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Electronic Medication Dispensing Cabinets at Aarhus University Hospital: Assessment of the Market prior to Implementation

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in Collaboration with the Hospital Pharmacy at Aarhus University Hospital Skejby

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1 Glossary

ADE	Adverse Drug Event.
AMDS	Automatic Medication Dispensing System, e.g. a dispensing robot.
ATC	Anatomical Therapeutic Chemical; a drug classification system.
Biometric ID	A unique, physiological feature to every human used for electronic identification, e.g. iris, voice, DNA, or fingerprint (as in this project).
Central pharmacy model	Most dispensed medications are stored in the pharmacy.
Combined central/decentral pharmacy model	Most medications are dispensed centrally in the pharmacy, and delivered to wards for decentral storage.
Controlled drug	Medication, which must be safely stored and strongly controlled due to the risk of abuse.
CPOE	Computerized Practitioner Order Entry.
Decentral pharmacy model	Most medications are stored in ward medication room(s) or cabinets.
Discrepancy	When an EMDC report shows conflicting information regarding current medication stock, e.g. the system has a pack of ten tablets registered, whereas the actual number in the pack is only five tablets.
EMA	European Medicines Agency.
End user	The health care staff using the EMDC, including pharmacists, pharmaconomists, and nurses.
FDA	U.S. Food and Drug Administration.
EMAR	Electronic Medication Administration Record.
EMDC	Electronic Medication Dispensing Cabinet.
EPJ	Electronic Patient Journal (Electronic Patient Record).

HL7	Health Level 7; a globally health care standard for IT.
HTA	Health Technological Assessment (In Danish: *Medicinsk Teknologivurdering (MTV)*).
New University Hospital in Aarhus, The	The existing Aarhus University Hospital Skejby is to be greatly expanded into the New University Hospital in Aarhus by 2019.
Patient safety	Defined by the Institute of Medicine as "absence of adverse events" (1) as well as following standards of quality and having access to the health care system (2).
PDA	Personal Digital Assistant.
PRN	Abbreviation of *pro re nata* (Latin for "as needed").
Remote lock	A refrigerator lock controlled and opened via an EMDC touch screen.
STAT	Abbreviation of *statim* (Latin for "immediately").
Traditional drug distribution system	A system, where medication is manually dispensed in the pharmacy or ward medication room.
Traditional medication room	A medication room, where all medication are stored in shelves and cabinets without any electronic registrations or security.
Unit dose	A single dose of medication packed in a small plastic bag. The bag contains printed drug information and a unique bar code.
Unit dose drug distribution system	A system, where the medication is delivered in unit doses from the pharmacy to each ward.
Unintended event	Refers to the Danish term "utilsigtede hændelser", which is an event that may harm the patient or increase the risk of harm caused by actions of health care staff or lack thereof (3).

2 Abstract

Patient safety is a great part of the worldwide health care system today. In Denmark, 30% of all unintended events and adverse drug events can be ascribed to medication errors. Medication errors occur during the daily medication management: Prescriptions by doctors, transcription by nurses, dispensing by pharmacists, and administration by nurses, where the first and last stages are most susceptible to errors. Medication errors not only have physiological effects on patients, as serious side effects and fatal complications are seen, but also a financial effect, as the costs for unravelling the errors are millions of dollars. Therefore, great focus is being turned towards preventing medication errors, but it is a long and complicated process.

The introduction of IT and automation to health care systems is a much used approach to reduce medication errors and increase patient safety, as every step of the medication management as well as medication stock management has become faster and more secure. Electronic patient records (including the Danish EPJ), CPOE, and EMAR are examples of IT systems in use. However, the targets of these systems are mainly the prescription and transcription stages, as prescriptions are made electronically, thus eliminating the transcription stage. The use of automatic dispensing and bar code scans of on every dose is one of the newest approaches to decrease the risk of medication errors. At Aarhus University Hospital, several wards are currently included in automatic dispensing procedures, as medications are dispensed into unit doses with unique bar codes. However, the medication is stored in often disorganized traditional medication room, thus increasing the need of time and resources to keep the rooms functioning.

Electronic medication dispensing cabinets (EMDC) are computer-controlled, cabinets with drawers and shelves for secure storage of medication. The use of EMDCs in the U.S. is now widespread. A combined use of an EMDC, bar codes, and the EPJ should enhance the documentation of medication dispensing and administration. Additionally, EMDCs can further improve stock management and increase the potential for allocation of staff time and resources. An assessment of the market and evaluation of each EMDC is thus made in order to locate the one most suited and useful to the wards at the hospital.

Sixteen EMDCs from twelve manufactures were found promising, and seven were selected as suitable for a future implementation in the New University Hospital in Aarhus. The EMDCs were *OmniRx G4* by Omnicell, *Pyxis® MedStation® 4000* and *Pyxis® CIISafe™ System* by CareFusion, *RxStation®* by Cerner, *medDispense Series* by Metro, *ServeRx™* by MDG Medical, and *AcuDose-Rx* by McKesson. The EMDCs had flexible options for configuration thereof (incl. drawers and auxiliary modules of different types), high security options (incl. biometric ID, guiding lights, and remote locks), and bar code scanners. However, implementing new IT is not an easy task, thus it is necessary to ensure a faultless interaction between existing IT systems and between health care staff and the new technology, as delays and staff annoyance can compromise patient safety.

Six of the seven EMDCs are to be considered an option for implementation. Based on the design and functionality, the *OmniRx G4* by Omnicell, *RxStation®* by Cerner and *Pyxis® MedStation® 4000* by CareFusion seem to be the best choices, as these have the most advantages. Although the costs of investing in EMDCs are high, the long term gains are considerable, especially for stock management and documentation thereof. Patient safety should also be improved, as fewer medication errors should be seen through the combined use of an EMDC, unit doses, bar code scans, and EPJ. Surveys prior and subsequent to implementation in two wards and a HTA are to be completed to clarify, if the benefits are higher than the costs.

3 Introduction

During the last decades, focus has been intensified worldwide on patient safety as well as how to reduce the number of unintended events, including adverse drug events (ADE) (4,5). Especially the industrialized countries have conducted large studies, which showed that the health care systems were not adequately safe and secure (2), leading to the formation of organizations for patient safety such as the Institute of Medicine in the U.S. (6), the National Patient Safety Agency in the United Kingdom (7), and Aktionsbündnis Patientsicherheit in Germany (8).

In Denmark, the Law of Patient Security was approved in 2004 and is now a part of the Danish Health Law. To uphold maximum safety for the patients, all Danish health care system workers are deemed to report all unintended events, and the number of reports has increased intensively over the past seven years. (3,9) In 2010, the Danish National Health Service (Sundhedsstyrrelsen) received over 34,000 reports on unintended events from the Danish regions, municipalities, and private hospitals, which is a 36% increase compared to 2009 and an almost 100% increase compared to 2004. (10) Figure 1 illustrates the total number of unintended events in Denmark in general, which was received by Sundhedsstyrrelsen from 2004 to 2010.

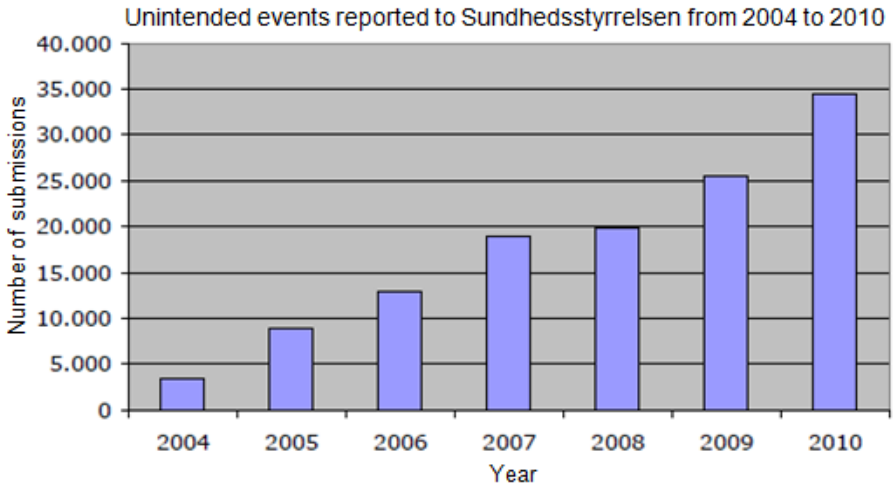

Figure 1. The number of unintended events reported to the Danish National Health Service (Sundhedsstyrrelsen) from 2004 to 2010. (10)

ADEs are a common cause of patient harm, and according to a German systematic review from 2006 approximately 10% of ADEs were preventable (11). The majority of ADEs are due to medication errors (12). A Danish report on patient safety by Sundhedsstyrrelsen from 2010 showed that over 30% of the reports on unintended events could be ascribed to medication errors (10). These may occur during the daily medication management, when doctors prescribe, nurses or secretaries transcribe, pharmacists or nurses dispense, or nurses administer medication (13-15). Especially the prescription and administration stages are vulnerable to errors (16), each accounting for approximately 40% of the total number of errors (17). Figure 2 illustrates a normal flow of medication management, and where errors may occur.

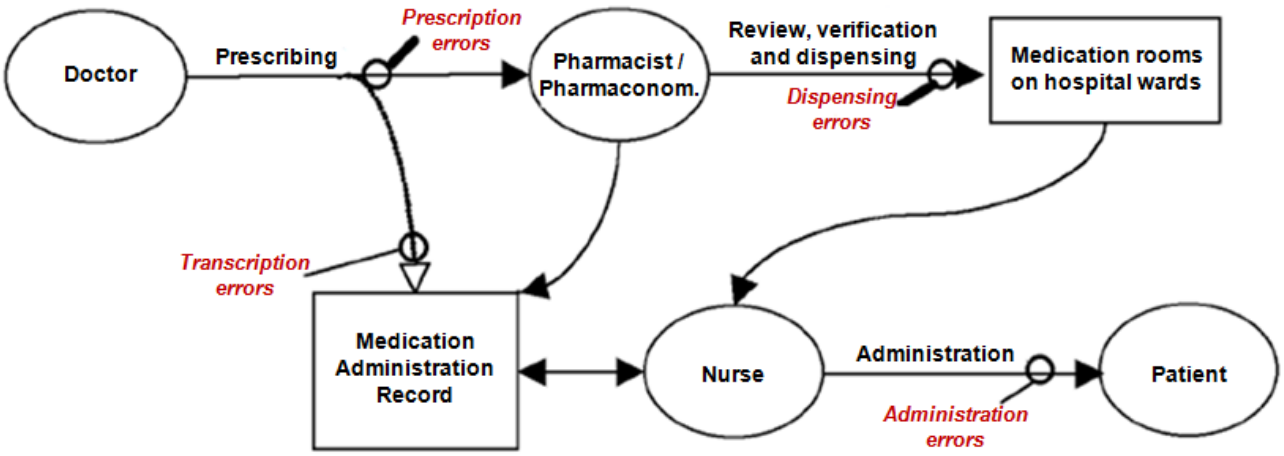

Figure 2. A normal flow of medication management with possible errors (marked red). A doctor prescribes medication for a patient; errors in prescription or transcription thereof may occur. A pharmacist and pharmaconomist review and verifies the prescription, and pharmacists dispense (manually or automatically) the medication prescribed; errors in medication dispensing may occur. In Denmark, the review and verification procedures are not a requisite, as it is in the U.S. (18). A nurse collects the medication needed from the medication room and administers it to the patient; errors in administration may occur. (Picture from (19), modified by the author)

Although the effects of medication errors are not always harmful for the patient itself, large economic costs as well as both physiological and psychological costs for health care staff and patients are often associated with it (1). In 2000, the American organization Institute of Medicine estimated that every patient admitted to a hospital was exposed to an error in administration of medication each day (20). More than one million medication errors occurred in the U.S. each year, and at least 44,000 deaths was caused by medication errors in 1997 (1), which was larger than the number of deaths caused by car accidents (≈43,500), breast cancer (≈42,300) or AIDS (≈16,500) (21). In 2006, Institute of Medicine estimated that more than 1.5 million patients were victims of medication errors at the cost of millions of dollars, e.g. expenses for additional care due to the errors, sick leave and reduced productivity (1,22).

Most medication errors may be prevented, but it is a long-term process and involves several, complicated steps, before a complete prevention of medication errors can be achieved (23). A study by Kopp et al. (4) from 2006 investigated ADEs as well as the incidence and preventability of errors in administration of medication in an intensive care unit in Arizona, U.S.. The study showed that more than two thirds of errors and ADEs could have been prevented by using direct observation. The majority of errors were due to administration omissions, incorrect dose, medication, route or technique of administration, or poor communication between health care staff. Furthermore, it was shown that one preventable error was present for every five medication administrations. (4) Table 1 shows examples of different medication errors that may occur.

Stage	Type of error	Examples
Prescription	Confusion of "sound-a-like" or "look-a-like" medication	Vinblastine instead of Vincristine Cisplatin instead of Carboplatin
	Omission of treatment	Anticoagulation or antihypertensive treatment
	Wrong dose	2 mg instead of 20 mg Citalopram 20 mg instead of 200 mg Acebutolol
	Wrong drug	Inadequate antiseptic
	Wrong formulation	Tablets instead of injections, e.g. Morphine
Transcription/ Dispensing		1 mg instead of one tablets of Lercanidipine 20 tablets instead of 20 mg Hydrocortisone
Administration	Confusion of "write-a-like" drugs	Solumedrol instead of Salbutamol
	Inadequate administration	Absence of ethambutol in treatment of tuberculosis
	Wrong patient	-
	Wrong route	Injection of anaesthetics through an intraarterial catheter instead of intravenous catheter.

Table 1. Stage, types, and examples of medication errors. The medication errors seen in the table occurred at the Henri Mondor academic hospital group in Paris from December 2007 to June 2008. The examples are modified to Danish recommendations by the author. (23-25)

A study by Cina et al. (26) from 2006 showed that 3.6% of approximately 141,000 medication doses prepared for administration during a period of seven months at an American hospital contained some kind of error. Although only 0.75% of the medication dose errors were undetected by health care staff, it was concluded that such a relatively small percentage could translate into a large number of potential harmful errors depending on the number of medication doses needed. An error rate of maximum 0.00001% was defined as a possible aim. Additionally, an increase in not only vigilance, but also automatic and manual monitoring should help to decrease the number of errors as well as create a high level of consistency. (26) Several other studies have shown error rates of related to administration of 36% (27), 44% (28), and 61% (29) out of all medication errors; however the severity of the consequences varies between them. A study by Rothschild et al. (29) from 2005 showed that 16 out of 120 adverse events (13%) were life-threatening or potentially fatal.

The continuously, worldwide introduction of information technology (IT) and automation to the health care system has not only changed the medication management and been somewhat economically effective[1] (30,31). It has also increased patient safety by minimizing the potential associated risk of medication errors (31). At hospitals without such systems, nurses are responsible for dispensing and administration of medication (32). Several hundred administrations are made each day along with paperwork, stock management, and dispensing (32), but the use of IT has made prescribing, transcribing, dispensing, administration, and stock management faster and easier accessible (31,33). An example of such IT systems are electronic patient records (EPJ) (15), computerized practitioner order entry (CPOE) with patient-specific decision support (34,35), and electronic medication administration records (EMAR) (36). Therefore, IT is strongly recommended in general health care (30). However, certain types of medication errors, such as dispensing or administering the incorrect medication or dose to the incorrect patient, are not removed through the use of the mentioned It systems, as these mostly focuses on decreasing the number of errors during the prescription and transcription stages (12). Therefore, additional technological implementations and innovations are necessary to further improve the IT already in use (15,37).

The next sections focus on improvements through automation, including automatic medication dispensing, and current administration procedures and medication storage at Aarhus University Hospital Skejby.

[1] Although the non-recurrent expenses for implementing IT systems are high, it is estimated that American hospitals can save approximately $500,000 in direct costs by implementing and using IT systems. (34)

3.1 Increasing Efficiency and Patient Safety Trough Automation

An approach to increase the efficiency and reducing the number of the potential medication errors mentioned in the previous chapter was proposed in a health technological assessment (HTA) from 2000 by Aarhus University Hospital (15). The HTA indicated that the use of automatic dispensing of medication into patient-specific, single "ready-to-use" dose bags (unit doses) with unique bar codes would ensure the highest possible quality through high efficiency and safety during the dispensing and administration stage. (15) Besides for patient-specific use, unit doses can be produced for first dose administrations, "as needed" PRN, and "immediate" STAT, and can thus be stored in medication cabinets, carts, or shelves either central in the pharmacy or decentral in each ward (14). Only special medications, such as IV liquids, are manually dispensed (32). An example of a unit dose with a unique bar code label can be seen in Figure 3 and will be further described in section 3.2.

Figure 3. A unit dose containing bar code and information about the contents (38).

Automation of drug dispensing in connection with EPJ as well as the use of bar codes should ensure better documentation and greater accuracy during dispensing and administration, as the *right dose* of the *right drug* is delivered to the *right patient* in the *right formulation* at the *right time* during the day (the five rights (R's) of medication delivery) (31). Although EPJ, CPOE, or EMAR may not be available at all hospitals, it is still possible to make automatic dispensing function (39-41). Additionally, health care staff saves time from stock management, and their work effort can therefore be allocated to other stations or tasks to increase the general quality of patient care (34). Automatic medication dispensing systems (AMDS) are slowly gaining ground in the U.S. with 20% to 24% of the American hospitals having implemented systems in 2009 (37,42). In Denmark, only Aarhus University Hospital has implemented an AMDS (43).

A study by DeYoung et al. (37) from 2009 showed a 56% reduction in medication errors related to administration between pre- and post-implementing of an AMDS with bar code technology, while studies by Johnson et al. (44) from 2002 and Paoletti et al. (45) from 2007 showed reductions of errors of 86% and 54% respectively. Several other studies have also investigated the number of medication errors in the each of the five R's, and reductions in errors from 62% to 100% was seen in wrong dose, from 75% to 87% in wrong time, 75% in wrong drug, 93% in wrong patient, and from 70% to 92% in dose omissions (44,46,47). In 2007, Maviglia et al. (48) made a cost-benefit analysis of the implementation of bar code technology, which showed that the investment would be equalized within five to ten years, as $2.2 million was saved each year from ADEs with a net benefit of $3.49 million after five years. In the U.S., the use of bar codes on

original pharmaceutical pack delivered from manufacturers has been a requisite since 2004 (49), and the FDA estimates that 500,000 ADEs are avoided every year (50). Figure 4 summarizes the normal flow of medication management with possible errors and the possible solutions.

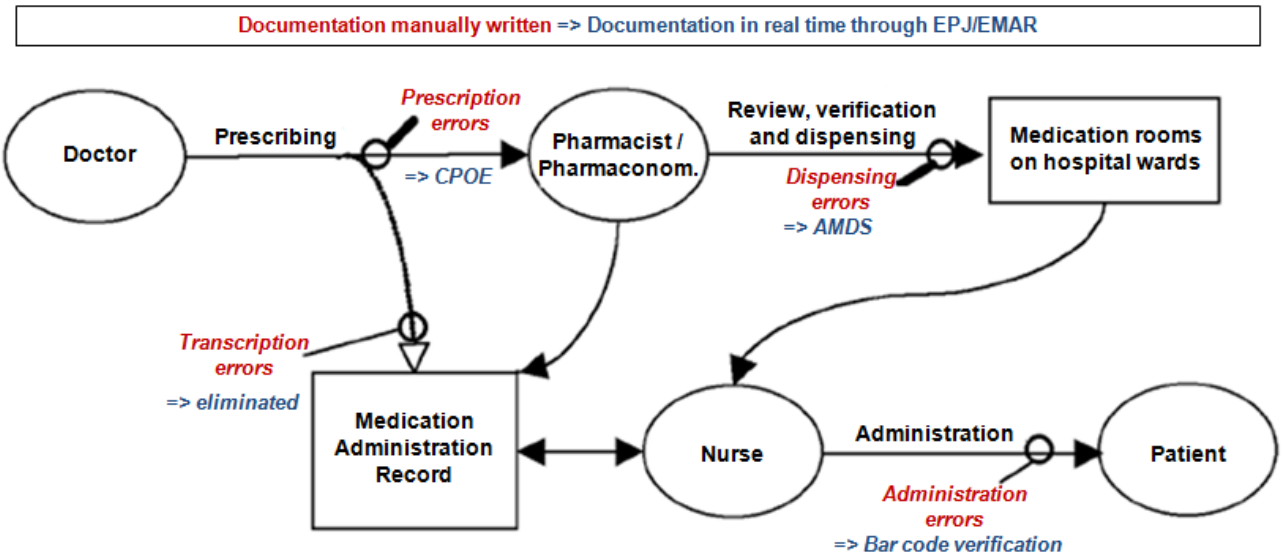

Figure 4. A normal flow of medication management with possible errors (marked red) and possible solutions (marked blue). During prescribing, the prescription errors may be avoided through the use of computerized practitioner order entry (CPOE). Transcription errors are completely eliminated, as the prescriptions are automatically registered in the electronic patient records (EPJ) or electronic medication administration records (EMAR). Errors in dispensing may be avoided though the use of automatic medication dispensing systems (AMDS). During administration, the bar codes on the patient wristband and medications are scanned, thus verifying the five R's (right patient, right drug, right dose, right formulation, and right time) and avoiding administration errors. ((19,34), modified by the author)

The usual process of administration of unit doses is for a nurse to bring them to the patient bedside. A portable PDA equipped with a bar code scanner is used to first scan the bar code on the patient wristband for identification, and then scan each unit dose for verification. The unit doses are only approved for administration, if each of the bar codes matches with the medication prescription on the PDA, and thus documenting the five R's. (20,37) Figure 5 shows the process of administrating unit doses through bar code scans.

(A) (B)

Figure 5. The administration of unit doses using bar codes. (A) Patient identification. The patient's wristband bar code is scanned to ensure that it is the right patient. (B) Unit dose verification. The unit dose bar codes are scanned with a PDA to verify the contents. If the unit dose bar codes match the medication prescription on the PDA, the unit doses may be administered to the patient. (51)

Although the use of AMDS' and bar code technology have shown to improve patient safety through fewer errors, increase the confidence of the clinical staff in automation, improve the economy, and save time compared to manual dispensing of medication (32,37,48,52), the implementation and use of AMDS' can still be improved (53). As previously mentioned, implementing AMDS' in American as well as Canadian hospitals are slow due to several reasons such as lack of health care staff acceptance, bad IT performance with bottlenecks arising, or poor patient outcome (12,54). Furthermore, the variation of supportive evidence in the literature or lack thereof also plays a significant role (32,54), as most are publications made by manufacturers and originates from low evidence case studies performed at smaller hospitals or wards. Balka, Kahnamoui, and Nutland (32) describe the existing literature as utopian visions, which fully guarantee increased efficiency and cost savings without the corresponding degree of evidence needed.

In Europe, several hospitals and international studies have so far witnessed similar challenges with the implementation and use of AMDS'. In 2006, the pharmacy of Aalborg Hospital in Denmark had to discard a 10 million DKK AMDS, because the software had too many glitches, leading to a high number of errors (55). A study by Bohand et al. (56) from 2008 investigated the number and types of dispensing errors in an AMDS in a French military hospital. During the nine month study, all unit doses were checked by pharmacists to categorize the different type of error that could arise, e.g. incorrect formulation, incorrect dose, expired or damaged medication, and incorrect patient. 706 errors were detected in approximately 89,000 unit doses, setting the margin of error at approximately 0.80%. The study showed that all unit doses must be continuously inspected following dispensing to prevent errors and thus increase patient safety. (56)

In extension thereof, Carayon et al. (57) and Vicente (58) also pointed out that although IT and automation has the potential to improve health care and patient safety, one must still be aware that human errors cannot be completely eradicated (57,58), as the path from medication prescription to administration involves multiple cognitive mechanisms of the human mind, e.g. decision making by doctors and nurses (59) and repetitive, often fatiguing tasks (42). It is therefore recommended that all patients receiving medication through automatic dispensing in American hospital should have their prescriptions reviewed by doctors and pharmacists prior to administration, as automatic dispensing may lead to a continuous repetition of inappropriate or incorrect medication administration with potential dangerous outcomes, if it is not corrected (60).

Implementing IT in health care often leads to unwelcome changes in daily tasks and workflow, the duration and efficiency thereof, communication between health care staff and wards, general planning and organization, economy and unseen expenses etc. Additionally, it is necessary to systematically ensure the most flawless interaction between IT systems as well as between the system interface and the end user, as patient safety may be compromised, health care staff workload increased, and workflow impeded by bad IT performances. (30,31,57) Optimisation of such parameters must be assessed prior to implementation for it to be as thorough as possible, because the ultimate end goal is safer and more efficient administration of medication to the patients. Automation of medication dispensing does not necessarily ensure this, unless all pitfalls are thoroughly explored and assessed (57,61).

