. Compliance can be determined by scanning medication before the patient takes it. The patient can be informed, notified, and the patient can communicate with the pharmacist by a channel selected by the patient (television, mobile phone, etc.). MediScan can be functionally decomposed as in Figure 9. This decomposition shows all customer requirements groups from Appendix A clustered together under certain functions.

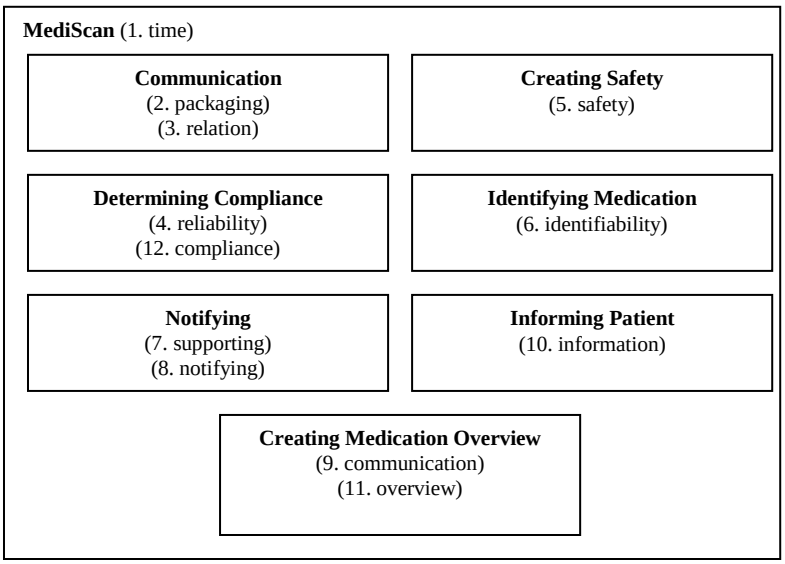

Figure 9. MediScan Functional Break-Down.

3.2 MediScan Functional Architecture

Based on the functions from Figure 9, a functional architecture of the MediScan concept is shown in Figure 10. In the functional architecture, the functions are assigned to the physical components of MediScan (i.e. the scanner, the presentation facility and the supporting information system). Moreover, the figure shows that there exist interfaces between the scanner and the supporting system, and between the presentation facility and the supporting system.