3.2 Automatic Medication Dispensing in Aarhus University Hospital

An AMDS (PillPick Pharmacy Automation System, Swisslog, Switzerland) was installed in the hospital pharmacy at Aarhus University Hospital Skejby in 2004 as part of a pilot study (62). Although the acquisition of an AMDS would be expensive, it was estimated that the implementation of an AMDS would save the hospi-

tal from 0.9 to 2.4 million DKK a year primarily through a smaller ward medication stock, a reduction in wastage, and less manual dispensing of medication (15). The total costs of the PillPick AMDS with a bar code solution were 21.5 million DKK (62). An evaluation of the pilot study showed that despite alteration in work flow, the health care staff was confident in the automatic dispensing of medication, as they believed it had increased the patient safety as well as saved time on manual dispensing of medication (62). As of February 25th 2011, 152 different medications can be packed by the PillPick AMDS; several of the medications having two or more available doses (63). However, this is only a small part of the entire medication selection at the hospital. Eventually, the use of unit dose medication will be expanded as additional departments and wards are included in the automatic dispensing procedure (18,62).

The PillPick AMDS is directly connected to the EPJ medication module (Systematic Columna, Aarhus, Denmark). All prescriptions made by the doctors are registered and thus presented in the PillPick AMDS software. However, in comparison to the U.S., all electronic medication prescriptions at Aarhus University Hospital are not verified by pharmacists, but pharmaconomists goes over the prescriptions once a day (43). The connection between the EPJ and the PillPick AMDS ensures that the medication can be automatically dispensed into either a 24 hour, patient-specific bar code labelled unit dose collection or a treatment-specific unit dose collection (51,62). Table 2 shows the major events of the AMDS at Aarhus University Hospital Skejby.

Year	Event
2000	HTA on automation of medication dispensing published
2004	AMDS installed in the pharmacy at Aarhus University Hospital Skejby
2006, April	Dispensing and delivery of treatment-specific unit dose collections for specific treatments initiated, e.g. pain management and medication-induced abortions. Delivery to surgery outpatient departments for patients to take home following surgery.
2007, October	Pilot study with patient-specific unit doses at the Department of Infectious Diseases Q at Aarhus University Hospital Skejby. Prescriptions through EPJ, and nurses use PDA's to identify correct patient and unit doses through bar code scans.
2008, October	Four-month study on the effect of an AMDS on patient safety initiated
2009, January	Dispensing and delivery of patient-specific unit doses to the Department of Geriatrics G at Aarhus Hospital. Documentation through PDA not used.
2009, March	Full functional dispensing and delivery of unit doses to the Department of Infectious Diseases Q at Aarhus University Hospital Skejby.
2011 - 2012	Pilot study regarding implementation of electronic medication dispensing cabinets. HTA is to be completed by late fall of 2012.

Table 2. Major events of the automatic medication dispensing system (AMDS) at Aarhus University Hospital Skejby from 2000 to 2012. HTA: Health Technological Assessment. EPJ: Electronic Patient Journal (electronic patient record). PDA: Personal Digital Assistant. ((62), modified by the author)

The PillPick AMDS consists of five sections and a software module: *AutoBox* (placing of PillBoxes with tablets), *AutoPhial* (placing of PhialBoxes with blisters, ampoules etc.), *PillPicker* (dispensing of medication in unit doses), *DrugNest* (computer controlled storage of all unit doses), *PickRing* (connection of patient-specific or treatment-specific unit doses in a plastic ring), and *PillPick Manager Software* (prescriptions from EPJ, safety, monitoring, and stock management). In addition, a conveyer belt is attached to the *PickRing*, which transports and collects the unit dose rings in a box, which is followed by manual sorting for each ward. Figure 6 illustrates the different sections of the PillPick. (38)

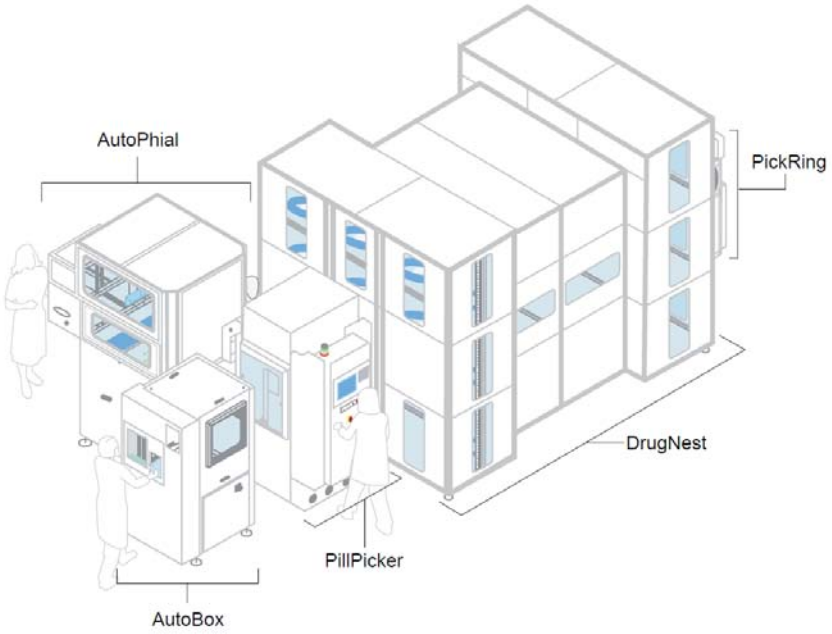

Figure 6. The PillPick AMDS from Swisslog, which consists of the AutoBox for placing of PillBoxes with tablets, the AutoPhial for placing of PhialBoxes with blisters and ampoules etc., the PillPicker for dispensing of medication in unit doses, the DrugNest for storage of unit doses, and the PickRing, which connects patient-specific or treatment-specific unit doses in a plastic ring. (38)

A PillBox is a sealed, sterile bar code labelled box containing a specific medicament (38). Every PillBox is filled and sealed in the hospital pharmacy in Aarhus University Hospital Nørrebrogade and transported to storage shelves in the hospital pharmacy at Aarhus University Hospital Skejby (64). According to new regulations, each PillBox can be stored up to three months, before the contents are discarded (43). However, as some medications may have a shorter shelf life, these are replaced more often (43). Additionally, the PillPick AMDS is not equipped to dispense medication that must be stored in a refrigerator or in airtight or amber containers, thus these are stored traditionally (38).

When a medicament is needed for dispensing, the bar code on the box containing the drug is scanned by an AMDS technician at a computer station next to the PillPick AMDS. If the bar code is consistent with the medication order in the software, the box is approved and may be placed in the *AutoBox*. The same applies to the *AutoPhial*, in which a PhialBox containing blisters, ampoules, syringes, vials, or cups can be placed. Besides a bar code, each PillBox and PhialBox is equipped with a radio frequency chip set (RFID), which is automatically scanned multiple times during dispensing to verify the content of the box, compare the contents to the medication prescription, and preparing the PillPicker with a size-fitting unit dose. (38) Figure 7 illustrates a selection of PillBoxes and a PhialBox respectively.

(A) **(B)**

Figure 7. Boxes for the PillPick AMDS. (A) A selection of PillBoxes, each containing a specific medicament. (B) A PhialBox containing a specific medicament dispensed in ampoules. (38)

The *AutoBox* may contain up to twelve different Pillboxes on the built-in circular plate. The AMDS technician places a PillBox on a conveyer belt and it is automatically loaded into the AutoBox, before it is loaded onto the plate. The RFID chip is scanned for verification, and the lid of the specific PillBox needed is unlocked and removed via air compression. Following verification, the PillBox is lifted into the PillPicker. When dispensing is completed, the matching lid is automatically reattached and sealed, and the PillBox is released for storage or cleaning and refilling. (38)

In the *AutoPhial*, a PhialBox is loaded, and the RFID chip is scanned for verification. If approved, the lid is unlocked and removed via air compression. Every blister, vial etc. is picked up separately and dropped into a cup one at the time by a pipe with compressed air. The cup is transported into the PillPicker and drops the drug into a size-fitting unit dose. (38)

Inside the *PillPicker*, every tablet from the PillBox is picked up separately by a new pipe with compressed air. The tablet is dropped into a size-fitting unit dose and sealed. If necessary, several tablets are packed together depending on the dose of the medication (38). However, at this point only few medications are packed two-by-two or more (43). Each unit dose is labelled with separate bar codes and medication data such as brand name, generic name, serial number, formulation, date of expiration etc. The bar code is scanned, and unit dose is sealed (38). Table 3 shows the specifications of a unit dose.

Unit dose specifications	
Material	Biaxial oriented polypropylene film
Size	74 mm
Length	55 – 195 mm
Information on unit doses	Brand name Generic name Date of expiration Dose Formulation Serial number Lot number BPOC bar code, linear or 2D Supplier lot number

Table 3. Unit dose specifications. BPOC: Bedside Point of Care. (38)

Each sealed unit dose is automatically transported from the *PillPicker* to a predetermined pin in the *DrugNest* for temporary storage (38). Figure 8(A) illustrates a section of storage pins inside the *DrugNest*. Every single pin of the 5,328 pins in total can hold up to ten unit doses each, which makes the capacity up to 53,280 unit doses (38,62). The dispensing frequency of the system is 7,000 unit doses per day, which corresponds to the current medication consumption at Aarhus University Hospital Skejby (62). The *DrugNest* is fitted with a robot at the entry and exit points respectively, making it possible to store and dispense concurrently. If a unit dose expires, it will automatically be discarded from the *DrugNest*. Additionally, it is possible to recycle unused, uncontaminated unit doses returned from the wards and place them manually in the *DrugNest*. (38)

When a 24 hour patient-specific unit dose collection is needed, the *DrugNest* will deliver the unit doses to the *PickRing*, which automatically assembles the respective unit doses together on a plastic ring, either alphabetically by drug name or by time of administration. A label containing bar code and patient information is placed in front of the unit doses. (38) Each unit dose ring is transported to a box for manual sorting for each ward. During sorting, the AMDS technician inspects the appearance of the content in each unit dose (43). Figure 8(B) illustrates a 24 hour patient-specific unit dose collection.

(A) (B)

Figure 8. Inside the DrugNest and PickRing. (A) A section of storage pins inside the storage module, DrugNest. Each pin contains unit doses of a specific medicament. (B) A 24 hour patient-specific unit dose collection. (38)

3.2.1 Current Medication Administration Procedures at Aarhus University Hospital Skejby

The unit doses dispensed in the PillPick AMDS are currently delivered from the hospital pharmacy to the medication rooms at the Department of Infectious Diseases Q1 and Q2, both at Aarhus University Hospital Skejby, as part of a combined central/decentral pharmacy model (15,62,65). Besides patient-specific unit doses, the two wards also has a local storage of PRN medication in unit doses and additional solid and liquid medications in original packs, which are stored on shelves by ATC codes or in a refrigerator. The current storage generally resembles a traditional medication room. In addition, the hospital pharmacy delivers patient-specific unit doses to the Department of Geriatrics G1 and G2 at Aarhus Hospital once a day as well as treatment-specific unit doses to several surgical and gynaecological wards in hospitals in Region Midtjylland. The collections of treatment-specific unit doses can be seen in appendix 1 and appendix 2. (62)

At Q1 and Q2, patient-specific unit doses were previously delivered two times a day for administration between 8.00 to 16.59 and 17.00 to 7.59, but as of May 23rd 2011 the delivery takes place once a day at 15.30. All unit doses dispensed by the PillPick AMDS are placed in separate boxes for each patient room, which is stacked in two larger baskets for Q1 and Q2 respectively and placed on a cart. The cart can be seen in Figure 9. A pharmaconomist takes the cart to the two respective medication rooms. A cart inside the medication room has several room-specific slots, where each box with patient-specific unit doses can be placed. The pharmaconomist replaces the empty boxes in the cart with the newly unit dose-filled boxes. Following delivery, the pharmaconomist takes the cart and unused and uncontaminated, or expired unit doses back to the hospital pharmacy. The local storage of unit doses and other medications is inspected and refilled each Monday and Thursday by a pharmaconomist.

Figure 9. The cart used to transport patient-specific unit doses to the Department of Infectious Diseases Q1 (top basket) and Q2 (bottom basket) respectively. Each of the blue boxes contains patient-specific unit doses for each patient room. (Picture by the author)

At the time of administration, the nurse picks up the ring of patient-specific unit doses needed. The nurse logs into the EPJ on a stationary computer; cross checks each unit dose with the prescriptions, inspects the condition of each unit dose, and approves the medication in the EPJ. The nurse brings the unit doses to the

patient. The patient wristband is scanned with a Motorola ES400 PDA followed by a scan of each unit dose. Following approval of all unit doses, the medication can be administered to the patient. (51)

At Aarhus University Hospital Skejby, the use of the EPJ and the AMDS has made prescriptions, dispensing and central storage of medication in unit doses more effective in spite of some of the previously mentioned disadvantages of IT implementation. However, new ways of decentral medication storage in ward medication rooms or medication cabinets are still under investigation, as these may be optimized. Saving time for health care staff, better stock management and overview, and improving documentation of medication transactions are a few of the areas that could benefit from an optimization. (42,53)

3.3 The Implementation of Electronic Medication Dispensing Cabinets

Electronic medication dispensing cabinets (EMDC) are computer-controlled, stationary cabinets of various sizes for secure storage of medication (32), which can be compared to ordinary vending machines, where a specific food product is selected and purchased. The first EMDC was available for purchase in 1961 in the U.S., and during the late 1980's and the 1990's several modern EMDCs were developed (15,66). The EMDCs contain a self-imposed selection of drawers of different sizes and numbers depending on the type of medication, whether it is unit doses, packs, vials, or IV liquids. The cost of each EMDC generally depends on the drawer setup and the level of security. Additionally, all drawers can be assigned to a variable level of security depending on the medication type, e.g. open drawers, lighted drawers, or lidded drawers, and the EMDCs are equipped with confidential user ID logins, colour touch screens, bar code scanners, and fingerprint readers. (32,67,68). A general EMDC setup normally consists of a main cabinet with the touch screen, an auxiliary cabinet, and a supply tower.

Following login, a patient profile is selected by the user, and a medication list or schedule appears on the screen. The required medication is selected, and the user type in the remaining number of medications e.g. tablets, blisters, or ampoules. A designated drawer or drawer compartment opens, and the medication can be extracted for administration. (32) In case of power failure, most EMDCs can be accessed from behind by manual key unlocking (40). As with the AMDS, the EMDCs may be connected to existing CPOEs, EMARs, or EPJs, where patients, prescriptions, and stock can be seen and approved of (67-70). EMDCs of different setups are commonly located in medication rooms in wards, surgical rooms, or emergency departments, where access to medication is needed (32). As an alternative to the stationary EMDCs, mobile carts with computer-controlled drawers are also available (71). Figure 10 shows examples of an EMDC, different drawer setups, and a mobile cart.

(A) **(B)** **(C)**

Figure 10. Electronic medication dispensing cabinets (EMDC) and drawers. (A) An EMDC from McKesson (67). (B) Examples of drawers fitting the EMDC from McKesson. The upper is an open drawer, and the lower is a locked lidded drawer (67). (C) A mobile cart from MTS (72).

As previously mentioned, the lack of evidence in the EMDC publications is apparent. Based on low evidence case studies from a few hospitals, the manufacturers report that money and time can be saved. Additionally, the few and mostly older studies conducted on cost-savings following implementation of EMDCs generally showed mixed results. While some are against implementing EMDCs in hospitals due to lack of evidence (73,74), a study by Lee et al. (75) indicated that the total costs of an implementation may be high, but the financial benefits from allocation of health care staff time as well as improvements in service and revenue, and billing efficiency could justify the implementation. A study by Schwarz and Browody (76) showed that a hospital with approximately 380 beds saved $1 million over a five-year period by installing 23 EMDCs. A study by Wise et al. (77) investigated the costs before and after implementation of EMDCs. The study indicated that cost-savings were only present, when health care staff time savings were included (77). Mixed opinions and results are also seen regarding potential reductions in medications errors and increased nurse time saving (15,32). It is clear that new cost-benefit analyses in modern settings must be made in order to produce evidence supporting an implementation of EMDCs (32), as it may be beneficial for both larger and smaller hospitals (48).

3.4 Collaboration with the Hospital Pharmacy at Aarhus University Hospital

Through collaboration with the hospital pharmacy at Aarhus University Hospital Skejby, the author participated in the first phase of a hospital pharmacy project and pilot study that is to evaluate a potential implementation of stationary EMDCs throughout all wards in the New University Hospital in Aarhus by 2019. All medication should be stored in the EMDCs as unit doses and dispensed by the PillPick ADMS. (53) The EMDCs must still contain the same stock of medication, and the EMDCs should have a high level of security. Additionally, the procedure for nurses in delivering unit doses and other medication from the medication room to each patient for administration is not to be changed for the time being. (18) The hospital pharmacy project is divided into seven phases: 1) A market assessment and user requirements, 2) composing of requirement specifications and materials for invitations to submit tenders, 3) period of tenders, 4) medication management survey prior to installation, 5) installation, validation, and implementation of an EMDCs in two wards (wards are to be determined), 6) medication management survey subsequent to installation, and 7) completion of a HTA. The hospital pharmacy project was initiated in February 2011 and will be finished in the late fall of 2012. (18) An outline of the course of the hospital pharmacy project can be seen in Table 4, and Figure 11 illustrates the concept of a complete, automated medication management flow from dispensing to administration, as it should be at the hospital wards.

Duration (month and year)	Phase	Event
February 2011 – May 2011	1	Market assessment and user requirements
June 2011 – August 2011	2	Requirement specifications, invitations to submit tenders
September 2011 – October 2011	3	Period of tenders
November 2011 – January 2012	4	Survey prior to installation
February 2012 – May 2012	5	Installation, validation, and implementation in two wards
June 2012 – September 2012	6	Survey subsequent to installation
August 2012 – December 2012	7	Completion of a health technological assessment

Table 4. An outline of the course of the hospital pharmacy project from February 2011 to December 2012. (18)

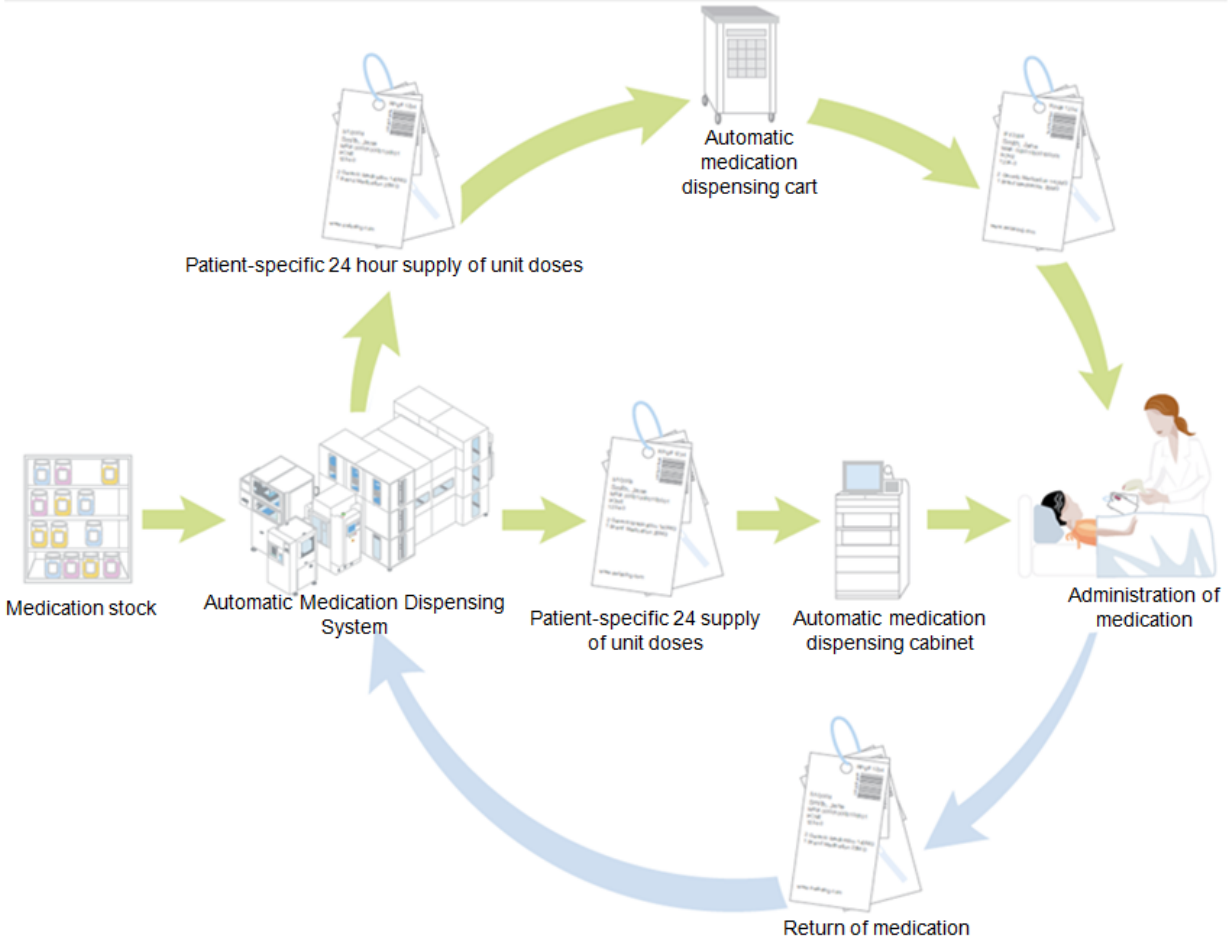

Figure 11. The concept of a complete automated medication flow. ((38), modified by the author)

4 Hypothesis & Aim

The implementation of AMDS' has been shown to not only improve the safety of patients through fewer medication errors, but also increase efficiency of medication dispensing and thereby the overall quality (33,34,37). However, the manner of delivering medication from the hospital pharmacy and AMDS to the respective ward medication rooms for storage has still not reached its full potential for automation, thus this step can be further optimized. The goal of the hospital project is thus to evaluate, if an implementation of EMDCs are beneficial for the wards and the hospital pharmacy itself. The combined use of the PillPick AMDS for dispensing of unit doses and the EMDC for decentral storage should provide better documentation of medication dispensing and administrations. If the medication cannot be dispensed as unit dose, it will remain in its original pack or vial, but stored in the EMDC as well. Additionally, the potential for allocation of resources (time, money etc.) to other areas as well as gaining a better medication stock management and refilling procedure may also be achieved, as some procedures are to be automated. However, due to little evidence in the published literature available regarding the use and effectiveness of the EMDCs, it is necessary to first explore the market to find the EMDC most suitable for implementation. Following the market assessment, one EMDC should stand out from the others as the most suitable for the upcoming pilot study.

The aim of this project was to 1) assess the current market of EMDCs and 2) evaluate which EMDC would be most suited and beneficial for the wards and hospital pharmacy at the New University Hospital in Aarhus.

5 The Market of Electronic Medication Dispensing Cabinets

In this chapter, the different EMDCs currently available on the market are described with regards to their appearance, functionality, and technical specifications. At this point, no wards at Aarhus University Hospital have yet been chosen to participate in the surveys, but the only requirement is that the participating wards should have a large flow of patients to fully investigate to capabilities of the EMDC (18). Currently, the wards do not administer unit doses, and all medications are thus delivered in and administered directly from the original packs. During the surveys, the wards should receive as much medication in unit doses as possible. Therefore, the following evaluation focus on a fictitious implementation in the medication rooms in the before-mentioned Department of Infectious Diseases Q, as these wards are already using unit doses.

The standard stock at Department of Infectious Diseases Q may be larger than in normal wards (43), as many different infectious diseases are treated at the two wards. During implementation of the PillPick AMDS, it was decided that the two wards should have access to as many different doses of medications as possible (43). As mentioned in the previous chapter, the medication rooms in the two wards resembles traditional medication rooms, thus they may appear inadequately organized, and although routines for stock management and refilling have been running since the beginning of the pilot study in 2007, it is still time- and resource-consuming. So far, an EMDC seems like a good choice to make the medication rooms simpler, improve stock management, and save time for health care staff.

Prior to the initial market search, the pharmacist Helle Jespersen from the hospital pharmacy at Aarhus University Hospital Skejby and the author completed a SWOT analysis on the implementation of EMDCs in order to make the advantages and disadvantages clear. Internal factors (**s**trengths and **w**eaknesses) and external factors (**o**pportunities and **t**hreats) were considered, and some factors can be both an advantage and a disadvantage (78). Table 5 shows the internal and external factors of the SWOT analysis.

SWOT analysis: Implementation of Electronic Medication Dispensing Cabinets		
	Strengths (+)	**Weaknesses (-)**
Internal factors	• Support from the hospital management. • Better documentation of transactions. • Unit dose dispensing. • Use of unit doses provides overview of total treatment costs.	• Lack of evidence in literature on patient safety. • Loss of efficiency during period of implementation. • Funds must be raised to complete project. • Lack of support from survey wards
	Opportunities (+)	**Threats (-)**
External factors	• Better overview of medication. • Automatic management of stock => save resources and time from manual refilling. • Automated medication dispensing => save resources and time from manual dispensing. • Automatic control of expiration • All prescriptions are reviewed by nurses. • Decrease in waste and loss of medication. • Better management of controlled drugs. • Fewer medication errors. • Increased patient safety. • Reduced stock value (one-off saving). • Better control of temperature. • Saves space inside medication room	• Bad IT performance => waiting time. • Non-user-friendly interface. • Non-acceptance by end users. • Bottlenecks when nurses extract medication. • Increased time consumption during refilling • Increased time consumption during dispensing • Increase in waste and loss of medication • High non-recurrent expense • Dispensed unit doses only valid for three months • Increased time consumption during prescription reviews • Increased time consumption during control of expiration

Table 5. A SWOT analysis of the implementation of EMDCs, including internal factors (strengths and weaknesses) and external factors (opportunities and threats). (By (18) and the author)

A statement from 2010 by the American Journal of Pharmacy Purchasing & Products showed that the EMDCs by Carefusion, Omnicell, and McKesson are the most used EMDCs in the U.S. with approximately 60%, 20%, and 15% market share respectively (79). Metro, AmerisourceBergen, MDG Medical, Cerner, and MTS as well as other smaller manufacturers each have a 3% market share or less (79). Following the SWOT analysis, an extensive literature and market search was performed, and sixteen EMDCs from twelve manufactures were found promising. Figure 12 shows the market shares for the major manufacturers in the U.S. from 2008 to 2010, and Table 6 shows the EMDCs of interest and their main specifications.

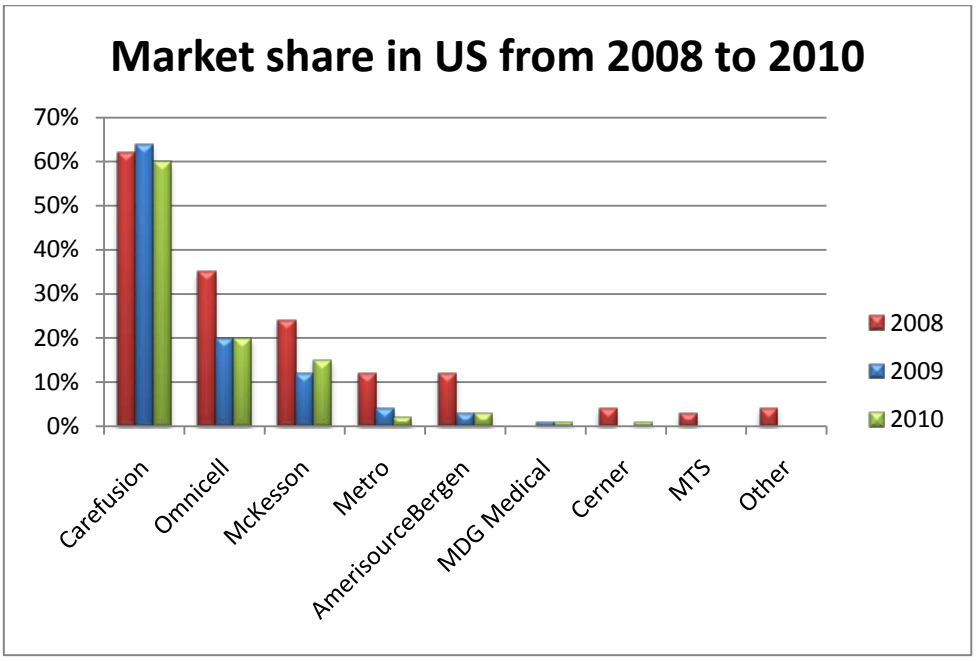

Figure 12. The market share from 2008 to 2010 in the U.S. for the major manufacturers of electronic medication dispensing cabinets (EMDC). The main manufacturer of EMDCs is Carefusion followed by Omnicell, McKesson, Metro, AmerisourceBergen, and MDG Medical. However, it should be noted that some institutions and hospitals in the survey have EMDCs from several manufacturers, thus the total percentage for each year exceeds 100%. (79-81)

Manufacturer	Name	Type	Configurable drawers	Auxiliary units	Security
Omnicell 	OmniRx G4	Cart	Yes (6 types)	• Additional stationary cabinets may be connected to the main cabinet.	• User ID and password • Biometric ID • Bar code scanner • Guiding lights
Omnicell 	OmniRx G4	Cabinet	Yes (6 types)	• Additional stationary cabinets may be connected to the main cabinet.	• User ID and password • Biometric ID • Bar code scanner • Return bin • Remote lock • Guiding lights
CareFusion* 	Pyxis® MedStation® 4000	Cabinet	Yes (5 types)	• Drawer auxiliary • Column Auxiliary (half-height, single, or double)	• User ID and password • Biometric ID • Bar code scanner • Return bin • Remote lock • Guiding lights
Cerner 	RxStation®	Cabinet	Yes (7 types)	• Controlled Substance Vault • Supply Tower • Supply Module	• User ID and password • Bar code scanner • Return bin • Remote lock • Guiding lights

CareFusion* 	Pyxis® CIISafe™ System	Cabinet	No (Only shelves)	• Column Auxiliary (single or double)	• User ID and password • Bar code scanner
Health Tech 	Dispenseren Minidispenseren Kabinettene	Cabinet	Partly (Several types)	-	• Unknown security • Remote lock
MTS 	MedLocker or MedLockerMini	Cabinet	No (Only slots for MTS packed medication)	• Additional cabinets may be connected to the main cabinet.	• User ID and password • Bar code scanner • Guiding lights
MTS 	MedTimes	Cart	No	-	• User ID and password • Bar code scanner • Guiding lights
Metro 	medDispense Series ** Base 25 / 45 / 72	Cabinet	Partly (2 sizes)	• Combo Tower • Supply Tower • Auxiliary Cabinet • Auxiliary Supply	• User ID and password • Biometric ID • Bar code scanner • Return bin (2 sizes) • Remote lock
MDG Medical 	ServeRx™	Cabinet	Yes (3 types)	• Supply Cabinet • Refrigerated Module	• User ID and password • Bar code scanner
MDG Medical 	SmartCart	Cart	Yes (Several sizes and numbers)	-	• User ID and password • Biometric ID • Bar code scanner
AmerisourceBergen 	MedSelect® Flex™	Cabinet	Yes (Several)	• SupplySelect® Tower	Unknown
McKesson 	AcuDose-Rx Large or AcuDose-Rx Small	Cabinet	Yes (4 types plus subtypes)	• Supply Tower • Large Aux. Cabinet • Small Aux. Cabinet	• User ID and password • Biometric ID • Bar code scanner • Return bin • Remote lock • Guiding lights
MEPS Real Time 	Intelliguard Auto-mated Dispensing Cabinet	Cart	Partly (2 types)	-	• Refrigerated option • Guiding lights
Swisslog 	MedRover™***	Cart	Partly (3 containers)	-	• User ID and password • Biometric ID • Bar code scanner
KRZ 	Autodrugs™	Cabinet		• Refrigerated module	• User ID and password • Spiral storage

Table 6. A list of electronic medication dispensing cabinets (EMDC) of interest. The list contains the name of the manufacturer, the name of the EMDC, the type (cabinet or cart), number of configurable drawers, number of auxiliary units, and measures of security. Biometric ID: Login through a fingerprint reader. Return bin: Box for medication to be returned to the pharmacy. Remote lock: An EMDC-controlled lock on a refrigerator door. Guiding lights: A flashing light indicates which compartment or section to pick medication from. *Carefusion was previously called CardinalHealth. **medDispense Series can also be purchased from Healthmark. ***MedRover™ can also be purchased from Sabal Medical, Inc. under the synonym sabalKOW™. (67-72,82-88))

During the initial market search, several EMDCs or carts were found unsuitable for Aarhus University Hospital. The *MedSelect® Flex™* cabinet from AmerisourceBergen and the *Dispenseren* cabinet from Health Tech in Norway were omitted due to little or no information from the manufacturers and websites. Although *Autodrugs™* from KRZ contains spiral storage comparable to vending machines, which ensure that the drugs with the lowest expiration date is extracted first, it was also omitted due to lack of information from the manufacturer and website. The *MedLocker* cabinet and *MedTimes* cart from MTS were omitted, because it required medication packed in specific unit dose punch cards. The punch cards are produced by MTS, thus it is not possible to fill the cabinet or cart with PillPick AMDS unit doses. The punch cards can be seen in Figure 13.

(A) **(B)** **(C)**

Figure 13. The MTS MedLocker cabinet and MedTimes cart were omitted due to medication packed in specific unit dose punch cards (A), which were only produced by MTS. The punch cards can only be inserted into the cabinet (B) or cart (C). ((A) and (B) from (85), (C) from (72))

The *MedRover* cart from Swisslog was omitted, because it is only available in North America. There are no existing plans regarding marketing or sales activities in the European market. (89) Also the carts by MDG Medical, MEPS Real Time, and Omnicell were omitted, as the carts do not have enough space for all types of medication located inside the medication room. Implementing carts would also create time-consuming problems, as only one nurse could use it at a time, leading to a long waiting time for other nurses at the ward, if they have to wait for the cart to be returned to the medication room or nurses station.

The remaining seven EMDCs were found suitable and can be seen in Table 7. The seven EMDCs are stationary; has different, flexible options for configuration (different drawers and auxiliary cabinets); high security options (biometric ID, guiding lights, and remote locks), and bar code scanners. Furthermore, the EMDCs were selected in the light of email responses from the manufacturers and available website materials.

The Seven EMDCs			
OmniRx G4	**Pyxis® MedStation® 4000**		**RxStation®**
			
Omnicell	**CareFusion**		**Cerner**
Pyxis® CIISafe™ System	**medDispense Series**	**ServeRx™**	**AcuDose-Rx**
			
CareFusion	**Metro**	**MDG Medical**	**McKesson**

Table 7. The seven EMDCs found suitable for a potential implementation in the New University Hospital in Aarhus. Specifications can be seen in Table 6 and appendix 5 to 11. (Pictures from (67-70,82,83,90))

The next sections focus on the author's study trip to London, England, where several sites with implemented EMDCs were visited; the hospital pharmacy project budget; and the current arrangements in the medication rooms in Department of Infectious Diseases Q1 and Q2.

5.1 Visit to Manufacturer and Hospitals in London, England

During a three-day trip to London, England, in April 2011, several sites were visited to see EMDCs in use in hospital environments. The EMDCs were the *RxStation®* in a fictitious clinical setup at Cerner UK Collaboration Centre; the *Pyxis® MedStation® 3500* and *Pyxis® CIISafe™ System* by Carefusion and the *ServeRx™* by MDG Medical at the Charing Cross Hospital; the *Pyxis® MedStation® 3500* at the Bupa Cromwell Hospital; and the *OmniRx G3* by Omnicell at Saint Thomas Hospital.

At Charing Cross Hospital, five *Pyxis® MedStation® 3500s* were installed in two cancer wards, two intensive care units, and one medical ward, and one *Pyxis® CIISafe™ System* was installed in the pharmacy. Additionally, a *ServeRx™* was installed in an emergency ward. The hospital used the EMDCs for controlled drugs, except for the *ServeRx™*. A Swisslog Pack-Picker was also installed in the pharmacy. This system was responsible for storage and retrieval of medications in original packing. The EMDCs were installed as part of a pilot study to gain experience with automation. Following implementation of EMDCs, approximately four hours of stock management were saved per week for pharmacists and pharmaconomist. (39)

At Bupa Cromwell Hospital, a *Pyxis® MedStation® 3500s* was installed in all wards except operating rooms. An average of 20 to 30 beds is supported by an EMDC setup one main cabinet, an auxiliary cabinet, and a supply tower. All medication and controlled drugs were stored in the EMDCs. (40)

At Saint Thomas Hospital, all 29 wards had an *OmniRx* setup. Their size depended on the ward medication consumptions and general stock. In average, 28 to 30 beds were supported by an EMDC setup of three to

six modules. All medications and IV fluids were stored in the EMDCs except controlled drugs, which were stored in separate, key-locked cabinets at the nurse's station. In March 2011, the Hospital saved approximately 228,000 DKK (£27,000) on medication returns. (41)

The visits provided a great insight into how the EMDCs function, interact with health care staff, and can be organized to obtain the highest possible functionality in a hospital setting. The EMDCs at each hospital were only connected to a patient admission system for registration of name and a specific ID number, which would be displayed on the EMDC immediately after admission (39-41). It was noted that none of the hospitals had implemented CPOE or EMAR, thus the nurses were still transcribing the doctor's handwritten prescriptions, before extracting medication from the EMDCs (39-41). Additionally, the nurses at Charing Cross Hospital were responsible for collecting the medication at the pharmacy and refilling their EMDCs (39), whereas pharmacists at Bupa Cromwell Hospital were responsible for the refilling (40,41). The nurses at Saint Thomas Hospital were responsible for the refilling following delivery of medications by pharmacists (41). The EMDCs were generally refilled two to three times a week, but some wards had their EMDCs refilled once every day (39-41). Lastly, incorrect use and management of stock by the nurses at all hospitals continuously lead to discrepancies, which were to corrected by pharmacy staff, thus increasing the work load (39-41).

5.2 The Hospital Pharmacy Project Budget

A project budget was made prior to the study trip to London and the composition of requirement specifications. However, as the total costs are currently unknown, the budget is based on estimations, thus it may not be harmonious with the actual costs. The hospital pharmacy can only provide financial support of 1,000,000 DKK, thus applications for several funds were made during the spring of 2011 (18,91). The project budget consists of five points (EMDC price, interface development, staff wages, study trip, and medication room renovation) and can be seen in Table 8.

Project budget	Amount
1. Purchase of two EMDCs • Estimated price for one EMDC setup: Approximately 1,000,000 DKK	2,500,000 DKK
2. Development of an interface between the EMDC and EPJ and Apovision	625,000 DKK
3. Staff wages (2¼ year's work for one person) • Survey prior to installation o ½ year pharmacist • Installation, validation, and implementation o ½ year IT staff and ½ year pharmacist/pharmaconomist • Survey subsequent to installation and HTA o ½ year pharmacist and ¼ year pharmaconomist	1,000,000 DKK
4. Study trip to London, England	25,000 DKK
5. Renovation of two medication rooms • Including room temperature controlling and CTS	400,000 DKK
Total amount	**4,550,000 DKK**

Table 8. The hospital pharmacy project budget. It includes five points (purchase of EMDCs for two wards; development of an interface with EPJ and Apovision; Staff wages; Study trip to London, England; and renovation of two medication rooms), which mounts up to 4,550,000 DKK. DKK: Danish crown (currency). EMDC: Electronic medication dispensing cabinet. EPJ: Electronic patient journal (electronic patient record). Apovision: The pharmacy accountancy system. HTA: Health Technological Assessment. CTS: Central Tilstandskontrol og Styring (Central monitoring of condition and control). (91)

5.3 Current Arrangement in Medication Rooms and Procedures

As seen in the budget above, it is necessary to renovate the medication rooms at Q1 and Q2 to some extent, which will also be the case during the actual pilot study. The area of the medication rooms is approximately 12.6 m^2 (depth: ≈4.50 m; width: ≈2.80 m), thus being rather big compared to medication rooms in other wards (18). The left side of the room (Figure 14(A)) has a washbasin; two wall-mounted EPJ computers; eight shelves with medication plus one extra larger shelf; and a small shelf next to the window with five PDA docking stations. The right side of the room (Figure 14(B)) has four shelves next to the window with supplies; a fume cupboard; a table and shelves with supplies; a refrigerator (Figure 14(C)); and an open cabinet for rarely used medication and returns to the pharmacy (Figure 14(C)). A moveable cart for patient-specific unit doses and supplies is placed in the middle of the room (Figure 14(D)). One approach to the implementation of an EMDC is to replace the shelves in the left side of the room with three to four EMDCs. The cart will also be removed from the medication room, as the patient-specific unit doses can be stored in the EMDCs as well. The shelves, fume cupboard, table, and refrigerator in the right side of the room will remain. The open cabinet behind the door could be replaced by an additional EMDC or a supply module. No temperature control or air-conditioning is installed in the two rooms, thus leading to large fluctuations in temperature between the summer and winter seasons (18). Figure 15 shows a schematic illustration of the current medication room at Q1, and Figure 16 shows a schematic illustration of the future medication room.

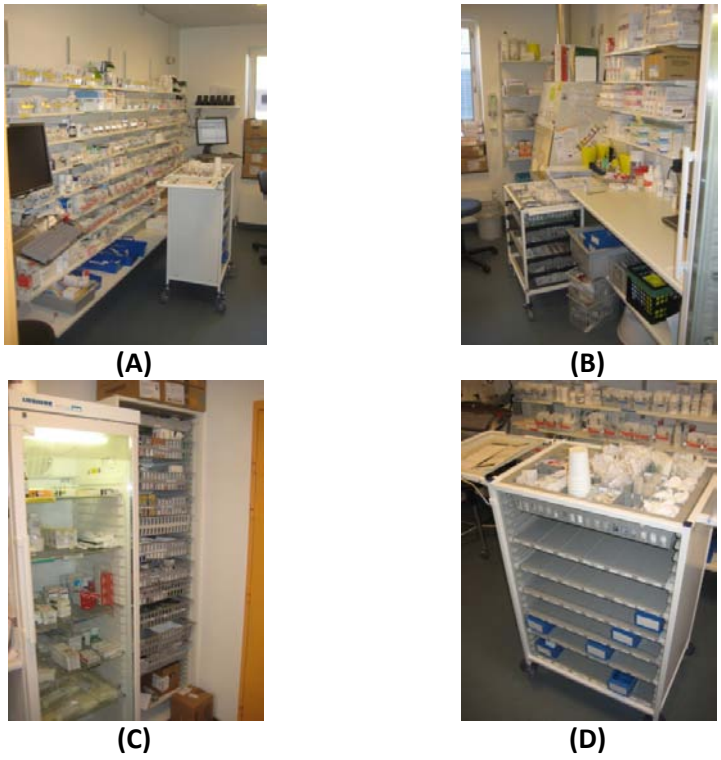

Figure 14. The medication room at Q1. (A) The left side of the room with two wall-mounted EPJ computers, shelves with medication, and a small shelf next to the window with docking stations for five PDAs. (B) The right side of the room with shelves, a fume cupboard, and a table and shelves with supplies. (C) The right side of the room also has a refrigerator and an open cabinet for rarely used medication and returns to the pharmacy. (D) A moveable cart is placed in the middle of the room. The cart contains patient-specific unit doses and supplies. (Pictures taken by the author)

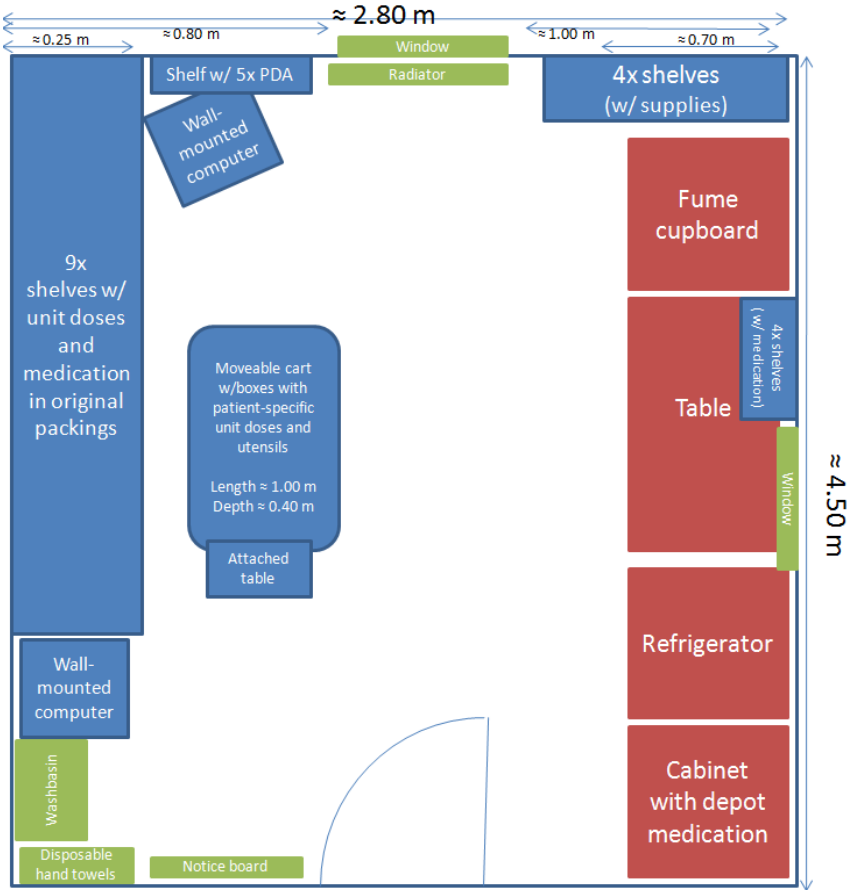

Figure 15. Schematic illustration of the current medication room at Q1. (Made by the author)

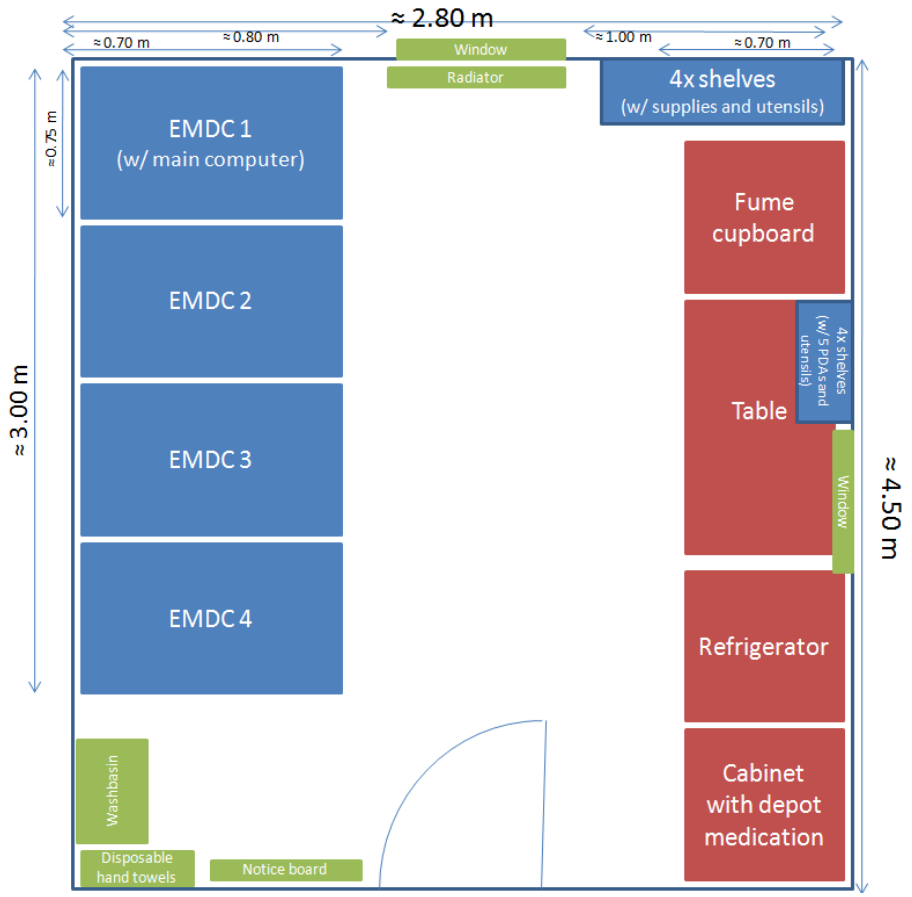

Figure 16. Schematic illustration of the future medication room at Q1. (Made by the author)

During a normal day, Q1 have 16 beds, and Q2 have 15 beds (65). The two wards are working closely together (65), thus the medications available are almost alike (92,93). The medications stored on the shelves are arranged according their ATC code. Table 9 shows the different types of packing in Q1 and Q2, and appendix 3 and appendix 4 shows the complete standard stock lists in the two medication rooms respectively.