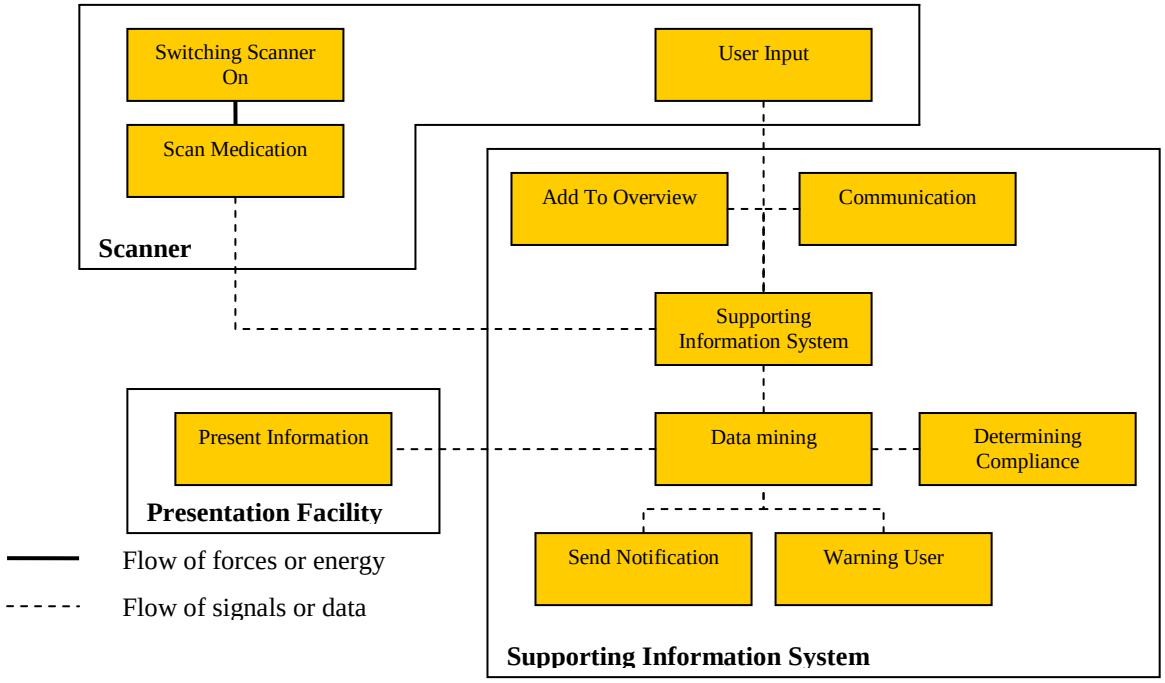

Figure 10. Functional Architecture of MediScan.

Communication (1) is started by user input. Through the supporting information system, which is most likely managed by the pharmacist and/or home care organization, the user can communicate with other stakeholders. Compliance is determined (2) by the information system that compares the data provided by the user with the medication plan inserted by the pharmacist or home care organization. The user provides data by scanning medication when it is taken. Medication can be identified (3) by the user through scanning the medication. By comparing information of the scan with information in the supporting information system, medication can be identified. Notifying the patient (4) can be done by the information system when any deviations from the medication plan are discovered. The patient is informed (5) when medication is scanned and information available in the information system is presented to the patient. A medication overview (6) is created by the user through adding scanned medication to the overview. Safety instructions (7) are provided to the user by the information system when needed.

3.3 MediScan Components

For the different components of MediScan, technical solutions have been chosen.

Tags

To show the flexibility of the MediScan solution concept, another tag is added to the MediScan solution concept, besides the RFID tag. This is the QR code, a specific matrix barcode (or two-dimensional code), readable by dedicated QR barcode readers and camera phones. Within MediScan, both the RIFID tags and QR codes store a link (i.e. URL) that provides automatic access to the supporting information system.

Scanner

Scanners that are commonly available at the user's home are most useful. Therefore, mobile phones and webcams are the most logical choice. However, other scanners exist as well that may be used in the future (for example, a dedicated RFID scanner). The supporting information system is flexible enough to deal with many types of scanners. For MediScan, two types of scanners are most useful to read the RFID tags and QR codes. First of all, a mobile phone is used. For scanning RFID tags, every mobile phone containing a NFC[3] chip is usable. For scanning QR codes, every mobile phone containing a camera is usable. The second scanner to be used is the webcam, which can read QR codes. For scanning tags, software is needed as well. For reading and writing QR codes with a mobile phone, free software is available. For scanning QR codes with a webcam, the same type of software is needed. For reading RFID tags with a mobile phone, no additional software is needed, as it is already available on NFC-enabled mobile phones.

Supporting Information System

The supporting information system is an online web-enabled information system with a back-end database in which information can be stored, and a number of functions for providing information to relevant stakeholders. The database is built in MySQL. The functions are given in Table 3.

Table 3. Defined Functions for the Supporting Information System.

Sub Function	Element In MediScan (as defined in Figure 10)	Function In MediScan (as defined in Figure 9)	Customer Requirements Group (as defined in Appendix A)
Sending A Warning For Double Intake By Patient	Warning User	Creating Safety	5. Safety
Sending A Warning For Conflicting Medication	Warning User	Creating Safety	5. Safety
Notifying For Collecting Of New Medication	Send Notification	Notifying	7. Supporting / 8. Notifying
Notifying Of Medication Outside Home	Send Notification	Notifying	7. Supporting / 8. Notifying
Counting Mistakes Made	Warning User	Creating Safety	5. Safety

The information system (i.e. website) has a URL, which is not provided for confidentially reasons. The scanner and the website are connected with each other by using the tag. The tag contains a link to the

[3] Near Field Communication or NFC, is a short-range high frequency wireless communication technology which enables the exchange of data between devices over about a 10 centimeter distance.