ATC code group	Packing	Medications at Q1	Medication at Q2
A **Alimentary tract and metabolism**	Unit dose	21 drugs in 22 doses	21 drugs in 22 doses
	Packs	2 drugs of 1 pack 3 drugs of 2 packs 1 drugs of 5 packs 3 drugs of 1 pack (refrig.) 2 drugs of 1 pack (order)	3 drugs of 1 pack 3 drugs of 2 packs 2 drugs of 5 packs 3 drugs of 1 pack (refrig.)
	Bottle	4 drugs of 1 bottle 2 drugs of 2 bottles 1 drug of 1 bottle (refrig.)	4 drugs of 1 bottle 2 drugs of 2 bottles 1 drug of 2 bottles (refrig.)
	Tube	1 drug of 2 tubes	1 drug of 2 tubes
B **Blood and blood forming organs**	Unit dose	8 drugs of 8 doses	8 drugs of 8 doses
	Packs	10 drugs of 1 pack 1 drug of 3 packs (refrig.)	10 drugs of 1 pack 1 drug of 4 packs (refrig.)
	Capped vial	1 drug of 6 vials (refrig.) 1 drug of 1 vial	1 drug of 5 vials (refrig.) 1 drug of 1 vial
	Box	3 drugs of 2 boxes 1 drug of 1 box (order)	1 drugs of 8 boxes 2 drugs of 1 box (order)
C **Cardiovascular system**	Unit dose	18 drugs of 27 doses	18 drugs of 27 doses
	Packs	4 drugs of 1 pack 1 drug of 1 pack (refrig.) 2 drug of 2 packs 2 drugs of 5 packs	2 drugs of 1 pack 1 drug of 1 pack (refrig.) 2 drug of 2 packs 2 drugs of 5 packs
	Tube	1 tube (refrig.) 1 tube *	1 tube (refrig.) 1 tube *
D **Dermatologicals**	Bottle	1 bottle *	1 bottle *
	Tube	1 drug of 1 tube (refrig.) * 3 drugs of 1 tube * 7 drugs of 2 tubes *	1 drug of 1 tube (refrig.) * 3 drugs of 1 tube * 7 drugs of 2 tubes *
G **Genito urinary system****	Unit dose	1 drug of 1 dose	1 drug of 1 dose
H **Systemic hormonal preparations, excl. Sex hormones and insulins**	Unit dose	2 drugs of 4 doses	2 drugs of 4 doses
	Packs	1 drugs of 1 pack 2 drugs of 2 packs 1 drugs of 5 packs 1 drugs of 8 packs 1 drugs of 20 pack	2 drugs of 2 packs 1 drugs of 5 packs 2 drugs of 10 packs
	Bottle	1 drug of 1 bottle	1 drug of 1 bottle
J **Anti-infective for systemic use**	Unit dose	18 drugs of 21 doses	18 drugs of 21 doses
	Packs	4 drugs of 1 pack 1 drug of 1 pack (order) 4 drug of 2 packs 1 drug of 3 packs 3 drug of 4 packs 1 drug of 5 packs 7 drugs of 6 packs	4 drugs of 1 pack 1 drug of 1 pack (order) 2 drugs of 2 packs 2 drugs of 3 packs 4 drugs of 4 packs 2 drugs of 5 packs 6 drugs of 6 packs
	Bottle	5 (8) drugs of 1 bottle	7 drugs of 1 bottle
	Capped vial	2 drugs of 1 vial 1 drug of 2 vials 1 drug of 3 vials 2 drugs of 10 vials 2 drugs of 12 vials	1 drug of 3 vials 1 drugs of 10 vials 2 drug of 12 vials
	Box	6 drugs of 1 box 2 drugs of 0 boxes (order)	4 drugs of 1 box 1 drugs of 2 boxes

M Musculoskeletal system	Unit dose	5 drugs of 7 doses	5 drugs of 7 doses
	Packs	1 drug of 1 pack	1 drug of 1 pack
	Bottle	1 drug of 1 bottle	-
N Nervous system	Unit dose	31 drugs of 39 doses	32 drugs of 39 doses
	Packs	11 drugs of 1 pack 1 drug of 2 packs 1 drug of 3 packs	12 drugs of 1 pack 2 drugs of 2 packs
	Bottle	1 drug of 1 bottle 1 drug of 4 bottles	1 drug of 1 bottle 1 drug of 4 bottles
P Anti-parasitic products, insecticides and repellents	Unit dose	5 drugs of 5 doses	5 drugs of 5 doses
	Packs	4 drugs of 1 pack	3 drugs of 1 pack
	Bottle	3 drugs of 1 bottle	3 drugs of 1 bottle
	Capped vial	1 drugs of 16 vials (refrig.)	1 drugs of 16 vials (refrig.)
R Respiratory system	Unit dose	2 drugs of 2 doses	2 drugs of 2 doses
	Packs	6 drugs of 1 pack 1 drug of 2 packs	6 drugs of 1 pack 2 drug of 2 packs
	Spray	1 spray	1 spray
S Sensory organs	Packs	1 drug of 1 pack	1 drug of 2 packs
	Bottle	1 drug of 1 bottle 1 drug of 2 bottles (refrig.)	1 drug of 1 bottle 1 drug of 2 bottles (refrig.)
	Tube	1 drug of 1 tube (refrig.)	1 drug of 1 tube (refrig.)
V Various	Packs	2 drugs of 1 pack	2 drugs of 1 pack
	Box	2 acute boxes GREEN 1 box of sterile water Sodium chloride (order) 2 colon cleaning kits	1 acute box GREEN 8 boxes of sterile water Sodium chloride (order) 2 colon cleaning kits
	Mixed	Alternative and project	Alternative and project
Å Other	Packs	2 packs of medical gum 2 packs of pregnancy tests 3 packs of inhalers	2 packs of medical gum 2 packs of pregnancy tests 3 packs of inhalers
	Bottle	1 bottle of sweetener 1 bottle of Calogen	1 bottle of sweetener 1 bottle of Calogen
	Box	6 bags of surgical spirit	6 bags of surgical spirit

Table 9. The standard stock list of the Department of Infectious Diseases Q1 and Q2 respectively, divided into ATC codes and packing (unit dose, pack, bottle, capped vial, box, tube, mixed). Refrig.: Must be stored in a refrigerator. * = stored in another room. ** = Genito urinary system and sex hormones. (92,93)

The next sections describe each of the seven suitable EMDCs. Furthermore, examples of the needed number of EMDCs and drawer setups for a fictitious implementation at the Department of Infectious Diseases Q1 and Q2 are made for the EMDCs from Omnicell, CareFusion, and Cerner, as these were seen during the trip to London and appear to be the EMDCs of highest potential for a future implementation.

5.4 OmniRx

The *OmniRx G4* by Omnicell is a high, slender stationary EMDC (termed "one-cell") with a built-in computer and keyboard, and it is a new and updated version of the *OmniRx G3* cabinet seen at Saint Thomas Hospital. The EMDC consist of a top section with two shelves behind a locked glass door and the main computer, a middle section with a drawer module, a lower section with up to nine shelves behind a glass door or a drawer module. A bar code scanner and optional return bin is attached to the side of the EMDC. The drawer module can be either a "three-drawer" with two to three drawers or a "nine-drawer" with five to nine drawers. (68) Each section is flexible and can easily be configured to the needs of each ward in a hospital (41,68). In addition, it is possible to connect additional cabinets to the main cabinet, thus becoming a "two-cell" or "three-cell" with one or two side-cabinets respectively. Only one cabinet can be equipped with a main computer, thus the top sections of the side-cabinets have space for additional shelves. However, as seen at Saint Thomas Hospital, it is possible to connect more than two cabinets to the main cabinet. Figure 17 shows a "one-cell" and a "two-cell", and a list of specifications can be seen in appendix 5. (68)

(A) **(B)**

"One-cell" with "three-drawer" module **"Two-cell" with two "nine-drawer" modules**

Figure 17. (A) An OmniRx "one-cell" with "three-drawer" module. (B) An OmniRx "two-cell" with two "nine-drawer" modules. Only the main cabinet is equipped with a computer and controls the additional cabinets. ((A) from (94) and (B) by the author)

For the "three-drawer" or "nine-drawer" module, several types of drawers are available. High security drawers with locked or sensing lid compartments (bins), or medium or low security matrix drawers with open compartments may be chosen depending on the type of medication to be stored. Additionally, a remote lock called *FlexLock* can be attached to an existing refrigerator, thus only allowing the refrigerator to be opened, when medication is needed from there. (68) Table 10 shows the different drawers and summarizes their specifications.

 **Locking Lid Drawer** High security. Single (SD) or double depth (DD). Guiding lights. 6 (SD+DD), 12 (SD), or 24 (SD) bins. Locked metal lid, tamper-proof.	 **FlexBin™ Single-Dose Drawer** High security. Single depth. 96 small, 48 medium, or 48 small/large bins	 **Sensing Lid Drawer** Medium security Single (SD) or double depth (DD) Guiding lights 6 (SD+DD), 12 (SD), or 24(SD) bins Clear plastic sensing lid Alert sensor feedback
 **Lighted Matrix Drawer** Low security Single depth Adjustable bin dividers Up to 24 bins Guiding lights	 **Matrix Drawer** Low security Single or double depth Adjustable bin dividers Up to 96 bins	 **Drawer Module** Low security Single depth Guiding lights w/ reorder buttons Adjustable bin dividers Up to 24 bins

Table 10. Types of drawers available for the OmniRx G4 by Omnicell. Security is either high with locked lids (only one lid opening per transaction) or low (all bin available). A double depth drawer occupies two slots in the EMDC drawer system. (94)

The system is accessed through either user ID with password or biometric ID (68). Following login, a patient is selected after which a list of medications available appears. As seen in Table 10, several of the drawers are equipped with a green guiding light, which will be flashing to indicate the correct drawer and compartment. If the medication is in a locked lidded drawer, only the designated compartment lid will open once the drawer is fully extended, whereas all lids can be opened in the sensing lid drawer. However, an alert will appear, if the incorrect compartment is accessed. Each shelf compartment can be fitted with a green button, which must be pressed to register the medication extraction and avoid discrepancies. (41) A wide selection of reports regarding stock, refilling needs, discrepancies etc. can be seen on the screen or in a computer located in the pharmacy (68). Each morning, the pharmacy at Saint Thomas Hospital received an EMDC stock report from each ward, and the pharmacy staff could then prepare and dispense new medication for each ward (41). Additionally, a connection between EMDCs ensures that one ward can see what the others wards have in stock, e.g. in case of out of stock or after hours (41).

According to the Omnicell website, the Guelph General Hospital in Ontario, U.S., had a decrease in medication errors from 90 to 66 over a period of three months. The general number of missed administrations decreased from 17 to 2.5 per day, and out-of-stock incidents decreased from 22 to 3.25 per day. Additionally, the average time from prescription of non-standard stock medication was dispensed to it becoming available in the EMDC was reduced significantly from 4.5 hours to 42 minutes. The hospital had 35 Omnicell EMDCs on 23 ward stations. (95)

5.4.1 OmniRx at Department of Infectious Diseases Q

Based on the selection of medication in Department of Infectious Diseases Q1 and Q2, the author proposed a setup with four *OmniRx* cabinets with a return bin and a remote lock in each medication room as seen in Table 11. For unit doses, the *Sensing Lid Drawers* are chosen, as each medication should have its own compartment. For packs, *Locking Lid Drawers* are chosen. Vials are stored in *Drawer Modules*, and bottles and additional vials are stored in the top sections of the four EMDCs. Patient-specific medications are stored on shelves in the previously mentioned blue boxes in the lower section in one of the EMDCs. *FlexBin™ Single-Dose Drawers* have been opted out due to lack of space in each compartment for unit doses and packs, although they could be used to store Fragmin syringes instead of in their original packs. One *Lighted Matrix Drawer* is chosen for each section for supplies and additional storage space if necessary. *Drawer modules* could also be chosen to contain the patient-specific unit doses, but in the proposed setup a module of shelves have been chosen to keep the existing system of blue boxes. The medications are generally organised by ATC codes, which will aid the transition from storing medication on shelves to storing it in EMDCs, as medication from the same group is stored in the same drawer or section.

Q1+Q2	EMDC 1 (main)	EMDC 2	EMDC 3	EMDC 4
Top section	Shelves for bottles Computer	Shelves for bottles	Shelves for bottles	Shelves for bottles
Middle section	1 lighted matrix single (empty/for utensils)	1 lighted matrix single (empty/for utensils)	1 lighted matrix single (empty/for utensils)	1 lighted matrix single (empty/for utensils)
	2 x 12 sense lid single (3 x tubes + B unit dose)	2 x 12 sense lid single (N unit dose)	2 x 24 sense lid single (A unit dose)	2 x 12 lock lid single (C pack)
	1 x 6 lock lid double (B packs)	2 x 12 sense lid single (N unit dose)	2 x 12 lock lid single (A packs)	1 x 6 sense lid double (C unit)
	1 x 6 lock lid double (B packs – Fragmin)	2 x 12 sense lid single (N unit dose)	1 x 6 lock lid double (H vials)	1 x 6 sense lid double (C unit)
	1 drawer double (B + J vials)	2 x 12 sense lid single (N unit dose)	1 x 6 lock lid double (S+V+Å packs)	2 x 12 sense lid single (C unit)
Lower section	1 lighted matrix single (empty/for utensils)	1 lighted matrix single (empty/for utensils)	1 lighted matrix single (empty/for utensils)	Shelves for patient-specific medication
	2 x 12 sense lid single (J unit dose)	2 x 12 lock lid single (N pack)	1 x 6 lock lid double (R pack)	
	2 x 12 lock lid single (J packs)	1 x 6 lock lid double (J packs)	2 x 12 sense lid single (G+H+M+P+R unit d.)	
	1 x 6 lock lid double (J packs)	1 drawer double (J vials)	1 x 6 lock lid double (P pack)	
	1 x 6 lock lid double (J packs)	1 x 6 lock lid double (M +N pack)	1 x 6 lock lid double (R pack)	

Table 11. Proposed setup of four OmniRx cabinets in the medication room of both wards at Department of Infectious Diseases Q. The top sections of the cabinets will be used for storing bottles. The middle and lower sections will be used for storing unit doses (Sensing Lid Drawers) and packs (Locking Lid Drawers). Vials are stored in Drawer Modules. A lower section of one of the cabinets will be used for patient-specific medications. EMDC: Electronic medication dispensing cabinet. (Made by the author)

The Omnicell business partner Mediq provided the author with an estimated price of the proposed EMDC setup. A setup of a “three-cell”, including the main cabinet, and a “one-cell” was proposed for each ward. With the EMDCs, seven “nine-drawer” modules, drawers of different types, return bin, remote lock, and biometric ID, the price will be approximately 950,056 DKK without VAT. Costs for external server hardware and software are not included. (96)

5.5 Pyxis® MedStation® 4000

The *Pyxis® MedStation® 4000* by Carefusion is a small, cubic-like stationary EMDC, which consists of a smaller upper section and larger lower section with drawers. Topmost is a colour touch screen, a keyboard with Biometric ID, and a built-in printer. A bar code scanner can also be attached. Each section in the EMDC can be configured to the needs of each ward in a hospital, thus making the EMDC into a 4-drawer, a 5-drawer, a 6-drawer, 7-drawer etc. depending on the drawer choice. Additional drawer auxiliaries as well as single or double column auxiliaries can be connected to the main cabinet. A combined main tower with drawers in the lower section and shelves in the upper section called Pyxis® DuoStation system can also be installed, and is similar to the previously mentioned *OmniRx*. Figure 18 illustrates a typical configuration of the Pyxis® MedStation® 4000 with a main cabinet, a drawer auxiliary, and a single column auxiliary as well as other column auxiliaries. A list of specifications can be seen in appendix 6. (69,97)

(A) **(B)**

Figure 18. The Pyxis® MedStation® 4000. (A) A typical configuration with a 6-drawer main cabinet (left), a 7-drawer auxiliary (middle), and a single column auxiliary (right). (B) A double column auxiliary (top) and a half-height column auxiliary (bottom). (69)

Several types of drawers are available for the main and drawer auxiliary. The drawers are either of high security as seen in the *CUBIE® system*, *Carousel drawer* or *MiniDrawer* or of low security as seen in the *Matrix drawer*. The *CUBIE® system* is a drawer (5x6) with a selection of pockets of different size (1x1, 1x2, or 1x3) and can thus be easily configured. Each pocket has a built-in memory chip with data of the specific medication, thus making it easy to move the different pockets around each drawer. In connection to the *CUBIE® system*, the *Pyxis CUBIE® Replenishment System* can be integrated, as this system allows each pocket to be pre-packed and programmed in the pharmacy. The locked pockets can then be put back into the drawers. *Matrix drawers* may contain medication or supplies of low security and a return bin can be

added to the drawer. In addition, a remote lock called *Pyxis SMART Remote Manager* can be attached to an existing refrigerator. Table 12 shows the different drawers and summarizes their specifications. (69,97)

		
CUBIE® system High security Single height Clear plastic lid Flexible configuration Only access to one pocket per transaction	**CUBIE® pockets** High security Built-in memory chip 30 x 1x1 pockets, 18 x 1x2 pockets, 10 x 1x3 pockets or combinations thereof.	**Carousel drawer** High security Double height Only access to one compartment per transaction 12 compartments per drawer
		
Matrix drawer Low security Double height Flexible configuration Optional return bin	**MiniDrawer (I-6)** High security For syringes etc.	**MiniDrawer (I-18)** High security For single doses etc.

Table 12. Types of drawers available for the Pyxis® MedStation® 4000 by Carefusion. Security is either high with CUBIE® system, carousel drawer, or MiniDrawer or low with Matrix drawer. All drawers is of single height except for the carousel drawer. (69)

The system can be accessed through either user ID with password or biometric ID. In the *CUBIE® system*, only the designated pocket opens, whereas the entire content of the *Matrix drawer* is accessible. In the *Carousel drawer* and *MiniDrawers*, only one compartment is accessible at a time, thus exposing the designated compartment in the carousel or pushing the *MiniDrawer* to the next full compartment. Reports on stock, refilling needs, discrepancies etc. can be seen directly on the screen or in a computer station in the pharmacy. In addition, a connection between EMDCs ensures that one ward can see what the others wards have in stock, e.g. in case of out of stock or after hours. (69,97)

According to the CareFusion website, the Avera McKennan Hospital & University Health Center in Sioux Falls, U.S., had a significant decrease in the average time from prescription of non-standard stock medication was made to it becoming available in the EMDC from 2.5 hours to 16 minutes. (97)

5.5.1 Pyxis® MedStation® 4000 at Department of Infectious Diseases Q

Based on the selection of medication in Department of Infectious Diseases Q1 and Q2, the author proposes a setup with one main cabinet, one drawer auxiliary, a single column auxiliary, and a remote lock in each medication room. All unit doses are placed in *CUBIE® system* drawers for high security and free configuration. Because only the *Carousel drawer* and *Matrix drawer* is of double height, all original packs, bottle, capped vials, tubes, and supplies will be stored in a single column auxiliary, except medications of one or two packs, which will be stored in *CUBIE® system* drawers as well. *Carousel drawers* and *MiniDrawers* have been omitted due to lack of compartments for medications and lack of space for medication packs respectively. However, the *MiniDrawer (I-6)* could be used to store Fragmin syringes instead of in their original packing. The medications are generally organised by ATC codes.

The main cabinet will consist of one *Matrix drawer* for supplies etc. and two *CUBIE® system* drawers in the upper section, whereas the lower section will consist of eight *CUBIE® system* drawers. All *CUBIE® system* drawers are for unit doses, and the pocket size have been chosen depending on the unit dose stock. Table 13 illustrates the proposed setup of each drawer in the main cabinet.

Main cabinet	Drawer type	Contents (by ATC codes)
Upper section	Matrix drawer	For supplies and a return bin
	CUBIE® system drawer	1 x 1x1 pocket (G) 4 x 1x2 pockets (3xP,1xR) 7 x 1x3 pockets (4xH,1xP,2xR)
	CUBIE® system drawer	1 x 1x1 pocket (A) 1 x 1x2 pocket (A) 9 x 1x3 pockets (A)
Lower section	CUBIE® system drawer	3 x 1x1 pockets (2xA, 1xB) 9 x 1x2 pockets (A) 3 x 1x3 pockets (B)
	CUBIE® system drawer	3 x 1x1 pockets (2xB, 1xC) 6 x 1x2 pockets (2xB,4xC) 5 x 1x3 pockets (C)
	CUBIE® system drawer	15 x 1x2 pockets (14xC,1xP)
	CUBIE® system drawer	10 x 1x3 pockets (J)
	CUBIE® system drawer	6 x 1x2 pockets (J) 6 x 1x3 pockets (C)
	CUBIE® system drawer	9 x 1x1 pockets (4xM,5xN) 6 x 1x2 pockets (N) 3 x 1x3 pockets (2xM,1xN)
	CUBIE® system drawer	3 x 1x2 pockets (N) 8 x 1x3 pockets (N)
	CUBIE® system drawer	15 x 1x2 pockets (N)

Table 13. Proposed setup of the main cabinet of the Pyxis® MedStation® 4000 in the medication room of both wards at Department of Infectious Diseases Q. The upper section consists of a Matrix drawer and two CUBIE® system drawers. The lower section consists of eight CUBIE® system drawers. All CUBIE® system drawers in the main cabinet are filled with unit doses and organised by ATC codes. (Made by the author)

The drawer auxiliary will consist of one *Matrix drawer* and four *CUBIE® system* drawers in the upper section and eight CUBIE® system drawers in the lower section. All *CUBIE® system* drawers are for packs. Some drawers have empty pockets, but can easily be filled with additional packs. Table 14 illustrates the proposed setup of each drawer in the drawer auxiliary.

Drawer auxiliary	Drawer type	Contents (by ATC codes)
Upper section	Matrix drawer	For supplies (plus an extra return bin)
	CUBIE® system drawer	18 x 1x1 pockets (empty), 6 x 1x2 pockets (empty)
	CUBIE® system drawer	15 x 1x2 pockets (empty)
	CUBIE® system drawer	10 x 1x3 pockets (empty)
	CUBIE® system drawer	10 x 1x3 pockets (empty)
Lower section	CUBIE® system drawer	10 x 1x3 pockets (A)
	CUBIE® system drawer	10 x 1x3 pockets (B)
	CUBIE® system drawer	10 x 1x3 pockets (C,H)
	CUBIE® system drawer	10 x 1x3 pockets (J)
	CUBIE® system drawer	10 x 1x3 pockets (M, N)
	CUBIE® system drawer	10 x 1x3 pockets (N, P)
	CUBIE® system drawer	10 x 1x3 pockets (R)
	CUBIE® system drawer	10 x 1x3 pockets (S,V,Å)

Table 14. Proposed setup of the drawer auxiliary of the Pyxis® MedStation® 4000 in the medication room of both wards at Department of Infectious Diseases Q. The upper section consists of a Matrix drawer and four CUBIE® system drawers. The lower section consists of eight CUBIE® system drawers. All CUBIE® system drawers contain packs and is organised by ATC codes. (Made by the author)

CareFusion was unable to provide the author with an estimated price of the proposed setup, as they would like to discuss the market potential for their EMDC in more details, e.g. in regards to drawer configurations, system interface etc.

5.6 RxStation®

The RxStation® by Cerner is a small, cubic-like stationary EMDC that consists of drawers (trays) of different sizes, which can be freely assembled into modules (82). The EMDC consists of a main tower of two to three modules with a touch screen, a keyboard and mouse, an optional printer, and an optional bar code scanner on the top (98). Additional supply and module towers can be connected to the main tower to increase the storage space (98). The additional towers can also be freely assembled, but generally consists of three to four modules (98). Figure 19 shows a configuration of a main tower with two modules and an additional tower with three modules. A list of specifications can be seen in appendix 7.