MediScan URL: http://www.url.info/home.php?id=RVG-000-000 forms the hidden link. The RVG number is an international standard and forms the unique number by which medication can be identified. By scanning the tag, the homepage of MediScan is opened, and the scanned medication is displayed. The relation between the website and the presentation facility is pretty straightforward. The website of the MediScan solution is shown on the internet-enabled presentation facility (see below).

Presentation Facility
For presenting information to the user, two locations can be identified on which the user would like to receive and/or provide information. This can in the home environment or outside the home environment. This means that both portable and non-portable devices should be used as presentation facilities. As a portable device, a mobile phone is the obvious choice for MediScan since it is already being used for scanning tags and can display internet pages effectively. As a non-portable device for home usage, a computer (with a webcam and internet) is the obvious choice. In the future, other presentation facilities may be used as well.

Evidence Facility
To prove compliance, MediScan should offer an evidence facility. The most reliable and cost-effective way to exactly determine patient compliance is to observe the patient while taking medication. However, it is practically impossible for the pharmacist or home care organization to check every patient at each moment. Therefore, proving compliance is the responsibility of the patient. The patient should record him/herself when taking medication and upload this recording to the supporting information system. If necessary, this recording can be checked to exactly determine patient compliance. For recording, several tools exist that contain a recorder. For example, most mobile phones and webcams can record the patient, and are widely available. As those two fit with the presentation facilities defined earlier, they will be used as evidence facilities in MediScan.

Interfaces
Two interfaces were defined earlier: an interface between the scanner and the supporting information system, and an interface between the supporting information system and the presentation facility. In case compliance needs to be proven by the patient, an interface exists between the supporting information system and the evidence facility. As the supporting information system is a website, all interfaces are internet connections.

4 Solution Implementation

4.1 MediScan Prototype

Because of time constraints, not all of the extra functions as defined in Table 3 have been implemented in the MediScan prototype, especially the notification functions. However, these can be added in the future by using for instance SMS technology. Thus, no warning is sent in the case of a double intake by the user, no notification for collection of new medication is sent, and no mistakes are counted. The last function that is not integrated in the prototype is sending a notification message when a patient forgets to take his/her medication when leaving the home environment.

In the prototype, the Nokia 6212 NFC was selected to scan RFID tags. The Nokia N81 8GB was selected to scan QR codes with the use of the software of i-nigma[4]. For the prototype, the selected

[4] http://www.i-nigma.com/i-nigmahp.html

mobile phones are also used as presentation facilities. In Figure 11, Figure 12, and Figure 13, the MediScan prototype is schematically displayed. In Figure 11, the tags and scanning devices are displayed. The QR code is displayed in Figure 11a, together with the Nokia N81 8GB. The i-nigma program is used to scan the QR code. By opening i-nigma, the camera of the mobile phone is activated. In the display of the mobile phone, the QR code has to be visualized, whereafter the software program automatically takes a picture of the QR code (Figure 11b). The information in the QR code is then translated to a web link, which can be opened by the user. In Figure 11c, the RFID tag is displayed. By holding the Nokia 6212 NFC closely to the tag, the tag is automatically recognized and the web link is opened.

Figure 11. (a) QR code and Nokia N81 8GB, (b) Scanning the QR code, (c) Scanning the RFID tag.

When the web link is activated after scanning, the MediScan website is opened and the name of the patient and scanned medication is displayed. In Figure 12a, this is "Patient X" and "Medicine A". Next, the user can select from five options. The user can select 'Take medication' and 'Add medication to overview' (Figure 12a). When the user scrolls down (Figure 12b), the other three options are given: 'Give information about medication', 'View medication overview' and 'Order medication at pharmacy'. Finally, the date and time are given.

Figure 12. (a) Welcome Screen Of MediScan, (b) Scrolling Down On Welcome Screen.

When the user selects the desired option, MediScan displays a corresponding screen. Figure 13 shows some of these screens. When the user chooses the option 'Take medication', the name of the medication, and the date and time it was taken are inserted into the database. The user is informed when a successful registration has occurred (Figure 13a). By choosing the option 'Add medication to overview', new

medication is entered into the patient's overview and set to active. Medication that is not used anymore is set to passive: this may automatically be done after a fixed period of non-usage of that medication. The user can get information on the medication as well. The current overview of medication can be viewed by clicking the relevant button. The overview of active medication will then be displayed (Figure 13b). By choosing the option 'Give information about medication', the user enters another menu. In that menu, three options can be chosen from. The first option is to browse information on the medication. In the second option, the pharmacist or other stakeholders can be contacted directly. By using a color code, several different contact options can be selected (Figure 13c). The third option is to enter comments about the medication.

Figure 13. (a) Taking Medication, (b) Browsing Medication Overview, (c) Contacting Stakeholders.

4.2 Prototype Testing

Five patients and home care employees, who were previously interviewed for the customer requirements, were involved in the prototype testing as users. Every user used the prototype for a 10 minute period. Afterwards, these users were interviewed for their opinions about how the prototype affects the four relevant causes from Figure 2: low identifiability of medication (1), low level of information on medication (2), low level of patient self-control over medication (3), and suboptimal relations between stakeholders (4).

Identifying medication was considered to be improved by all interviewees. However, almost every interviewee had a preference for the RFID tags over the QR codes. For the QR codes, the user had to watch the screen on the mobile phone closely to get the tag into the right area for proper detection. The RFID tag could be read more easily: holding the mobile phone closely to the tag was enough to identify the tag properly. However, interviewees indicated that the scanning of QR codes would become easier over time. Moreover, interviewees indicated that can identify pills instead of medication boxes is desired. The level of information has increased as well. Besides the information that was already available, like the information leaflet, the extra information offered is appreciated especially because the information is not fixed. For both home care employees and patients, the information on interactions between medications was considered to be most useful. The presentation facility (i.e. mobile phone) was not considered to be very visually attractive by both the patients and home care employees. The ultimate solution can use different presentation facilities. The interviewees suggested it may be better to decouple the scanner and presentation facility. The level of experienced self-control by the user or patient increased too, mainly because MediScan allows the patient to initiate the different available functions when they need it without consulting someone else. Moreover, the solution can be carried around, which increases patient's sense of self-control. Opinions about the state of optimality of relations between

stakeholders differ. The home care employees think the state of the relations has improved. This is caused by the prototype being able to communicate with the pharmacist directly. The possibility to contact the pharmacist was also valued positively by the patients. At the moment, MediScan primarily communicates with the pharmacist. Home care employees indicated that the user should be able to decide whom to contact. As all interviewees in general responded positively to the MediScan prototype, it can be expected that compliance will rise and the number of mistakes made with medication will drop. However, this can only be said for certain when MediScan has been used in practice for a longer time period.

5 Participants

This research is based on the master thesis research of Jeroen van Dijk. The current report is a summary of the full master thesis written by Jeroen. The research was conducted to complete the master of Industrial Engineering and Management at the Faculty of Mathematics and Natural Sciences, University of Groningen. The master thesis was finalized in June 2010.