Figure 19. A RxStation® main tower (right) with a touch screen and two modules and an additional tower (left) with one supply module and two drawer modules. (82)

Seven types of trays are available for the EMDC. One is an *Open Matrix Tray* with low security. The six other trays have high security with locked lids, which are either of *Quarter Height* with ten or twenty compartments, *Half Height* with six larger compartments, *Half Height Return* with three or five large compartments, or *Single Dose Dispense Tray* with up to 30 small compartments, 12 medium compartments, or combinations thereof. (98) Figure 20(A) shows the different trays and their number of compartments. A locked supply module with up to four shelves with configurable compartments and guiding lights can also be connected to other modules or assembled into a supply tower (98). Figure 20(B) shows a single supply module and a supply tower. Furthermore, a remote lock can be attached to an existing refrigerator (82).

(A) **(B)**

Figure 20. Types of trays available for the RxStation®. (A) All trays have high security, locked plastic lids, and guiding lights, except the Open Matrix Tray, which has low security and access to the entire content. A module can contain four Quarter Height trays; two Quarter Height trays and one Half Height tray; or two Half Height trays. The Half Height Return trays contain two locked return bins each in combination with three or five locked compartments. (B) A single supply module (top) can be added to existing modules or assembled into a supply tower (bottom). All compartments in the supply module or tower have guiding lights. (98,99)

The system is accessed through a user ID and password (82). Following login and selection, a flashing light will indicate the tray or supply module door to open. Inside the tray or supply module, additional flashing lights indicate which compartment to extract the correct medication from. (100) Reports and single files regarding stock, refilling needs, expiration, discrepancies, administration history, patient history, auditing etc. can be seen at the EMDC or at a computer located in the pharmacy. An allergy alert system enables the nurses to avoid potential allergic reactions in patients by crosschecking the recommended dose with the prescription order. In addition, a connection between EMDCs ensures that one ward can see what the others wards have in stock, e.g. in case of out of stock or after hours. (82)

The RxStation® is an integrated part of the closed-looped Cerner Millennium, which can be compared to the Danish Systematic Columna EPJ, thus displaying real-time updates from EMARs with regards to diagnosis, results, prescriptions, medications, tasks, allergies, dose range checking etc. (82)

5.6.1 RxStation® at Department of Infectious Diseases Q

Based on the selection of medication in Department of Infectious Diseases Q1 and Q2, the author proposes a setup with four module towers and a remote lock in each medication room. All unit doses are stored in either *Quarter Height* trays with ten or twenty compartments or *Half Height* trays with six large compartments for maximum security. Medication in one pack is stored in *Quarter Height* trays with ten compartments, and medications of two packs are stored in *Half Height* trays with six large compartments. Bottles, capped vials, and medication of three packs or above are stored in supply modules. Single-dose dispense trays are omitted due to lack of space for unit doses or packs. The medications are generally organised by ATC codes. Table 15 illustrates the proposed setup of each drawer in the four module tower.

Q1	Tower 1 (main) Unit doses	Tower 2 Unit doses	Tower 3 Unit doses	Tower 4 Packs
Top section	Touch screen 	Supply Module	Supply Module	Supply module
Upper section		Half Height 6 (N,M,P,R) Half Height 6 (N)	Supply Module	Quarter height 10 Quarter height 10 Quarter height 10 Quarter height 10
Middle section	Open Matrix Tray (-) Quarter Height 20 (B,G,M,N) Quarter Height 10 (A) Quarter Height 10 (A,B)	Quarter Height 10 (N) Quarter Height 10 (N) Quarter Height 10 (N) Quarter Height 10 (C,J)	Half Height 6 (J) Half Height 6 (J)	Quarter height 10 Quarter height 10 Half height 6
Lower section	Half Height 6 (A) Half Height 6 (A,B)	Quarter Height 10 (C) Quarter Height 10 (C) Half Height 6 (C)	Half Height 6 (J,H) Half Height Return 5 (-)	Half height 6 Half height 6

Table 15. Proposed setup of the four RxStation® tower modules in the medication room of both wards at Department of Infectious Diseases Q. The main, second, and third module towers are for storage of unit doses in drawers, and bottle and capped vials in supply modules. The fourth EMDC is for storage of medication in one or two packs and the supply module is for the additional medication of three packs or more. (Made by the author; Picture of touch screen from (82))

Cerner was unable to provide the author with an estimated price of the proposed setup.

5.7 Pyxis® CIISafe™

The *Pyxis®CIISafe™* by CareFusion is a large, stationary double EMDC with a built-in computer and integrated printer (termed "Double integrated main"). The EMDC consists of eight sections of which one is the computer, and the other seven are separate compartments with shelves. Additional single or double column auxiliaries can be connected to the main EMDC to increase the storage capacity. A bar code scanner is also attached to the main cabinet. The EMDC is primarily used to store controlled drugs in original packs, and the EMDC has been approved by the Joint Commission and the DEA. Figure 21 shows the main and auxiliary EMDCs, and a list of specifications can be seen in appendix 8. (83)

(A) **(B)**

"Double integrated main" **"Double column auxiliary"**

Figure 21. The Pyxis® CIISafe™. (A) The "Double integrated main" with a built-in computer and printer, bar code scanner, and seven sections with shelves for medication storage. (B) The "Double column auxiliary" with additional eight sections for medication storage. A "Single column auxiliary" with four sections is also purchasable. (83)

The EMDC can be integrated with the previously mentioned *Pyxis® MedStation® 4000*, and can be accessed through user ID and password. After login, the patient and medication is selected, the designated door opens, and the medication can be extracted. Real-time reports on stock, refilling needs, discrepancies etc. can be seen at the EMDC or at a computer located in the pharmacy. (83) According to the pharmacy staff at Charing Cross Hospital, the operating system is an older version of Microsoft Windows NT, and some interface problems did arise during implementation. (39)

5.8 medDispense Series

The *medDispense Series* by Metro is a small, cubic-like EMDC on wheels with 25 (Base 25 Mini Supply), 45 (Base 45), or 72 small drawers (Base 72). A touch screen, a keyboard, and an optional bar code scanner are attached on top of the EMDC. Several auxiliary towers and modules can be connected to the main cabinet (base unit). Each drawer can be divided into six chambers or less and can be either of single or double width. However, the drawers are only of one depth and height. A remote lock can be attached to an existing refrigerator. (90) Figure 22 shows the three types of base units, and Figure 23 shows the auxiliary towers and modules. A list of specifications can be seen in appendix 9.

(A)
Base 25 Mini Supply

(B)
Base 45

(C)
Base 72

Figure 22. The medDispense base unit with (A) 25 drawers and a small locker, (B) 45 drawers, or (C) 72 drawers. (90)

(A)
Combo Tower

(B)
Supply Tower

(C)
Auxiliary Supply

(D)
Auxiliary Cabinet

Figure 23. medDispense Series auxiliary towers and modules. (A) A Combo Tower with a Base 45 module as the lower section and an Auxiliary Supply with four shelves as the upper section. (B) A Supply Tower consisting of two Auxiliary Supply modules with six sliding shelves and two stationary shelves. (C) An Auxiliary Supply with four shelves. (D) An Auxiliary Cabinet with 45 drawers. (90)

The system can be accessed through user ID and password or biometric ID. Following login, the patient and medication can be selected, and the designated drawer or door will open, thus allowing extraction of the medication. Because of the large amount of drawers in the EMDC, each patient can have designated drawer. Reports on billing and pharmacy management such as stock and refilling needs can be seen on the screen. (86)

5.9 ServeRx™

The *ServeRx™* by MDG Medical is a high, slender stationary EMDC consisting of three sections, which can be either 18 large open drawers, 36 small open drawers, or a locked shelf section with a glass door. *SmarTrays* with guiding lights and two, four, or eight lidded compartments can also be inserted instead of open drawers. A sign with medication data can easily be fitted onto each drawer to improve overview. Refrigerated modules and locked supply modules with shelves or baskets can be connected to the main cabinet. A touch screen, a keyboard, and a wireless bar code scanner are attached to an external arm on the side of the EMDC. (70) Figure 24 shows the main cabinet, and a list of specifications can be seen in appendix 10.

(A) **(B)**

Figure 24. The ServeRx™ EMDC. (A) The main cabinet with three sections of shelves (top), 36 small open drawers (middle), or 18 large drawers (bottom). (B) A SmarTray with eight locked lidded compartments. (70)

The system can be accessed through user ID and password ID. Following login, the patient and medication can be selected, and the designated drawer or door will open, thus allowing extraction of the medication. Due to the large amount of drawers in the EMDC, each patient can have designated drawer. Reports on stock, refilling needs, expiration, patient information etc. can be seen on the screen. (70)

5.10 AcuDose-Rx

The *AcuDose-Rx* by McKesson is a small, cubic-like stationary EMDC, which is similar in appearance to the *Pyxis® MedStation® 4000*. The *AcuDose-Rx* can be fitted with up to eight drawers of standard height, but a great variety of other drawers can be inserted. Topmost is a colour touch screen, a keyboard with biometric ID, and an optional bar code scanner. Additional towers and auxiliary cabinets similar to the main cabinets can be connected to the main cabinet, and a remote lock can be attached to an existing refrigerator. (67) Figure 25 shows the two sizes on main cabinets and the medication tower. A list of specifications can be seen in appendix 11.

(A) **AcuDose-Rx large main cabinet** **(B)** **AcuDose-Rx small main cabinet** **(C)** **Medication tower**

Figure 25. The AcuDose-Rx main cabinet in a large (A) or small version (B). (C) A medication tower with up to twelve shelves is also available. Auxiliary cabinets similar to the large and small cabinet in size are also available. (67)

Four types of drawers are available for the main and drawer auxiliary cabinets. The first type is *High Capacity Drawers* of half height, which can either be *Locking Drawers* with locked plastic lids and guiding lights; Detecting Drawers with unlocked plastic lids and "incorrect pocket" alerts; or *Open Drawers* of four open compartments with two to 25 separate rooms each. The second type is *Locked Lidded Drawers* with six, eight, nine, or twelve compartments. A return bin can also be inserted into the *Locked Lidded Drawer* together with five or seven compartments. The third type is *Unit Dose Dispensing Drawers* of single or double width for single doses. These drawers are inserted as a module into a drawer slot. The fourth type is *Open Matrix Drawers* of single height or double height with optional return bin. In addition, one to three existing refrigerators can be fitted with remote locks. (67) Table 16 shows the different drawers and summarizes their capabilities.

 **High Capacity Locking Drawer** High security Half height Guiding lights 1x1, 1x2, or 2x2 pockets Locked, clear plastic lid	 **High Capacity Detecting Drawer** Medium security (“wrong pocket” alert) Half height 1x1, 1x2, or 2x2 pockets Unlocked, clear plastic lid	 **Locked Lidded drawer** High security Standard height Single- or double wide pockets Optional return bin Locked, plastic lid
 **Unit Dose Dispensing Drawers** High security Fits into a specific module Locked, clear plastic lid	 **Tall Matrix Drawer** Low security Double height Up to 24 pockets Optional return bin	 **Open Drawer** Low security Standard height Four compartments Up to 12 room per compartment

Table 16. Types of drawers available for the AcuDose-Rx. Security is either high with High Capacity Locking Drawer, Locked Lidded Drawer, or Unit Dose Dispensing Drawers; medium with High Capacity Detecting Drawer; or low with Tall Matrix Drawer or Open Drawer. A High Capacity Open Drawer of half height is also available. (67)

The system is accessed through user ID and password or biometric ID. After login, the patient and medication are selected, after which the drawer or door will open. In the *Locked Lidded* and *Unit Dose Dispensing Drawers* only the designated compartment will open. Over 70 types of standard reports regarding stock, refilling needs, expiration, discrepancies, patient dispensing profile, billings, medication details etc. are available in the system. Custom reports can also be extracted. An alert system for high risk medications or allergies is also implemented in the system, and automatic decision support enables the end user to investigate patterns of dispensing to avoid medication errors. Additionally, a connection between EMDCs ensures that one ward can see what the others wards have in stock.

A case study from Bloomington Hospital, U.S., showed a reduction from 3,700 to 600 medication errors per year after the implementation of 65 EMDCs in 26 wards. The average time from prescription of non-standard stock medication was made to it becoming available in the EMDC was reduced significantly from 1.5 hours to 7 minutes. (101) The JFK Medical Center in Florida, U.S., installed 45 EMDCs, and showed a 75% reduction in time for refilling (102). The Comanche County Memorial Hospital in Lawton, U.S., showed a 75% reduction in out-of-stock incidents from 20 to 5 per day (103).

5.11 Summary

Although the EMDCs presented above may appear to be similar in appearance, each of the EMDCs has its own advantages and disadvantages, and one EMDC may work better in one ward than in other wards, but generally all EMDCs can be configured to fit most needs. Seven EMDCs were found suitable for future implementation in the New University Hospital in Aarhus, which can be seen in Table 7 above. All EMDCs except one have configurable drawers of high, medium, or low security, and all have optional bar code scanners and can be connected to additional auxiliary modules. The systems are generally accessed through user ID and password, but four systems can also be accessed through biometric ID. Five EMDC have remote locks for refrigerators, and a sixth has a refrigerator module. The seven EMDCs will be evaluated in the discussion below.

6 Discussion

It is common knowledge that humans make mistakes. During normal circumstances, it is not of vital importance, but when it comes to patient safety and medication errors, mistakes are crucial and can have potential expensive and fatal consequences. As Akiyama, Koshio, and Kaihotsu (52) stated in 2010, health care staff were making errors, because they were performing too many different tasks. By simplifying or eliminating certain tasks in the daily work flow, such as storing all medication in EMDCs and eliminating the transcription of prescriptions respectively, not only the number of errors should decrease, as only one medicament can be accessed at a time, but also the work load of the health care staff should lighten. However, implementing new IT in hospitals is not an easy task. Thus, as Balka, Kahnamoui, and Nutland (32) concluded, it is strictly necessary to perform surveys and cost-benefit analyses to investigate both financial and work-related aspects in order to reach a final decision of whether or not to invest in the new technology.

Implementation of the Electronic Medication Dispensing Cabinets

The EMDCs were generally intended for the U.S. market, where strict governmental regulations regarding patient safety and medication use must be complied with. This will thus allow a simpler entry to the European market, including the Danish hospitals. Furthermore, a general difference between the UK and U.S. is that the English hospitals use the EMDC for storage of medication in original packs, whereas the American hospitals mainly use the EMDCs for storage of unit or single doses for higher security, which would also speed up the entry, as the EMDCs are already designed for unit doses. Furthermore, a standard EMDC setup in the London hospitals could store medication for up to 30 beds in a regular ward (40,41). It may thus be possible to implement EMDCs in most wards at Aarhus University Hospital and eventually at the New University Hospital in Aarhus, as the number of beds per ward currently ranges from four to approximately 30 with an estimated average of 16.

As the Swisslog PillPick AMDS is already installed at Aarhus University Hospital Skejby and dispenses patient- and treatment-specific unit doses for several wards throughout Region Midtjylland, it would be of high relevance to continue the automation of medication dispensing and storage. As additional wards are to be included in the unit dose dispensing for the surveys (62), it is evident that the resource and the time consumption of manual stock management will be immense. Implementation of EMDCs could thus lead to better documentation through extensive automatic stock reporting and a better overview of the medication stock. Additionally, it could save time for pharmacists and pharmaconomists during the refilling process, as it did at Charing Cross Hospital in London, and eventually nurses during the medication administration process, as they learn to use and be comfortable with the EMDC.

The stronger, automatic control of medication may also result in a decrease in medication waste and stock value, as the use and necessary stock of each type of medication is monitored electronically, especially for rarely used and treatment-specific medication as seen in the treatment of various infectious diseases. Expiration of medication is also automatically monitored, thus the pharmacy will receive a report regarding the expiring medication and removal. Furthermore, as seen at Saint Thomas Hospital in London, approximately a quarter million DKK was saved during March 2011 (41), indicating that money indeed can be saved on refilling the EMDCs with unused and uncontaminated medication and unit doses. The loss of medication, e.g. of controlled drugs, would also decrease, as all transactions are recorded along with the user ID, thus preventing unexplained disappearances or thefts.

Appearance of the Electronic Medication Dispensing Cabinets

As the physical appearance of the EMDC is the first thing the health care staff is exposed to, is must appear to be user-friendly, of high stability, and easily accessible to gain acceptance in the first place. An inaccessible and blockish appearing EMDC will instantly frighten the end users, even though it may be easy to use and has good capacity.

The *Pyxis®CIISafe™* is a good example of an inaccessible EMDC. At first sight it appears sterile and difficult to form an overview of, as the medication is locked away behind large metal doors and placed on shelves. Additionally, the non-touch screen is "hidden" and small compared to the entire EMDC, although the latter can be solved by using a stationary computer next to a single or double column auxiliary. The *OmniRx G4* has a similar blockish appearance, but as it is fitted with glass doors and drawers, it improves the overview. Although the touch screen is also placed within a section, it is not as concealed as the previous mentioned EMDC. The *medDispense Series* has a larger touch screen and optional modules with open sections with glass doors, but the high number of small, thin drawers as well as the grey colour may frighten some end users. It can be compared to the *ServeRx™*, which is also fitted with a high number of drawers. However, this EMDC appears more accessible with the light colour theme and optional signs on each drawer. The *AcuDose-Rx* and *Pyxis® MedStation® 4000* are similar in appearance: A smaller main cabinet fitted with a large touch screen and fewer, but equally spacious drawers. By limiting the number of drawers in sight, the EMDCs appear more accessible, as all medications are not in display at the same time. The open auxiliary modules with glass doors are also similar. Finally, the RxStation® has the most accessible design due to the blue-light grey colour theme, large touch screen, free assemblage of modules, and the large and easy to drawer handles.

Functionality of the Electronic Medication Dispensing Cabinets

The EMDC to be chosen must have a high functionality to be as efficient as possible. Besides the level of security, which is highly weighed in the hospital pharmacy project, high levels of drawer flexibility and user-friendliness as well as numerous options for interfacing are important. The more options available for configuration of the EMDC, the better the EMDC will work.

All seven EMDCs have optional bar code scanners, which can be used to scan and register unit doses and other medication during refilling. During this step, only the pharmaconomist would use extra time to refill the EMDC. However, as the stock reports are delivered automatically to the pharmacy, the pharmaconomist only needs to visit each ward one time with the needed medication. Overall, this may save time for pharmaconomist in the refilling process, but it must be assessed during the surveys in order to prove time savings. Once the nurses have extracted and checked the medication, they bring it to the patients for verification and administration, thus a minor increase in time used for medication extraction may be seen.

As a general level of security, all EMDCs can be accessed by the health care staff using a unique user ID and password. However, these can somewhat be easily compromised. A nurse from Saint Thomas Hospital in London had passed her user ID and password to a colleague to lighten the work load during a vacation period, but the colleague had continuously used the borrowed user ID and password instead of her own, thus creating discrepancies for the wrong user to be accounted for (41). Although everything was sorted out, and no theft was seen (41), it demonstrates that the EMDC system can be bypassed, thus increasing the risk of disappearances, thefts, or out-of-stock. Most of the EMDCs have also incorporated a fingerprint reader into their EMDC, which increases the security regarding system access, as fingerprints are unique and can-

not be copied without breaching the security on a higher level. Using the fingerprint reader also speeds up the login process, as the time spend on typing in user ID and password is eliminated. This is especially welcome in the *OmniRx G4*, as the keyboard is rather small compared e.g. *RxStation®* and *Pyxis® MedStation® 4000*. Additional measures of security are also seen in the use of remote locks on existing refrigerators, as the medications stored in the refrigerator are also secured. Furthermore, only the *ServeRx™* has a refrigerated module, thus medication stored in the EMDCs must not be too sensitive to changes in room temperature. During the renovation of the medication rooms, room temperature control must be installed.

As previously mentioned, the configuration of drawers and compartments can be chosen to accommodate the level of security and the standard stock needed on each ward. The *Pyxis®CIISafe™* is generally the weakest of the EMDCs. Although it is approved by the Joint Commission and DEA for controlled drugs (83), the only level of security is the locked section doors. Once one section has been accessed, all medications beside the one to be administered can be extracted, thus not only compromising the general stock management, but also the patient safety as wrong medication could accidentally be administered. The shelved medications in each section may also become disorganized more often, if general order is not maintained. The low level of security is also the case with open matrix drawers as seen in the other EMDCs (67,90,94), as all medication from the drawers can be extracted without creating immediate discrepancies. The discrepancies will not be corrected or investigated, until the EMDC is scheduled for refilling or the ward is out-of-stock. This would lead to delays in the workflow, but also compromise patient safety, if the medication is strictly necessary for acute treatments. The *medDispense Series* and *ServeRx™* only contains open drawers, but the high number of drawers available in each section, especially in the latter, may allow for each medication to be stored in separate drawers. Although it may not be suitable at the Department of Infectious Diseases Q due to the large amount of medications and various sizes thereof, other wards with a smaller medication stock may find the two EMDCs useful. Furthermore, the use of guiding lights in some of the open drawers aids the nurses in locating the correct medication, e.g. in cases of look-a-like or sound-a-like medications.

The use of locked, lidded compartments or pockets for each medication solves the security issue by only allowing the compartment containing the prescribed medication to be opened. Only if incorrect medication is purposely extracted by selecting the incorrect patient or medication than the system and prescription issues, the locked compartments can be compromised. Locked compartments are seen in *AcuDose-RX*, *OmniRx G4*, *RxStation®*, and *Pyxis® MedStation® 4000*. The *AcuDose-RX* and *OmniRx G4* have the widest selection of drawers, as these are of different sizes with high, medium, or low security. The *RxStation®* and *Pyxis® MedStation® 4000* also have a variable selection, but the drawer compartments and *CUBIE® system* pockets in the latter seems to be more suited for small unit doses than the combination of unit doses, packs, vials etc. as seen in the Department of Infectious Diseases Q, if the highest possible security is to be maintained. This would increase the need of additional cabinets. However, in the future with a higher number of unit doses or in wards with a smaller medication stock, the two EMDCs may be more appropriate. Furthermore, the flexible design of the *RxStation®* allows its drawers to be freely assembled and stacked, whereas the drawers of the *AcuDose-RX*, *OmniRx G4*, and *Pyxis® MedStation® 4000* must fit into predetermined slots in the main and auxiliary cabinets or modules.

When selecting which EMDC to purchase, each ward or department must figure out, what the level of security should be. Wards with a high number of controlled drugs, such as opioids or analgesics, or expensive medications, such as chemotherapeutics, should have their medications stored in locked compartments, whereas wards with less important medications have enough security with open and lighted matrix draw-

ers. By using the less secure and larger open matrix drawers than the smaller locked and lidded drawers, more storage space is also released to the medication itself, thus reducing the need of additional cabinets, opposite the EMDC setups made by the author for the *OmniRx G4*, *Pyxis® MedStation® 4000*, and *RxStation®*. A reduction in the number of additional drawers or modules needed would also reduce the costs. Conversely, this would raise logistic problems, if new medications are introduced to the ward. This could be solved by increasing the number of drawers or modules, thus a balance between the currently needed storage space, the potential extra space needed in the future, the level of security, and general costs for each point must be assessed. Furthermore, the medication rooms to be build in the New University Hospital in Aarhus supposedly has an area of only 8 m^2 (18), which would further increase the demand of a flexible EMDC configuration to save space and have room for all medications.

Threats to the Implementation of the Electronic Medication Dispensing Cabinets

As the manufacturer publications show, several advantages can be achieved by implementing EMDCs. However, the level of bias in the publications is high, as only the positive and distinct improvements are presented. Some EMDCs are even presented without any evidential support. Therefore, the decision to purchase an EMDC must not be based only on the publications, but also on market analyses or surveys of higher evidence levels as well as extensive communication with the manufacturer to ensure that all EMDC demands, service in case of breakdowns, and warranties are complied with.

An important aspect regarding the use of EMDCs is that the interface must be user-friendly to gain acceptance among the end users. Bad IT performance will not only frighten the older and "IT-dislike" staff, but also irritate the hardened "IT-like" staff. Even worse, the longer the system takes to respond or open drawers, the longer the waiting time becomes, thus leading to bottlenecks and thus great annoyance. The EMDCs seen in London hospitals all responded quickly, and the interface in especially the *RxStation®* and *Pyxis® MedStation® 4000* was user-friendly with large touch screen with clear and simple indications on the screen of which buttons to push and what medication to select. However, in relation to previously mentioned statements that human errors never disappear (32,52), a blind trust in new IT can also be dangerous, as the system could have unseen glitches. Without a bar code scanning procedure, human errors could have a potential dangerous impact, as medication may accidentally be stored in a compartment designated for another without anyone ever noticing it. If a bar code scanning procedure is not used, continuous control or randomised inspections may be a solution, but it would lead to large time consumptions for the pharmacy staff or nurses.