Appendix A – Customer Requirements

Time
PH: The solution concept decreases the amount of time spent on medication management by both the user and the pharmacist.
HCP: The solution concept provides information both inside and outside pharmacist opening hours.
Packaging
HCP: The solution concept removes limitations for a proper use of medication caused by packaging.
HCP: The solution concept improves the readability of information on medication packaging.
HCP: The solution concept improves the usage of medication, even for patients with a physical disability.
HCP: The solution concept improves the readability of information enclosed in medication packaging.
Relation
PA: The solution concept improves the relation between prescriber, provider, healthcare professional, and the patient.
PH: The solution concept improves relations between stakeholders in healthcare.
HCP: The solution concept gives responsibility for medication to one single person.
HCP: The solution concept contacts the pharmacist when contradictory information is given to the user.
HCP/PH: The solution concept creates a personal, both digital and physical, contact between user and pharmacist.
PH: The solution concept simplifies contacting the pharmacist by the user.
Reliability
HCP: The solution concept is reliable when used by the patient.
HCP: The solution concept is reliable in case the patient tries to mislead the solution concept.
HCP: The solution concept stores that the patient took his medication.
HCP: The solution concept can prove that the patient took his medication.
HCP: The solution concept can prove that the patient did not take his medication.
Safety
HCP: The solution concept makes medication management safe.
HCP: The solution concept warns the home care organization in case the patient loses control of his/her medication.
HCP: The solution concept removes mistakes made by distributing medication.
HCP: The solution concept prevents mistakes from happening in case multiple users are involved in medication management of a patient.
HCP/PA: The solution concept lets the patient treat him/herself in the right way.
Identifiability
HCP/PA: The solution concept can recognize and identify medication.
HCP: The solution concept makes identification of medication by users possible.
PA: The solution concept can recognize medication once it is out of its packaging.
Supporting
PA/DCP: The solution concept supports the patient's medication routine.

DCP: The solution concept supports the user by a changing medication routine.
DCP: The solution concept simplifies the medication routine, even if a small amount of medication is used, or if a steady routine is being used.
DCP: The solution concept simplifies the medication routine, in case a large amount of medication is used, or if the medication routine changes.
PA: The solution concept motivates the patient to finish his/her treatment in the right way.
PA: The solution concept notifies the patient of errors in his/her medication usage.
Notifying
DCP: The solution concept notifies the user to take his medication on the right moment.
HCP/DCP: The solution concept notifies the user to take his medication when he is outside his home.
HCP/DCP: The solution concept notifies the user to take his medication with him/her when leaving the home environment.
HCP: The solution concept can trace lost medication.
DCP: The solution concept notifies the user to pick up his medication from the pharmacist.
Communication
HCP: The solution concept is reliable when it is used by multiple users.
HCP: The solution concept can save changes in medication.
HCP: The solution concept can communicate changes in medication (to the pharmacist).
HCP: The solution concept informs the user about the validity of the medication list.
HCP: The solution concept can keep track of changes in medication.
HCP: The solution concept is flexible by dealing with changes in medication whilst preventing mistakes.
HCP: The solution concept communicates changes in medication to the stakeholders involved, or receives changes in medication from the stakeholders involved.
DCP: The solution concept informs other, authorized people about the medication usage of the patient.
DCP: The solution concept informs other, authorized people about the right way of using medication.
Information
HCP/DCP/PH: The solution concept informs the user about medication.
HCP: The solution concept provides information about interactions between medications.
HCP: The solution concept combines information from several caretakers.
HCP: The solution concept provides consistent information: information from different caretakers is consistent.
PA: The solution concept provides more information about medication than currently available.
PA: The solution concept provides information repeatedly.
PA: The solution concept provides information on a level of difficulty, matching the user.
PA: The solution concept provides more information to the patient than the current information leaflet.
PA: The solution concept improves the user's knowledge about medication.
DCP: The solution concept provides information about medication from multiple sources.
DCP: The solution concept provides information about medication in case the packaging is not available.
DCP/PH: The solution concept provides information when needed.
PH: The solution concept leverages the knowledge of the pharmacist.
Overview

HCP: The solution concept provides an overview of the used medication.
HCP: The solution concept provides an overview of the used medication containing no mistakes.
HCP: The solution concept provides an overview of the medication currently used.
PA: The solution concept provides an overview of medication used in the past, and the way the user has experienced the treatment.
PA: The solution concept provides an overview of medication the patient has an allergy to.
PA: The solution concept makes sure the patient only uses medication that has been prescribed.
DCP: The solution concept lets the prescriber know that some medication cannot be used by the patient.
DCP: The solution concept has a useful way of saving new treatment information.
Compliance
PH: The solution concept is able to determine patient compliance.
PH: The solution concept informs the pharmacist about the actual patient compliance.