A major disadvantage is that the system can only be accessed by one end user at a time, thus creating bottlenecks and increasing the waiting time. Unfortunately, it is only possible to have on computer per EMDC setup (41,100). Additionally, when using the locked lidded drawers, only one compartment can be accessed at a time. Therefore, medication for acute administration such as epinephrine or antihistamines should be kept elsewhere, as the time for extraction may be too long for critically ill patients. Some EMDCs have overwrite procedures to access such medication, but acute administration procedures should be tested to find the best possible site for storage of acute medication.

Furthermore, an important aspect, which is relevant for implementation of EMDCs in a Danish hospital, is the interface to EPJ and the hospital pharmacy accounting system Apovision. The EMDCs generally support HL7 systems, which EPJ (104) and Apovision (105) currently are not a part of, thus some interface developments are required. This is also accounted for in the budget. The extent of the interface development is

unknown at this point, but since the Swisslog PillPick AMDS is connected to the EPJ and Apovision, only minor problematic issues should arise.

Lastly, even though breakdowns rarely occur (39-41,100), the maintenance and service must also be addressed. As the manufacturers and their technicians are located outside Denmark, telephonic service and guidance must be available every day throughout the year, which most manufactures have. Depending on the severity of the breakdown, a local technician may have to be educated in the use and repair of the EMDC, and be either on call or available on site during the day.

Aspects of Economics and Efficiency prior and subsequent to Surveys

In order to gain insight in the advantages and disadvantages of the EMDCs in Danish hospital settings, a comparative study (surveys) of the daily tasks and work flow for both pharmacy staff and nurses prior to (current traditional medication room) and subsequent to implementation (EMDC medication room) will be carried out in two participating wards. Through observations, end user interviews, and meetings, the investigators will measure time, efficiency, and user-friendliness, and patient safety through the number of medication errors. The duration of all tasks and entire workflow from dispensing of unit doses at the hospital pharmacy to administration of medication to the patient (incl. delivery to wards, refilling of EMDCs, extraction of medication by nurses, rounds of medication administration, and number of repeats and waiting time) will be measured to investigate, if an EMDC has the proposed time saving effect. The accessibility to each type of medication (incl. access to the most and least used medications), type of drawer and module, and the general EMDC system is also measured. The use of automatically created reports is also investigated to find to best possible approach to the refilling procedure and logistics.

During the implementation, there will be some loss of efficiency, as the two medication rooms will be renovated to fit the EMDCs, and the staff will therefore not be able to fully perform their tasks. This is an unavoidable, but necessary cost, as the existing medication rooms are smaller than at Department of Infectious Diseases Q, thus having no additional floor space available.

Both the financial perspectives for the society and the investing and running costs for the hospital must also be calculated to investigate, if an EMDC has the proposed resource saving effect. The use of EPJ, automatic dispensing, and bar code scans combined with an EMDC should further decrease the number of medication errors. This should in turn reduce the costs and be beneficial for the society through shorter hospital admissions, fewer side effects due to fewer medication errors, and eventually less sick leave and increased productivity. For the hospital itself, the investment in the two EMDCs (price, delivery, installation, and interface development) as well as running costs for the pharmacy and wards (incl. staff wages, dispensing of unit doses to additional wards, delivery of medication to wards, medication waste and loss, service and maintenance of the EMDC, electricity and backup power, cleaning, and changes/reductions in medication stock) must be calculated. Because only one price estimation regarding the proposed EMDC setups was received, it is not possible to compare and evaluate on the costs thereof. However, the costs of the proposed *OmniRx* setup is somewhat within the boundaries of the hospital pharmacy project budget. By restricting the setup to a “three-cell” with less secure drawers for more space, the price would also be reduced.

No IT implementation can be carried through unless the staffs are well-trained (15,41,48). Once two wards have been chosen to host the surveys, introductory EMDC material will be produced for the staff, as the current material available contains insufficient descriptions. Each nurse at Saint Thomas Hospital in London received a 45 minute training session (41), which should be similar at Aarhus University Hospital. However, the training session should be carefully planned by the investigators and the pharmacy to avoid unnecessary time and nurse wasting. Additionally, training and educative sessions should take place before implementation, so the nurses can form an overview of the EMDC and its system. If the budget allows it later on, an additional EMDC with all drawer types may be purchased for training purposes only.

It is important that the pharmacy staff and especially the nurses lean to be honest about stock management to get the EMDC to work properly (39-41). As the author saw in the three London hospitals, many discrepancies arise, when nurses forget to type in the correct number of medications left in the EMDC. Stock management is especially important in open matrix drawers, where many medications can be extracted without accounting.

Perspectives of using Electronic Medication Dispensing Cabinets in Clinical Trials

A hitherto unknown approach to the EMDCs is that they could be of use in clinical trials. During double blinded, randomized controlled trials, the EMDC may contain the drug under investigation as well as placebo. The same unique, predetermined clinical trial ID assigned to each test subject could be typed into the EMDC along with drug and placebo ID, which are all to be chosen on the EMDC screen during extraction. The drawer with either the active drug or placebo will open for the following extraction thereof. If the clinical trial is a dose ranging or tolerability study, the number of drawers in the EMDC should match the number of doses under investigation.

The use of an EMDC during clinical trials would increase the safety of the test subjects, as the drug or placebo selected for administration is always located in the correct drawer, thus reducing the risk of errors. Time will also be saved from locating the correct drug stored in a large open cabinet or elsewhere, and the need for additional storage space is also reduced. Reports are automatically created, thus documenting the administration. The test subject ID, breaking codes etc. may be added to the reports for additional safety and documentation.

To maintain a high quality and homogeneity throughout the conduction of clinical trials, the use an EMDC may be most beneficial in a unicenter trial rather than a multicentered trial, as it cannot be guaranteed that the multiple centres participating have the same EMDC, uses it similarly, or would even like to invest in it for the purpose of storing the drug under investigation. A standard EMDC setup consisting of one or a few cabinets may be useful in phase I or phase II trials, as the number of centres participating as well as then number of test subjects are not as comprehensive as during phase III trials.

Conclusion

In conclusion, six of the seven EMDCs should be considered an option for implementation at Aarhus University Hospital. Based on the design, functionality, and availability in Denmark, the *OmniRx G4* by Omnicell and the *RxStation®* by Cerner followed by the *Pyxis® MedStation® 4000* by CareFusion seem to be the best choices, as the advantages of these are higher than the other EMDCs. The disadvantages are similar for all seven EMDCs. Although the costs of investing in EMDCs are high, the long term gains are considerable, especially for stock management and documentation thereof. Patient safety should also be improved, as fewer medication errors should be seen through the use of EMDCs, bar code scans, and EPJ. However, to gain a clearer perspective on the possible time and resource savings before a consistent implementation in the New University Hospital in Aarhus, surveys and an extensive HTA are to be completed to clarify, if the benefits are in fact higher than the costs.

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9 Figures and Tables

10 Appendix

10.1 Appendix 1: Treatment-Specific Unit Dose Collections

This appendix provides an overview of the treatment-specific unit dose collections dispensed in the PillPick AMDS located in the hospital pharmacy at Aarhus University Hospital Skejby as of March 3rd 2011, which can be seen in Table 17. The collections are delivered to several wards and departments in Aarhus hospitals as well as in Region Hospitals Randers, Grenaa, and Silkeborg in Region Midtjylland. (106)

Name	Contents	Delivered to
Pain relief (Pamol/Celebra)	Celebra 200 mg 1 unit x 2 Pamol 500 mg 2 units x 4	Department of Gynaecology and Obstetrics Y5
RR Medical abortion	Cytotec 0,2 mg 2 units x 1 Cytotec 0,2 mg 1 unit x 1 Mifegyne 200 mg 1 unit x 1 Pamol 500 mg 2 units x 2 Burana 400 mg 1 unit x 2	Region Hospital Randers Dept. of Gynaecology B5 Region Hospital Randers Gynaecology Outpatient Department Region Hospital Grenaa Surgery Outpatient Department
RS Medical abortion	Cytotec 0,2 mg 2 units x 1 Cytotec 0,2 mg 1 unit x 1 Mifegyne 200 mg x 1 unit x 1 Emperal 10 mg 1 unit x 3	Region Hospital Silkeborg Dept.of Gynaecology and Obstetrics G1
RR/RG Ketogan	Ketogan 5+25mg 1 unit x 4	Region Hospital Randers Day Surgery Region Hospital Grenaa Day Surgery
RR Ondansetron 4 mg	Ondansetron 4 mg 1 unit x 4	Region Hospital Randers Day Surgery Region Hospital Grenaa Day Surgery
RR Toilax	Toilax 5 mg 3 unit x 1	Region Hospital Silkeborg Medical MD
RR/RG Magnesia	Magnesia 500 mg 2 units x 3	Region Hospital Randers Day Surgery Region Hospital Grenaa Day Surgery
RR/RG Burana 600 mg	Burana 600 mg 1 unit x 3	Region Hospital Randers Day Surgery
SKS Pain relief (weight > 80 kg)	Pamol 500 mg 2 units x 4 Burana 600 mg1 unit x 4	Day Surgery
SKS Pain relief (weight < 80 kg)	Pamol 500 mg 2 units x 4 Burana 400 mg1 unit x 4	Day Surgery
Y Flagyl vagitories w/ metronidazol supplement	Flagyl vag 500 mg 1 unit x 2 Metronidazol sup 1 g 1 unit x 1	Department of Gynaecology and Obstetrics Y5 Clinic of Urology and Gynaecology Department of Gynaecology and Obstetrics Y6
C-section	Zantac 150 mg 1 unit x 2 Pinex retard 500 mg 4 unit x 1	Region Hospital Silkeborg Gynaecology G3
Pain relief (Pamol/Bur 400)	Pamol 500 mg 2 units x 4 Burana 400 mg 1 unit x 3	Region Hospital Randers Organ Surgery C6 Region Hospital Randers Day Surgery Region Hospital Grenaa Day Surgery Dept. of Heart, Lung and Vascular Surgery T3 Region Hospital Silkeborg Day Surgery Region Hospital Silkeborg Dept. of Gynaecology and Obstetrics G1 Dept. of Urinary Tract Surgery K (prostate) Dept. of Urinary Tract Surgery K (bladder)
Pain relief (Bonyl-Pamol)	Bonyl 500 mg 1 unit x 2 Pamol 500 mg 2 units x 4	Region Hospital Randers Department of Gynaecology B5
Spontaneous abortion (Pamol)	Pamol 500 mg 2 units x 6	Fertility clinic Y

Spontaneous abortion (Bonyl-Cytotec)	Bonyl 500 mg 1 unit x 3 Cytotec 0,2 mg 2 units x 1 Cytotec 0,2 mg 1 unit x 1	Fertility clinic Y
Before female egg harvesting (Pamol-Halcion)	Pamol 500 mg 2 units x 1 Halcion 0,125 mg 1 unit x 1	Fertility clinic Y
Pain relief (Bonyl-Pinex retard)	Pinex retard 4 unit x 2 Bonyl 500 mg 1 unit x 2	Department of Gynaecology and Obstetrics Y1 Department of Gynaecology and Obstetrics Y2
SKS Medical abortion (Ring 1)	Mifegyne 200 mg 1 unit x 1	Department of Gynaecology and Obstetrics Y6
SKS Medical abortion (Ring 2)	Cytotec 0,2 mg 2 units x 1 Pamol 500 mg 2 units x 1 Burana 600 mg 1 unit x 1	Department of Gynaecology and Obstetrics Y6
SKS Medical abortion (Ring 3)	Burana 600 mg 1 unit x 5	Department of Gynaecology and Obstetrics Y6
Stent Neuroradiology	Plavix 75 mg 1 unit x 1 Magnyl svage 1 unit x 1	Department of Neuroradiology

Table 17. Overview of the treatment-specific unit dose collections dispensed in the PillPick AMDS in the hospital pharmacy at Aarhus University Hospital Skejby. Unless other hospitals are noted under "Delivered to", the unit dose collections are delivered to local wards and departments at Aarhus University Hospital Skejby. Dept.: Department. (106)

10.2 Appendix 2: Unit Doses Delivered to Hospitals in Region Midtjylland

This appendix provides an overview of the medication dispensed in separate unit doses in the PillPick AMDS located in the hospital pharmacy at Aarhus University Hospital Skejby as of March 3rd 2011, which can be seen in Table 18. Packages are delivered to several wards and departments in Aarhus hospitals as well as to Region Hospital Randers in Region Midtjylland. (106)

Name	Contents	Delivered to
Acetylsalicylic acid ("*Hjertemagnyl*")	Acetylsalicylic acid 75 mg x 1	Region Hospital Randers Service Production
Pantoprazol	Pantoprazol 40 mg x 1	Region Hospital Randers Day Surgery
Toilax	Toilax 5 mg x 1	Region Hospital Randers Organ Surgery Outpatient Department K
Contalgin	Contalgin 10 mg x 1	Day Surgery
Morfin	Morfin 10 mg	Day Surgery
Pinex Retard	Pinex Retard 500 mg x 4	Aarhus University Hospital NBG Neurosurgical Ward NSA5 Aarhus University Hospital THG Orthopeadic Surgery Ward E9 and E10 Aarhus University Hospital THG Outpatient Dept. E
Toilax	Toilax 5 mg x 2	Aarhus University Hospital NBG Service Production
Procoralan	Procoralan 5 mg x 1	Heart medication outpatient department B
Atenodan	Atenodan 100 mg x 1	Heart medication outpatient department B

Table 18. Overview of the medication dispensed in separate unit doses by the PillPick AMDS in the hospital pharmacy at Aarhus University Hospital Skejby. Unless other hospitals are noted under "Delivered to", the unit dose collections are delivered to local wards and departments at Aarhus University Hospital Skejby. Dept.: Department. NBG: Aarhus University Hospital Nørrebrogade. THG: Aarhus University Hospital Tage-Hansens Gade. (106)

10.3 Appendix 3: Standard Stock List of the Medication Room at Q1

This appendix shows the standard stock list of the medication room at the Department of Infectious Diseases Q1 as of April 29th 2011 (Table 19). The list is arranged alphabetically by ATC codes. The number of medications may appear longer than at other wards, as many different infectious diseases are treated at Q1. Additionally, several medications are available in multiple doses. (65)

ATC code	Name, manufacturer, form, dose, concentration etc.	Packing	Q1 stock
A02AA04	Magnesia "DAK", film-coated tablets, 500 mg x 2	Unit dose	30, each w/ 2 tablets
A02AD01	Link, oral suspension, 150 mg/ml, 500 ml	Bottle	1
A02AH	Sodium bicarbonate MEDIC, 500 mg	Unit dose	10
A02BC02	Pantoloc "Nycomed", powder for IV solution 40 mg	Capped vial	2 packs of 5 x 40 mg
A02BC02	Pantoprazol "Nycomed", enterotablets, 20 mg	Unit dose	12
A02BC02	Pantoprazol "Nycomed", enterotablets, 40 mg	Unit dose	12
A02BX13	Gaviscon "Nordic Drugs", oral suspension, 500 ml	Bottle	1
A03FA01	Emperal, tablets, 10 mg	Unit dose	30
A03FA01	Primperan "Sanofi-Aventis", suppositories, 20 mg	Unit dose	12
A04AA01	Ondasetron "Nycomed", film-coated tablets, 4 mg	Unit dose	12
A04AA01	Zofran "GlaxoSmithKline Ph", suppositories, 16 mg	Suppository	2 packs of 5 tablets
A06A	Colon cleaning kit prior to colonoscopy	Kit	2
A06AB02	Toilax, entorotablets, 5 mg	Pack	0 packs of 100 tablets
A06AB08	Actilax, oral drops, solution, 7,5 mg/ml, 30 ml	Bottle	2
A06AD11	Lactulose "SAD", oral solution, 667 mg/ml, 500 ml	Bottle	2
A06AD65	Moxalole, powder for oral solution	Pack	2 packs of 20 bags
A06AG01	Phosphate "SAD", rectal fluid, solution, 150 ml	Tube	2
A06AG02	Toilax, rectal fluid solution, 2 mg/ml	Tube	5 packs of 50 x 5 ml tubes
A06AG06	Oil Klysma, 250 ml	Bottle	1
A07AA02	Mycostantin "2care4", oral susp., 100,000 IE/ml, 60 ml	Bottle *	2
A07AA09	Vancocin, capsules, hard, 250 mg	Pack	0 packs of 30 capsules
A07AA09	Vancomycin "Xellia", capsules, hard, 125 mg	Unit dose	15
A07DA03	Imodium, tablets, 2 mg	Unit dose	20
A10AB01	Insuman Rapid Solostar, injection fluid, susp., pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10AC01	Insulatard FlexPen, injection fluid, susp., pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10AD05	NovoMix 30 FlexPen, injection fluid, susp., pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10BA02	Metformin "Actavis", film-coated tablets, 500 mg	Unit dose	8
A10BB01	Hexaglucon, tablets, 3.5 mg	Unit dose	8
A10BB12	Amaryl "Sanofi-Aventis, tablets, 1 mg	Unit dose	8
A11A	Multi-tabs 11 years and up, tablets	Unit dose	30
A11CC05	D3 vitamin "Naturdrogeriet", tablets, 35 µg	Unit dose	12
A11DA01	Tiamin B1 extra strong "Apovit", tablets, 300 mg	Unit dose	30
A11DA01	Tiamin "SAD, injection fluid, 100 mg/ml	Ampoule	1 pack of 10 x 2 ml amps.
A11EA	B-combin "Apovit", strong, tablets	Unit dose	30
A11EA	B-combin strong "SAD", injection fluid, 100 mg/ml	Ampoule	1 pack of 10 x 2 ml amps.
A11HA02	Pyridoxin, tablets, 20 mg	Unit dose	10
A12AX	Unikalk Forte (calcium) w/ D vitamin, tablets, 800 mg + 38 µg	Unit dose	30
A12BA01	Kaleorid, depot tablets, 750 mg	Unit dose	50
A12BA01	Potassium chloride "PS", oral solution, 75 mg/ml, 500 ml	Bottle	1
A12CA01	Sodium chloride "MEDIC", enterotablets, 250 mg	Unit dose	10
A12CB01	Zinklet (zinc sulfate), tablets, 0,35 mmol/tabl	Unit dose	10
A12CC10	Mablet (magnesium) "S-R", tablets, 360 mg	Unit dose	15
B01AA03	Marevan, tablets, 2.5 mg	Unit dose	30
B01AB01	Heparin "Leo", injection fluid, solution, 100 IE/ml	Ampoule *	3 packs of 10 x 10 ml
B01AB04	Fragmin, injection fluid, solution, 12,500 anti-Xa IE/ml	Syringe	1 pack of 25 x 0.2 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 25 x 0.2 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 10 x 0.3 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.72 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.4 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.5 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.6 ml
B01AC04	Clopidogrel "Stada", film-coated tablets, 75 mg x 4	Unit dose	10, each w/ 4 tablets
B01AC06	Hjertemagnyl (acetylsalicylic acid), film-coated tablets, 75 mg	Unit dose	30
B01AC07	Persantin Retard "Abacus", depot capsules, hard, 200 mg	Unit dose	10
B01AD01	Streptase, powder for infusion fluid, solution, 250,000 IE	Capped vial *	6
B02BA01	Konakion "Novum", injection fluid, solution, 10 mg/ml	Ampoule	1 packs of 5 x 1 ml amps.
B02BA01	Menadion "Medic", tablets, 10 mg	Unit dose	6
B03AA07	Ferro Duretter, depot tablets, 100 mg	Unit dose	25

B03BA01	Betolvex “Actavis”, film-coated tablets, 1 mg	Unit dose	6
B03BB01	Folic Acid “SAD”, tablets, 5 mg	Unit dose	6
B05AA07	Voluven, infusion fluid, solution, 60 mg/ml	Pack	1 pack of 20 x 250 ml
B05BA	Glucose, injection fluid, 200 mg/ml, 100 ml	Capped vial	1
B05BB01	Sodium hydrogencarbonate, infusion fluid, 84 g/l	Bag	2 boxes of 10 x 100 ml
B05BB01	Sodium chloride “Fres.Kabi”, infusion fluid, 9 mg/ml	Bag	2 boxes of 20 x 250 ml
B05BB02	Potassium-Sodium-Glucose “Fres.Kabi”, inf. fluid, solution	Bag **	2 boxes of 10 x 1000 ml
B05BC01	Mannitol “Fres.Kabi”, infusion fluid, solution, 150 mg/ml	Bag	0 boxes of 15 x 500 ml
B05XA01	Potassium chloride “SAD”, conc. inf. fluid,, 1 mmol/ml	Bag	1 pack of 10 x 20 ml
C01AA05	Digoxin “DAK”, tablets, 62,5 µg	Unit dose	20
C01AA05	Digoxin “DAK”, tablets, 250 µg	Unit dose	10
C01AA05	Digoxin “SAD”, injection fluid, 250 µg/ml	Ampoule	1 pack of 10 x 1 ml
C01BD01	Cordarone “Sanofi-Aventis”, inject. fluid, solution, 50 mg/ml	Ampoule	1 pack of 10 x 3 ml
C01CA24	Adrenalin “DAK”, injection fluid, solution, 1 mg/ml	Ampoule *	1 pack of 5 x 1 ml
C01DA02	Glytrin, sublingual spray, 0.4 mg/dose	Spray	2 packs of 200 doses
C01DA02	Nitro-glycerine “DAK”, sublingual resoriblets, 0,25 mg	Tablet	1 pack of 100 units
C01DA02	Nitro-glycerine “DAK”, sublingual resoriblets, 0,50 mg	Tablet	1 pack of 100 units
C01DA08	Cardopax Retard, depot tablets, 40 mg	Unit dose	10
C01DA14	Fem-Mono Retard, depot tablets, 60 mg	Unit dose	10
C01DA14	Isodur, depot tablets, 30 mg	Unit dose	20
C03AB01	Centyl w/ potass. chloride “Leo”, coated tablets (2.5+573 mg)	Unit dose	25
C03CA01	Diural, tablets, 40 mg	Unit dose	40
C03CA01	Diural, tablets, 20 mg	Unit dose	20
C03CA01	Furix, injection fluid, solution, 10 mg/ml	Ampoule	5 packs of 5 x 2 ml
C03CA01	Furix, injection fluid, solution, 10 mg/ml	Ampoule	5 packs of 5 x 4 ml
C03DA01	Spiron, tablets, 25 mg	Unit dose	12
C05AA01	Protosedyl “Sanofi-Aventis”, suppositories	Suppository *	2 packs of 12 suppositories
C05AA01	Protosedyl “Sanofi-Aventis”, rectal ointment, 30 g	Tube *	1
C05BA01	Hirudoid “PharmaCoDane”, ointment, 3 mg/g	Tube***	1
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 25 mg	Unit dose	10
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 100 mg	Unit dose	10
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 50 mg	Unit dose	10
C07AG02	Carvedilol “Teva”, tablets, 12.5 mg	Unit dose	10
C07AG02	Carvedilol “Teva”, tablets, 3.125 mg	Unit dose	10
C08CA01	Amlopidin “BMM Pharma”, tablets, 10 mg	Unit dose	10
C08CA01	Amlopidin “Sandoz”, tablets, 5 mg	Unit dose	10
C08CA02	Felodipin “Ratiopharm”, depot tablets, 2.5 mg	Unit dose	10
C08CA02	Plendil “ASTRAZENECA, depot tablets, 5 mg	Unit dose	10
C09AA02	Enacodan, tablets, 5 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 1.25 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 2.5 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 5 mg	Unit dose	10
C09CA01	Losarstad, film-coated tablets, 50 mg	Unit dose	10
C09CA06	Atacand “ASTRAZENECA”, tablets, 8 mg	Unit dose	8
C09DA03	Diovan Comp, film-coated tablets, 160 mg + 12.5 mg	Unit dose	10
C10AA01	Simvastatin “Bluefish”, film-coated tablets, 20 mg	Unit dose	15
C10AA01	Simvastatin “Bluefish”, film-coated tablets, 40 mg	Unit dose	15
D01AC08	Nizoral “MCNIEL”, shampoo, 2%, 60 ml	Bottle***	1
D01AC20	Brentacort “Janssen-Cilag”, crème, 20+10 mg/g, 30 g	Tube */***	1
D01AE15	Finigen, crème, 10 mg/g, 15 g	Tube***	2
D02AB	Zink “MEDIC”, liniment, 12.5%, 100 ml	Tube***	1
D02AX	Locobase Repair, crème, 30 g	Tube***	2
D05AA	Inotyol, ointment, 50 g	Tube***	1
D06AX01	Fucidin “Leo”, ointment, 2%, 15 g	Tube***	2
D06BB03	Acivir, crème 50 mg/g, 2 g	Tube***	2
D07AB02	Locoid Astellas, crème, 0.1%, 30 g	Tube***	2
D07AC13	Elocon, crème, 0.1%, 30 g	Tube***	2
D07AD01	Dermovat “GlaxoSmithKline Ph”, ointment, 0.5 mg/g, 25 g	Tube***	2
D07CC01	Fucicort “Leo”, crème, 1+20 mg/g, 15 g	Tube***	1
D08A	Hospital alcohol “Kemetyl”, 70%, 1 liter	Bag	6
G04CA01	Xatral “Sanofi-Aventis”, film-coated tablets, 2.5 mg	Unit dose	6
H01AA02	Synacthen, injection fluid, solution, 0.25 mg/ml	Capped vial	2 packs of 1 x 1 ml
H01BA04	Variquel, powder and injection solution, 1 mg	Capped vial	1 packs of 5 sets
H02AB02	Fortecortin “Merck Serono”, injection fluid, 4 mg/ml	Ampoule	20 packs of 3 x 1 ml
H02AB04	Solu-medrol “Pfizer”, powder and injection solution, 125 mg	Capped vial	5 packs of 1 vial+solution
H02AB04	Solu-medrol “Pfizer”, powder and injection solution, 40 mg	Capped vial	2 packs of 1 vial+solution
H02AB06	Prednisolon “DAK”, tablets, 5 mg	Unit dose	30
H02AB06	Prednisolon “DAK”, tablets, 25 mg	Unit dose	30

H02AB09	Solu-cortef, powder and injection solution, 100 mg	Capped vial	8 packs of 1 vial+solution
H03AA01	Eltroxin, tablets, 100 µg	Unit dose	20
H03AA01	Eltroxin, tablets, 50 µg	Unit dose	20
H03BB02	Thycapzol “SANDOZ”, tablets, 5 mg	Bottle	1 bottle w/ 100 tablets
J01AA02	Vibradox, tablets, 100 mg	Unit dose	25
J01CA01	Pentrexyl, powder for injection + infusion solution, 1 g	Capped vial	4 packs of 5 vials
J01CA01	Pentrexyl, powder for injection + infusion solution, 500 mg	Capped vial	2 packs of 5 vials
J01CA01	Pentrexyl, powder for injection + infusion solution, 2 g	Capped vial	3 packs of 5 vials
J01CA04	Imadrax, film-coated tablets, 1000 mg	Unit dose	20
J01CA08	Penomax “Orion Pharma”, film-coated tablets, 200 mg	Unit dose	20
J01CA11	Selexid “Leo, powder for injection fluid, solution, 1 g	Capped vial	12
J01CE01	Benzylpenicillin “Panpharma”, powder for inject.+inf.sol. 3 g	Pack	6 packs of 10 x 3 g
J01CE01	Benzylpenicillin “Panpharma”, powder for inject.+inf.sol. 0.6g	Pack	6 packs of 10 x 0.6 g
J01CE01	Benzylpenicillin “Panpharma”, powder for inject.+inf.sol. 1.2g	Pack	6 packs of 10 x 1.2 g
J01CE02	Vepicombin “Novum”, film-coated tablets, 1,000,000 IE	Unit dose	20
J01CF01	Dicillin, capsules, hard, 500 mg	Unit dose	20
J01CF01	Diclocil, powder for injection + infusion solution, 1 g	Pack	5 packs of 5 x 1 g
J01CR02	Bioclavid, film-coated tablets, 500 mg + 125 mg	Blister	2 packs of 30 units
J01CR05	Piperacil./Tazobactam, “Stragen”, powder inject+inf, 4g+0.5 g	Capped vial	4 packs of 10 x 1 vial
J01CR05	Piperacil./Tazobactam, “Stragen”, powd. inject+inf, 2g+0.25g	Capped vial	2 packs of 10 vials
J01DC02	Cefuroxim “Fresenius Kabi”, powd.inject.fluid, solut., 750 mg	Capped vial	2 packs of 10 x 750 mg
J01DC02	Cefuroxim “Fresenius Kabi”, powd.inject.fluid, solut., 1500mg	Capped vial	5 packs of 10 x 1.5 g
J01DD04	Ceftriaxon “ACS Dobfar Generics, powder.i.f, solute, 2 g	Capped vial	6 packs of 5 x 1 vial
J01DH02	Meropenem “Hospira”, powder for inject.+inf.sol, 1 g	Capped vial	6 packs of 10 vials
J01EB02	Sulfametizol “Activis”, tablets, 500 mg	Unit dose	20
J01EC02	Sulfadiazin, tablets, 500 mg	Bottle	1 bottle w/ 100 tablets
J01EE01	Bactrim “Roche”, infusion concentrate, 400 mg/80 mg	Ampoules	1 pack of 10 x 5 ml
J01EE01	Sulfametoxazol with trimetoprim, tablets, 400 mg/80 mg	Bottle	1 bottle w/ 100 tablets
J01FA06	Surlid “Sanofi-Aventis, film-coated tablets, 150 mg	Unit dose	20
J01FA09	Clarithromycin “PCD), film-coated tablets, 500 mg	Unit dose	20
J01FA09	Klacid “Abbott”, powder for infusion fluid, solution, 500 mg	Capped vial	10
J01FA10	Azithromycin “Teva”, film-coated tablets, 500 mg	Unit dose	12
J01FF01	Clindamycin “Stragen, injection fluid/inf. concentrate, 150 mg/ml	Ampoule	2 packs of 10 x 4 ml
J01FF01	Dalacin “Pfizer”, capsules, hard, 300 mg	Unit dose	15
J01GB03	Hexamycin, injection fluid, solution, 40 mg/ml	Ampoule	4 packs of 10 x 3 ml
J01MA01	Tarivid “Sanofi-Aventis”, film-coated tablets, 200 mg	Unit dose	20
J01MA02	Ciprofloxacin “Actavis”, film-coated tablets, 250 mg	Unit dose	30
J01MA02	Ciprofloxacin “BMM Pharma”, film-coated tablets, 500 mg	Unit dose	30
J01MA02	Ciprofloxacin “Fresenius Kabi”, inf. fluid, solution, 2 mg/ml, 100 ml	Bag	1 box of 10 x 100 ml
J01MA02	Ciprofloxacin “Fresenius Kabi”, inf. fluid, solution, 2 mg/ml, 200 ml	Bag	1 box of 10 x 200 ml
J01MA14	Avelox “BAYER”, infusion fluid, solution, 1.6 mg/ml	Bag	1 box of 5 x 250 ml
J01MA14	Avelox “BAYER”, film-coated tablets, 400 mg	Unit dose	12
J01XA01	Vancomycin “Hospira”, powder for infusion fluid, solution, 500 mg	Capped vial	3
J01XA01	Vancomycin “Xellia”, powder for inf. fluid, solution, 1000 mg, 20 ml	Capped vial	10
J01XB01	Colimycin “Medilink, powder for inject. fluid, solution, 1,000,000 IE	Capped vial	1 pack of 10 vials
J01XD01	Metronidazol “B. Braun”, infusion fluid, solution, 5 mg/ml	Bag	1 box of 20 x 100 ml
J01XX08	Zyvoxid “Pfizer”, infusion fluid, solution, 2 mg/ml	Bag	1 box of 10 x 300 ml
J02AC01	Fluconazol “B. Braun”, infusion fluid, solution, 2 mg/ml	Bag	1 box of 20 x 100 ml
J02AC01	Fluconazol “BMM Pharma”, capsules, hard, 50 mg	Unit dose	12
J02AC01	Fluconazol “BMM Pharma”, capsules, hard, 200 mg	Unit dose	12
J02AC03	Vfend, film-coated tablets, 200 mg	Unit dose	15
J02AX01	Ancotil, infusion fluid, 10 mg/ml	Bag	0 boxes of 5 x 250 ml
J04AB02	Eremfar “REIMSER”, powder for injection/infusion	Capped vial	10
J04AB02	Rimactan “SANDOZ”, capsules, hard, 150 mg	Bottle	1 bottle w/ 100 capsules
J04AB02	Rimactan “SANDOZ”, capsules, hard, 300 mg	Bottle	1 bottle w/ 100 capsules
J04AB02	Rimactan “SANDOZ”, coated tablets, 450 mg	Bottle	1 bottle w/ 100 tablets
J04AC01	Isoniazid, tablets, 100 mg	Bottle	1 bottle with 100 tablets
J04AC01	Isoniazid “OBA, tablets, 300 mg	Bottle	1 bottle with 50 tablets
J04AK01	Pyrazinamid “SAD”, tablets, 500 mg	Bottle	1 bottle with 112 tablets
J04AK02	Myambutol “Orifarm”, tablets, 400 mg	Unit dose	20
J04AM06	Rimstar, film-coated tablets	Blister	0 packs of 60 blisters
J05AB01	Aciclodan, tablets, 200 mg	Unit dose	20
J05AB01	Aciclodan, tablets, 400 mg	Unit dose	20
J05AB01	Aciclovir “Hospira”, concentrate for infusion fluid, 25 mg/ml, 10 ml	Capped vial	6 packs of 5 x 10 ml
J05AB01	Aciclovir “Hospira”, concentrate for infusion fluid, 25 mg/ml, 20 ml	Capped vial	6 packs of 5 x 10 ml
J05AB06	Cymevene, powder for infusion fluid, 500 mg	Capped vial	1 pack of 5 x 1 vials
J05AB11	Zelitrex “GlaxoSmithKline Ph”, film-coated tablets, 500 mg	Unit dose	18
J05AD01	Foscavir “AstraZeneca”, infusion fluid, 24 mg/ml	Bag	0 boxes of 10 x 250 ml

J06BA02	Privigen, infusion fluid, solution, 100 mg/ml, 50 ml	Capped vial	1
J06BA02	Privigen, infusion fluid, solution, 100 mg/ml, 100 ml	Capped vial	2
J06BA02	Privigen, infusion fluid, solution, 100 mg/ml, 200 ml	Capped vial	1
J07BC01	Engerix-B “GlaxoSmithKline Ph”, injection suspension, 20 µg/ml	Ampoule *	1 pack of 25 x 1 ml
M01AB01	Confortid, suppositories, 100 mg	Suppository	1 pack of 10 suppositories
M01AB08	Todolac, film-coated tablets, 200 mg	Unit dose	6
M01AE01	Burana, film-coated tablets, 400 mg	Unit dose	50
M01AE01	Burana, film-coated tablets, 600 mg	Unit dose	30
M03BB03	Klorzoxazon “DAK”, tablets, 250 mg	Bottle	1 bottle w/ 25 tablets
M03BX01	Baklofen “Mylan”, tablets, 25 mg	Unit dose	6
M04AA01	Allopurinol “DAK, tablets, 100 mg	Unit dose	6
M04AA01	Allopurinol “DAK, tablets, 300 mg	Unit dose	6
M05BA04	Alendronat “Arrow”, tablets, 70 mg	Unit dose	4
N01BB02	Lidokain “SAD”, injection fluid, 10 mg/ml	Ampoule	1 pack of 10 x 5 ml
N02AA01	Contalgin, depot tablets, 10 mg	Unit dose	20
N02AA01	Contalgin, depot tablets, 30 mg	Unit dose	20
N02AA01	Morphine “DAK”, tablets, 10 mg	Unit dose	20
N02AA01	Morphine “SAD”, suppositories, 20 mg	Pack *	1 pack of 10 units
N02AA01	Morphine “SAD”, injection fluid, 10 mg/ml	Ampoule *	3 packs of 10 x 1 ml
N02AB03	Durogesic “Janssen-Cilag”, depot patches, 12 µg/hour	Pack	1 pack w/ 8 patches
N02AB03	Durogesic “Janssen-Cilag”, depot patches, 50 µg/hour	Pack	1 pack w/ 8 patches
N02AB03	Durogesic “Janssen-Cilag”, depot patches, 25 µg/hour	Pack	1 pack w/ 8 patches
N02AX02	Taldol, suppositories, 100 mg	Unit dose	12
N02AX02	Tradolan, tablets, 50 mg	Unit dose	40
N02BE01	Pamol, film-coated tablets, 500 mg x 2	Unit dose	50 unit doses, each w/ 2 tablets
N02BE01	Panodil Fizz (Brus), soluble tablet, 500 mg	Blister	2 packs of 24 blisters
N02BE01	Pinex “Actavis”, suppositories, 500 mg	Unit dose	12
N02BE01	Pinex “Actavis”, suppositories, 1000 mg	Unit dose	12
N02CC01	Sumatriptan “Sandoz”, film-coated tablets, 50 mg	Unit dose	6
N03AA02	Fenemal “DLF”, tablets, 100 mg	Unit dose	8
N03AA02	Fenemal “SAD”, injection fluid, 100 mg/ml	Ampoule *	1 pack of 10 x 1 ml
N03AE01	Rivotril “ROCHE”, tablets, 0.5 mg	Unit dose	8
N03AE01	Rivotril “ROCHE”, tablets, 2 mg	Unit dose	8
N03AF02	Apydan “Desitin, tablets, 300 mg	Unit dose	10
N03AF02	Trileptal “Novartis Healthcare”, film-coated tablets, 300 mg	Unit dose	10
N03AG01	Delepsine Retard, depot tablets, 500 mg	Unit dose	10
N03AX09	Lamotrigin “BMM Pharma”, tablets, 100 mg	Unit dose	10
N03AX12	Gabapentin “PCD”, capsules, hard, 300 mg	Unit dose	10
N04BA02	Madopar “62.5” “ROCHE”, caps., hard, 50mg levodopa+12.5mg benserazid	Unit dose	10
N04BA02	Sinemet 12.5/50, tablets, 50 mg levodopa + 12.5 mg carbidopa	Unit dose	10
N05AD01	Serenase, tablets, 2 mg	Unit dose	10
N05AD01	Serenase, injection fluid, solution, 5 mg/ml	Ampoule	1 pack of 5 x 1 ml
N05AH03	Zyprexa, coated tablets, 10 mg	Unit dose	10
N05BA01	Diazepam “DAK, tablets, 5 mg	Unit dose	20
N05BA01	Stesolid, suppositories, 5 mg	Unit dose	10
N05BA01	Stesolid, rectal fluid, solution, 5 mg/dose	Tube	1 pack of 5 x 1
N05BA01	Stesolid, tablets, 2 mg	Unit dose	20
N05BA01	Stesolid Emulsion, injection fluid, 5 mg/ml	Ampoule	1 Pack of10 x 2 ml
N05BA04	Oxapax, tablets, 15 mg	Unit dose	15
N05CD02	Nitrazepam “DAK”, tablets, 5 mg	Unit dose	10
N05CF01	Imoclone, film-coated tablets, 7.5 mg	Unit dose	40
N05CF02	Zolpidem “Actavis”, film-coated tablets, 10 mg	Unit dose	20
N06AB04	Citalopram “Orion”, film-coated tablets, 20 mg	Unit dose	10
N06AB04	Citalopram “Sandoz”, film-coated tablets, 10 mg	Unit dose	10
N06AB10	Cipralex “Lundbeck”, film-coated tablets, 10 mg	Unit dose	10
N06AB10	Cipralex “Lundbeck”, film-coated tablets, 20 mg	Unit dose	10
N06AX03	Tolmin, film-coated tablets, 30 mg	Unit dose	10
N06AX11	Combar, film-coated tablets, 15 mg	Unit dose	10
N06AX11	Combar, film-coated tablets, 30 mg	Unit dose	10
N06AX16	Venlafaxin “Actavis”, depot capsules, hard, 75 mg	Unit dose	10
N06AX16	Venlafaxin “Actavis”, depot capsules, hard, 150 mg	Unit dose	10
N06BC01	Caffeine, tablets, 100 mg	Unit dose	20
N07BA01	Nicorette “McNiel Denmark”, depot patches, 5 mg /16 hours	Patch	1 pack of 14 patches
N07BA01	Nicorette Invinsible, depot patches, 10 mg/16 hours	Patch	1 pack of 14 patches
N07BA01	Antabus, soluble tablets, 400 mg	Bottle	1 bottle w/ 50 tablets
N07BC02	Metadon “DAK”, tablets, 20 mg	Unit dose	20
N07BC02	Metadon “DAK”; oral solution, 1 mg/ml, 300 ml	Bottle	4
P01AB01	Flagyl, suppositories, 0.5 g	Unit dose	12

P01AB01	Metronidazol “DAK”, film-coated tablets, 500 mg	Unit dose	20
P01B	Primaquine phosphate, tablets, 7.5 mg	Bottle	1 bottle w/ 100 tablets
P01BA01	Malarex, film-coated tablets, 250 mg	Blister	1 pack of 20 blisters
P01BB51	Malarone, film-coated tablets, 100+250 mg	Unit dose	12
P01BC01	Klinin, infusion concentrate, 100 mg/ml	Ampoule	1 pack of 10 x 5 ml
P01BC01	Klinin “DAK”, film-coated tablets, 100 mg	Unit dose	10
P01BC02	Lariam, tablets, 250 mg	Unit dose	10
P01BD01	Daraprim “GlaxoSmithKline Ph”, tablets, 25 mg	Bottle	1 bottle w/ 30 tablets
P01BE03	Artesunate, powder and solvent for injection, 60 mg	Capped vial*	16
P01BE52	Riamet “Novartis”, tablets, 20+120 mg	Blister	1 pack of 24 blisters
P02BA01	Biltricide “Bayer”, tablets, 600 mg	Bottle	1 bottle w/ 6 tablets
R01A07	Zymelin unpreserved, nasal spray, solution, 1 mg/ml, 10 ml	Spray	2 packs of 1 bottle
R03AC02	Ventoline, inhalation spray, suspension, 0.1 mg/dose, 200 doses	Spray	1
R03AK03	Duovent “Orifarm”, inhalation fluid, nebulizer solution, 1.25+0.5 mg	Bottle	1 pack of 60 x 4 bottles
R03BA02	Spirocort Turbuhaler, inhalation powder, 200 µg/dose	Pack	1 pack of 100 doses
R03BB04	Spiriva “BOEHRINGER”, inhalation powder in capsules, 18 µg	Blister	1 pack of 30 blisters
R03CC02	Ventoline, infusion concentrate, 1 mg/ml	Ampoule	1 pack of 10 x 5 ml
R03CC03	Bricanyl “ASTRAZENECA, concentrate for infusion fluid, 0.5 mg/ml	Ampoule	1 pack of 10 x 5 ml
R05DA04	Kodein “DAK”, film-coated tablets, 25 mg	Unit dose	60
R06AA04	Tavegyl, injection fluid, solution, 1, mg/ml	Ampoule	1 pack of 5 x 2 ml
R06AE07	Cetirizin “Mylan”, film-coated tablets, 10 mg	Unit dose	10
S01AA01	Kloramfenikol “DAK”, eye drops, solution, 0.5%, 10 ml	Bottle *	2
S01AA01	Kloramfenikol “DAK”, eye ointment, 1%, 5 ml	Tube *	2
S01AA13	Fucithalmic “Leo”, eye drops, suspension, 2.4 g	Pipette	1 pack of 12 disposable pipettes
S01XA20	Viscous eye drops, “Ophtha”, eye drops, 10 ml	Bottle	1
V03	Alternative medication	Mixed	0
V03	Medication for projects	Mixed	0
V03A	Acute box GREEN SKS + THG + NBG	Box	2
V03AB15	Naloxon “B. Braun”, injection fluid, solution, 0.4 mg/ml	Ampoule	1 pack of 10 x 1 ml
V03AB25	Flumazenil “Hameln, injection fluid, solution, 0.1 mg/ml	Ampoule	1 pack of 5 x 5 ml
V04CF01	Tuberkulin PPD RT23 “SSI”, injection fluid, solution, 2 TE/dose, 1.5 ml	Capped vial *	2
V01AB	Sodium chloride “Fresenius Kabi”, solvent for parenteral use, 9 mg/ml	Ampoule	0 packs of 20 x 10 ml
V01AB	Sodium chloride “Fresenius Kabi”, solvent for parenteral use, 9 mg/ml	Capped vial	0 packs of 00 x 100 ml
V01AB	Sterile water Fresenius Kabi”, solvent for parenteral use	Capped vial	1 box of 40 x 100 ml
V01AB	Sterile water Fresenius Kabi”, solvent for parenteral use	Ampoule	0 packs of 20 x 10 ml
V01AB	Sterile water Fresenius Kabi”, solvent for parenteral use	Capped vial	0 box of 10 x 100 ml
Å	Calogen Energy dense supplement, 500 ml	Bottle	0 (1)
Å	Caroxin sugar free medical chewing gum	Pack	2 packs w/ 100 pieces of gums
Å	Clearblue Plus, pregnancy test	Pack	2 packs of 2 units
Å	Dakaryl “Lev-vel”, sweetener,	Bottle	1 bottle of 250 units
Å	Handi Haler, for inhalation of Spiriva	Pack	3

Table 19. The standard stock list of the medication room at the Department of Infectious Diseases Q1 as of April 29th 2011. The list is arranged alphabetically by ATC codes. A stock of “0” is either “outside standard stock” or “storage leftovers”. Susp.: Suspension. Inject.: injection. Inf.: infusion. * = stored in refrigerator. ** = stored in another room. * = stored in a drawer in another room. (65)**

10.4 Appendix 4: Standard Stock List of the Medication Room at Q2

This appendix shows the standard stock list of the medication room at the Department of Infectious Diseases Q2 as of April 29th 2011 (Table 20). The list is arranged alphabetically by ATC codes. The number of medications may appear longer than at other wards, as many different infectious diseases are treated at Q2. Additionally, several medications are available in multiple doses (65).

ATC code	Name, manufacturer, form, dose, concentration etc.	Packing	Q2 stock
A02AA04	Magnesia "DAK", film-coated tablets, 500 mg x 2	Unit dose	30, each w/ 2 tablets
A02AD01	Link, oral suspension, 150 mg/ml, 500 ml	Bottle	1
A02AH	Sodium bicarbonate MEDIC, 500 mg	Unit dose	10
A02BC02	Pantoloc "Nycomed", powder for IV solution 40 mg	Capped vial	2 packs of 5 x 40 mg
A02BC02	Pantoprazol "Nycomed", enterotablets, 20 mg	Unit dose	12
A02BC02	Pantoprazol "Nycomed", enterotablets, 40 mg	Unit dose	12
A02BX13	Gaviscon "Nordic Drugs", oral suspension, 500 ml	Bottle	1
A03FA01	Emperal, tablets, 10 mg	Unit dose	30
A03FA01	Primperan "Sanofi-Aventis", suppositories, 20 mg	Unit dose	12
A04AA01	Ondasetron "Nycomed", film-coated tablets, 4 mg	Unit dose	12
A04AA01	Zofran "GlaxoSmithKline Ph", suppositories, 16 mg	Suppository	2 packs of 5 tablets
A06A	Colon cleaning kit prior to colonoscopy	Kit	2
A06AB02	Toilax, entorotablets, 5 mg	Pack	5 packs of 100 tablets
A06AB08	Actilax, oral drops, solution, 7,5 mg/ml, 30 ml	Bottle	2
A06AD11	Lactulose "SAD", oral solution, 667 mg/ml, 500 ml	Bottle	2
A06AD65	Moxalole, powder for oral solution	Pack	2 packs of 20 bags
A06AG01	Phosphate "SAD", rectal fluid, solution, 150 ml	Tube	2
A06AG02	Toilax, rectal fluid solution, 2 mg/ml	Tube	5 packs of 50 x 5 ml tubes
A06AG06	Oil Klysma, 250 ml	Bottle	1
A07AA02	Mycostantin "2care4", oral susp., 100,000 IE/ml, 60 ml	Bottle *	2
A07AA09	Vancomycin "Xellia", capsules, hard, 125 mg	Unit dose	15
A07DA03	Imodium, tablets, 2 mg	Unit dose	20
A09AA02	Creon Lipase 25,000 EP-e, enterocapsules, hard,	Pack	1 pack of 100 capsules
A09AA02	Kreon Lipase 10,000 EP-e "EuroPharmaDK", enterocapsules, hard	Pack	1 pack of 100 capsules
A10AB01	Actrapid "Novolet", injection fluid, solution, pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10AC01	Insulatard FlexPen, injection fluid, susp., pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10AD05	NovoMix 30 FlexPen, injection fluid, susp., pen, 100 IE/ml	Pack *	1 pack of 5 x 3 ml
A10BA02	Metformin "Actavis", film-coated tablets, 500 mg	Unit dose	8
A10BB01	Hexaglucon, tablets, 3.5 mg	Unit dose	8
A10BB12	Amaryl "Sanofi-Aventis, tablets, 1 mg	Unit dose	8
A11A	Multi-tabs 11 years and up, tablets	Unit dose	30
A11CC05	D3 vitamin "Naturdrogeriet", tablets, 35 µg	Unit dose	12
A11DA01	Tiamin B1 extra strong "Apovit", tablets, 300 mg	Unit dose	30
A11DA01	Tiamin "SAD, injection fluid, 100 mg/ml	Ampoule	1 pack of 10 x 2 ml amps.
A11EA	B-combin "Apovit", strong, tablets	Unit dose	30
A11HA02	Pyridoxin, tablets, 20 mg	Unit dose	10
A12AX	Unikalk Forte (calcium) w/ D vitamin, tablets, 800 mg + 38 µg	Unit dose	30
A12BA01	Kaleorid, depot tablets, 750 mg	Unit dose	50
A12BA01	Potassium chloride "PS", oral solution, 75 mg/ml, 500 ml	Bottle	1
A12CA01	Sodium chloride "MEDIC", enterotablets, 250 mg	Unit dose	10
A12CB01	Zinklet (zinc sulfate), tablets, 0,35 mmol/tabl	Unit dose	10
A12CC10	Mablet (magnesium) "S-R", tablets, 360 mg	Unit dose	15
B01AA03	Marevan, tablets, 2.5 mg	Unit dose	30
B01AB01	Heparin "Leo", injection fluid, solution, 100 IE/ml	Ampoule *	4 packs of 10 x 10 ml
B01AB04	Fragmin, injection fluid, solution, 12,500 anti-Xa IE/ml	Syringe	1 pack of 25 x 0.2 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 25 x 0.2 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 10 x 0.3 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.72 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.4 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.5 ml
B01AB04	Fragmin, injection fluid, solution, 25,000 anti-Xa IE/ml	Syringe	1 pack of 5 x 0.6 ml
B01AC04	Clopidogrel "Stada", film-coated tablets, 75 mg x 4	Unit dose	10, each w/ 4 tablets
B01AC06	Hjertemagnyl (acetylsalicylic acid), film-coated tablets, 75 mg	Unit dose	30
B01AC07	Persantin Retard "Abacus", depot capsules, hard, 200 mg	Unit dose	10
B01AD01	Streptase, powder for infusion fluid, solution, 250,000 IE	Capped vial *	5
B02BA01	Konakion "Novum", injection fluid, solution, 10 mg/ml	Ampoule	1 packs of 5 x 1 ml ampoules
B02BA01	Menadion "Medic", tablets, 10 mg	Unit dose	6
B03AA07	Ferro Duretter, depot tablets, 100 mg	Unit dose	25

B03BA01	Betolvex “Actavis”, film-coated tablets, 1 mg	Unit dose	6
B03BA02	Betolvex “Actavis”, injection fluid, suspension, 1 ml/ml	Ampoule	1 pack of 5 x 1 ml ampoules
B03BB01	Folic Acid “SAD”, tablets, 5 mg	Unit dose	6
B05BA	Glucose, injection fluid, 200 mg/ml, 100 ml	Capped vial	1
BA05BA03	Glucose isotonic, “SAD”, infusion fluid, 55 g/l	Vial	0 boxes of 10 x 100 ml
B05BB01	Sodium chloride “Fres.Kabi”, infusion fluid, 9 mg/ml	Bag	8 boxes of 20 x 250 ml
B05BB02	Potassium-Sodium-Glucose “Fres.Kabi”, inf. fluid, solution	Bag **	1 boxes of 10 x 1000 ml
B05BC01	Mannitol “Fres.Kabi”, infusion fluid, solution, 150 mg/ml	Bag	0 boxes of 15 x 500 ml
B05XA01	Potassium chloride “SAD”, conc. inf. fluid,, 1 mmol/ml	Bag	1 pack of 10 x 20 ml
C01AA05	Digoxin “DAK”, tablets, 62,5 µg	Unit dose	20
C01AA05	Digoxin “DAK”, tablets, 250 µg	Unit dose	10
C01CA24	Adrenalin “DAK”, injection fluid, solution, 1 mg/ml	Ampoule *	1 pack of 5 x 1 ml
C01DA02	Glytrin, sublingual spray, 0.4 mg/dose	Spray	2 packs of 200 doses
C01DA02	Nitro-glycerine “DAK”, sublingual resoriblets, 0,25 mg	Tablet	1 pack of 100 units
C01DA02	Nitro-glycerine “DAK”, sublingual resoriblets, 0,50 mg	Tablet	1 pack of 100 units
C01DA08	Cardopax Retard, depot tablets, 40 mg	Unit dose	10
C01DA14	Fem-Mono Retard, depot tablets, 60 mg	Unit dose	10
C01DA14	Isodur, depot tablets, 30 mg	Unit dose	20
C03AB01	Centyl w/ potass. chloride “Leo”, coated tablets (2.5+573 mg)	Unit dose	25
C03CA01	Diural, tablets, 40 mg	Unit dose	40
C03CA01	Diural, tablets, 20 mg	Unit dose	20
C03CA01	Furix, injection fluid, solution, 10 mg/ml	Ampoule	5 packs of 5 x 2 ml
C03CA01	Furix, injection fluid, solution, 10 mg/ml	Ampoule	5 packs of 5 x 4 ml
C03DA01	Spiron, tablets, 25 mg	Unit dose	12
C05AA01	Protosedyl “Sanofi-Aventis”, suppositories	Suppository *	2 packs of 12 suppositories
C05AA01	Protosedyl “Sanofi-Aventis”, rectal ointment, 30 g	Tube *	1
C05BA01	Hirudoid “PharmaCoDane”, ointment, 3 mg/g	Tube***	1
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 25 mg	Unit dose	10
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 100 mg	Unit dose	10
C07AB02	Selo-zok “ASTRAZENECA”, depot tablets, 50 mg	Unit dose	10
C07AG02	Carvedilol “Teva”, tablets, 12.5 mg	Unit dose	10
C07AG02	Carvedilol “Teva”, tablets, 3.125 mg	Unit dose	10
C08CA01	Amlopidin “BMM Pharma”, tablets, 10 mg	Unit dose	10
C08CA01	Amlopidin “Sandoz”, tablets, 5 mg	Unit dose	10
C08CA02	Felodipin “Ratiopharm”, depot tablets, 2.5 mg	Unit dose	10
C08CA02	Plendil “ASTRAZENECA, depot tablets, 5 mg	Unit dose	10
C09AA02	Enacodan, tablets, 5 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 1.25 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 2.5 mg	Unit dose	10
C09AA05	Ramipril, “Stada”, tablets, 5 mg	Unit dose	10
C09CA01	Losarstad, film-coated tablets, 50 mg	Unit dose	10
C09CA06	Atacand “ASTRAZENECA”, tablets, 8 mg	Unit dose	8
C09DA03	Diovan Comp, film-coated tablets, 160 mg + 12.5 mg	Unit dose	10
C10AA01	Simvastatin “Bluefish”, film-coated tablets, 20 mg	Unit dose	15
C10AA01	Simvastatin “Bluefish”, film-coated tablets, 40 mg	Unit dose	15
D01AC08	Nizoral “MCNIEL”, shampoo, 2%, 60 ml	Bottle***	1
D01AC20	Brentacort “Janssen-Cilag”, crème, 20+10 mg/g, 30 g	Tube */***	1
D01AE15	Finigen, crème, 10 mg/g, 15 g	Tube***	2
D02AB	Zink “MEDIC”, liniment, 12.5%, 100 ml	Tube***	1
D02AX	Locobase Repair, crème, 30 g	Tube***	2
D05AA	Inotyol, ointment, 50 g	Tube***	1
D06AX01	Fucidin “Leo”, ointment, 2%, 15 g	Tube***	2
D06BB03	Acivir, crème 50 mg/g, 2 g	Tube***	2
D07AB02	Locoid Astellas, crème, 0.1%, 30 g	Tube***	2
D07AC13	Elocon, crème, 0.1%, 30 g	Tube***	2
D07AD01	Dermovat “GlaxoSmithKline Ph”, ointment, 0.5 mg/g, 25 g	Tube***	2
D07CC01	Fucicort “Leo”, crème, 1+20 mg/g, 15 g	Tube***	1
D08A	Hospital alcohol “Kemetyl”, 70%, 1 liter	Bag	6
G04CA01	Xatral “Sanofi-Aventis”, film-coated tablets, 2.5 mg	Unit dose	6
H01AA02	Synacthen, injection fluid, solution, 0.25 mg/ml	Capped vial	2 packs of 1 x 1 ml
H02AB02	Fortecortin “Merck Serono”, injection fluid, 4 mg/ml	Ampoule	10 packs of 3 x 1 ml
H02AB04	Solu-medrol “Pfizer”, powder and injection solution, 125 mg	Capped vial	2 packs of 1 vial+solution
H02AB04	Solu-medrol “Pfizer”, powder and injection solution, 40 mg	Capped vial	10 packs of 1 vial+solution
H02AB06	Prednisolon “DAK”, tablets, 5 mg	Unit dose	30
H02AB06	Prednisolon “DAK”, tablets, 25 mg	Unit dose	30
H02AB09	Solu-cortef, powder and injection solution, 100 mg	Capped vial	5 packs of 1 vial+solution
H03AA01	Eltroxin, tablets, 100 µg	Unit dose	20
H03AA01	Eltroxin, tablets, 50 µg	Unit dose	20

H03BB02	Thycapzol “SANDOZ”, tablets, 5 mg	Bottle	1 bottle w/ 100 tablets
J01AA02	Vibradox, tablets, 100 mg	Unit dose	25
J01CA01	Pentrexyl, powder for injection + infusion solution, 1 g	Capped vial	4 packs of 5 vials
J01CA01	Pentrexyl, powder for injection + infusion solution, 500 mg	Capped vial	3 packs of 5 vials
J01CA01	Pentrexyl, powder for injection + infusion solution, 2 g	Capped vial	3 packs of 5 vials
J01CA04	Imadrax, film-coated tablets, 1000 mg	Unit dose	20
J01CA08	Penomax “Orion Pharma”, film-coated tablets, 200 mg	Unit dose	20
J01CA11	Selexid “Leo, powder for injection fluid, solution, 1 g	Capped vial	12
J01CE01	Benzylpenicillin “Panpharma”, powder for inject.+inf.sol. 3 g	Pack	6 packs of 10 x 3 g
J01CE01	Benzylpenicillin “Panpharma”, powder for inject.+inf.sol. 1.2g	Pack	6 packs of 10 x 1.2 g
J01CE02	Vepicombin “Novum”, film-coated tablets, 1,000,000 IE	Unit dose	20
J01CF01	Dicillin, capsules, hard, 500 mg	Unit dose	20
J01CF01	Diclocil, powder for injection + infusion solution, 1 g	Pack	6 packs of 5 x 1 g
J01CR02	Bioclavid, film-coated tablets, 500 mg + 125 mg	Blister	2 packs of 30 units
J01CR05	Piperacil./Tazobactam, “Stragen”, powder inject+inf, 4g+0.5 g	Capped vial	4 packs of 10 x 1 vial
J01CR05	Piperacil./Tazobactam, “Stragen”, powd. inject+inf, 2g+0.25g	Capped vial	2 packs of 10 vials
J01DC02	Cefuroxim “Fresenius Kabi”, powd.inject.fluid, solut., 750 mg	Capped vial	1 packs of 10 x 750 mg
J01DC02	Cefuroxim “Fresenius Kabi”, powd.inject.fluid, solut., 1500mg	Capped vial	6 packs of 10 x 1.5 g
J01DD04	Ceftriaxon “ACS Dobfar Generics, powder.i.f, solute, 2 g	Capped vial	6 packs of 5 x 1 vials
J01DH02	Meronem “Abacus”, powder for inject.+inf.sol, 500 mg	Capped vial	0 packs of 1 x 1 vials
J01DH02	Meropenem “Hospira”, powder for inject.+inf.sol, 1 g	Capped vial	6 packs of 10 vials
J01EB02	Sulfametizol “Activis”, tablets, 500 mg	Unit dose	20
J01EE01	Sulfametoxazol with trimetoprim, tablets, 400 mg/80 mg	Bottle	1 bottle w/ 100 tablets
J01FA06	Surlid “Sanofi-Aventis, film-coated tablets, 150 mg	Unit dose	20
J01FA09	Clarithromycin “PCD), film-coated tablets, 500 mg	Unit dose	20
J01FA09	Klacid “Abbott”, powder for infusion fluid, solution, 500 mg	Capped vial	10
J01FA10	Azithromycin “Teva”, film-coated tablets, 500 mg	Unit dose	12
J01FF01	Dalacin “Pfizer”, injection fluid, solution, 150 mg/ml,	Ampoule	1 pack of 10 ampoules
J01FF01	Dalacin “Pfizer”, capsules, hard, 300 mg	Unit dose	15
J01GB03	Hexamycin, injection fluid, solution, 40 mg/ml	Ampoule	4 packs of 10 x 3 ml
J01MA01	Tarivid “Sanofi-Aventis”, film-coated tablets, 200 mg	Unit dose	20
J01MA02	Ciprofloxacin “Actavis”, film-coated tablets, 250 mg	Unit dose	30
J01MA02	Ciprofloxacin “BMM Pharma”, film-coated tablets, 500 mg	Unit dose	30
J01MA02	Ciprofloxacin “Fresenius Kabi”, inf. fluid, solution, 2 mg/ml, 100 ml	Bag	1 box of 10 x 100 ml
J01MA02	Ciprofloxacin “Fresenius Kabi”, inf. fluid, solution, 2 mg/ml, 200 ml	Bag	1 box of 10 x 200 ml
J01MA14	Avelox “BAYER”, infusion fluid, solution, 1.6 mg/ml	Bag	1 box of 5 x 250 ml
J01MA14	Avelox “BAYER”, film-coated tablets, 400 mg	Unit dose	12
J01XA01	Vancomycin “Hospira”, powder for infusion fluid, solution, 500 mg	Capped vial	3
J01XA01	Vancomycin “Xellia”, powder for inf. fluid, solution, 1000 mg, 20 ml	Capped vial	12
J01XB01	Colimycin “Medilink, powder for inject. fluid, solution, 1,000,000 IE	Capped vial	1 pack of 10 vials
J01XB01	Promixin “Paranova Danmark”, powder for solut. for nebulizer, 1,000,000 IE	Pack	1 pack of 30 units
J01XD01	Metronidazol “B. Braun”, infusion fluid, solution, 5 mg/ml	Bag	1 box of 20 x 100 ml
J02AC01	Fluconazol “B. Braun”, infusion fluid, solution, 2 mg/ml	Bag	2 box of 20 x 100 ml
J02AC01	Fluconazol “BMM Pharma”, capsules, hard, 50 mg	Unit dose	12
J02AC01	Fluconazol “BMM Pharma”, capsules, hard, 200 mg	Unit dose	12
J02AC03	Vfend, powder for infusion fluid, solution, 200 mg	Pack	4 packs of 1 unit
J02AC03	Vfend, film-coated tablets, 200 mg	Unit dose	15
J04AB02	Rimactan “SANDOZ”, capsules, hard, 150 mg	Bottle	1 bottle w/ 100 capsules
J04AB02	Rimactan “SANDOZ”, capsules, hard, 300 mg	Bottle	1 bottle w/ 100 capsules
J04AB02	Rimactan “SANDOZ”, coated tablets, 450 mg	Bottle	1 bottle w/ 100 tablets
J04AC01	Isoniazid, tablets, 100 mg	Bottle	1 bottle with 100 tablets
J04AC01	Isoniazid “OBA, tablets, 300 mg	Bottle	1 bottle with 50 tablets
J04AK01	Pyrazinamid “SAD”, tablets, 500 mg	Bottle	1 bottle with 112 tablets
J04AK02	Myambutol “Orifarm”, tablets, 400 mg	Unit dose	20
J04AM06	Rimstar, film-coated tablets	Blister	0 packs of 60 blisters
J05AB01	Aciclodan, tablets, 200 mg	Unit dose	20
J05AB01	Aciclodan, tablets, 400 mg	Unit dose	20
J05AB01	Aciclovir “Hospira”, concentrate for infusion fluid, 25 mg/ml, 10 ml	Capped vial	5 packs of 5 x 10 ml
J05AB01	Aciclovir “Hospira”, concentrate for infusion fluid, 25 mg/ml, 20 ml	Capped vial	5 packs of 5 x 10 ml
J05AB11	Zelitrex “GlaxoSmithKline Ph”, film-coated tablets, 500 mg	Unit dose	18
J07AM51	diTeBooster, injection fluid, suspension, syringe	Pack *	1 pack of 5 x 0.5 ml
M01AB01	Confortid, suppositories, 100 mg	Suppository	1 pack of 10 suppositories
M01AB08	Todolac, film-coated tablets, 200 mg	Unit dose	6
M01AE01	Burana, film-coated tablets, 400 mg	Unit dose	30
M01AE01	Burana, film-coated tablets, 600 mg	Unit dose	30
M03BX01	Baklofen “Mylan”, tablets, 25 mg	Unit dose	6
M04AA01	Allopurinol “DAK, tablets, 100 mg	Unit dose	6
M04AA01	Allopurinol “DAK, tablets, 300 mg	Unit dose	6

M05BA04	Alendronat “Arrow”, tablets, 70 mg	Unit dose	4
N01BB02	Lidokain “SAD”, injection fluid, 10 mg/ml	Ampoule	1 pack of 10 x 5 ml
N02AA01	Contalgin, depot tablets, 10 mg	Unit dose	20
N02AA01	Contalgin, depot tablets, 30 mg	Unit dose	20
N02AA01	Morphine “DAK”, tablets, 10 mg	Unit dose	20
N02AA01	Morphine “SAD”, suppositories, 20 mg	Pack *	1 pack of 10 units
N02AA01	Morphine “SAD”, injection fluid, 10 mg/ml	Ampoule *	2 packs of 10 x 1 ml
N02AB03	Durogesic “Janssen-Cilag”, depot patches, 50 µg/hour	Pack	1 pack w/ 8 patches
N02AB03	Durogesic “Janssen-Cilag”, depot patches, 25 µg/hour	Pack	1 pack w/ 8 patches
N02AB03	Matrifen, depot patches, 12 µg/hour	Pack	1 pack w/ 8 patches
N02AX02	Taldol, suppositories, 100 mg	Unit dose	12
N02AX02	Tradolan, tablets, 50 mg	Unit dose	40
N02BE01	Pamol, film-coated tablets, 500 mg x 2	Unit dose	50 unit doses, each w/ 2 tablets
N02BE01	Panodil Fizz (Brus), soluble tablet, 500 mg	Blister	2 packs of 24 blisters
N02BE01	Pinex “Actavis”, suppositories, 500 mg	Unit dose	12
N02BE01	Pinex “Actavis”, suppositories, 1000 mg	Unit dose	12
N02CC01	Sumatriptan “Sandoz”, film-coated tablets, 50 mg	Unit dose	6
N03AA02	Fenemal “DLF”, tablets, 100 mg	Unit dose	8
N03AA02	Fenemal “SAD”, injection fluid, 100 mg/ml	Ampoule *	1 pack of 10 x 1 ml
N03AE01	Rivotril “ROCHE”, tablets, 0.5 mg	Unit dose	8
N03AE01	Rivotril “ROCHE”, tablets, 2 mg	Unit dose	8
N03AF02	Apydan “Desitin, tablets, 300 mg	Unit dose	10
N03AF02	Trileptal “Novartis Healthcare”, film-coated tablets, 300 mg	Unit dose	10
N03AG01	Delepsine Retard, depot tablets, 500 mg	Unit dose	10
N03AX09	Lamotrigin “BMM Pharma”, tablets, 100 mg	Unit dose	10
N03AX12	Gabapentin “PCD”, capsules, hard, 300 mg	Unit dose	10
N04BA02	Madopar “62.5” “ROCHE”, caps., hard, 50mg levodopa+12.5mg benserazid	Unit dose	10
N04BA02	Sinemet 12.5/50, tablets, 50 mg levodopa + 12.5 mg carbidopa	Unit dose	10
N05AD01	Serenase, tablets, 2 mg	Unit dose	10
N05AD01	Serenase, injection fluid, solution, 5 mg/ml	Ampoule	1 pack of 5 x 1 ml
N05AH03	Zyprexa, coated tablets, 10 mg	Unit dose	10
N05BA01	Diazepam “DAK, tablets, 5 mg	Unit dose	20
N05BA01	Stesolid, suppositories, 5 mg	Unit dose	10
N05BA01	Stesolid, rectal fluid, solution, 5 mg/dose	Tube	1 pack of 5 x 1
N05BA01	Stesolid, tablets, 2 mg	Unit dose	20
N05BA01	Stesolid Emulsion, injection fluid, 5 mg/ml	Ampoule	1 pack of10 x 2 ml
N05BA04	Oxapax, tablets, 15 mg	Unit dose	15
N05CD02	Nitrazepam “DAK”, tablets, 5 mg	Unit dose	10
N05CF01	Imoclone, film-coated tablets, 7.5 mg	Unit dose	40
N05CF02	Zolpidem “Actavis”, film-coated tablets, 10 mg	Unit dose	20
N06AB04	Citalopram “Orion”, film-coated tablets, 20 mg	Unit dose	10
N06AB04	Citalopram “Sandoz”, film-coated tablets, 10 mg	Unit dose	10
N06AB10	Cipralex “Lundbeck”, film-coated tablets, 10 mg	Unit dose	10
N06AB10	Cipralex “Lundbeck”, film-coated tablets, 20 mg	Unit dose	10
N06AX03	Tolmin, film-coated tablets, 30 mg	Unit dose	10
N06AX11	Combar, film-coated tablets, 15 mg	Unit dose	10
N06AX11	Combar, film-coated tablets, 30 mg	Unit dose	10
N06AX16	Venlafaxin “Actavis”, depot capsules, hard, 75 mg	Unit dose	10
N06AX16	Venlafaxin “Actavis”, depot capsules, hard, 150 mg	Unit dose	10
N06BC01	Caffeine, tablets, 100 mg	Unit dose	20
N07BA01	Nicorette “McNiel Denmark”, depot patches, 5 mg /16 hours	Patch	1 pack of 14 patches
N07BA01	Nicorette Classic, medican chewing gum, 2 mg	Pack	1 pack of 210 chewing gums
N07BA01	Nicorette Freshmint, medical chewing gum, 4 mg	Pack	1 pack of 30 chewing gums
N07BA01	Nicorette Invinsible, depot patches, 10 mg/16 hours	Pack	1 pack of 14 patches
N07BA01	Nicotinell Mint, tablet, 1 mg	Pack	1 pack of 36 tablets
N07BA01	Antabus, soluble tablets, 400 mg	Bottle	1 bottle w/ 50 tablets
N07BC02	Metadon “DAK”, tablets, 20 mg	Unit dose	20
N07BC02	Metadon “DAK”; oral solution, 1 mg/ml, 300 ml	Bottle	4
P01AB01	Flagyl, suppositories, 0.5 g	Unit dose	10
P01AB01	Metronidazol “DAK”, film-coated tablets, 500 mg	Unit dose	20
P01B	Primaquine phosphate, tablets, 7.5 mg	Bottle	0 bottle w/ 100 tablets
P01BA01	Malarex, film-coated tablets, 250 mg	Blister	1 pack of 20 blisters
P01BB51	Malarone, film-coated tablets, 100+250 mg	Unit dose	12
P01BC01	Klinin, infusion concentrate, 100 mg/ml	Ampoule	1 pack of 10 x 5 ml
P01BC01	Klinin “DAK”, film-coated tablets, 100 mg	Unit dose	10
P01BC02	Lariam, tablets, 250 mg	Unit dose	10
P01BE52	Riamet “Novartis”, tablets, 20+120 mg	Blister	1 pack of 24 blisters
P02BA01	Biltricide “Bayer”, tablets, 600 mg	Bottle	1 bottle w/ 6 tablets

R01A07	Zymelin unpreserved, nasal spray, solution, 1 mg/ml, 10 ml	Spray	2 packs of 1 bottle
R03AC03	Bricanyl Turbuhaler "ASTRAZENECA", inhalation powder, 0.5 mg/dose	Pack	1 pack of 200 doses
R03AC12	Serevent "GlaxoSmithKline Ph", inhalation powder, 50 µg in discus	Pack	1 pack of 60 doses
R03AK03	Duovent "Orifarm", inhalation fluid, nebulizer solution, 1.25+0.5 mg	Bottle	2 pack of 60 x 4 bottles
R03BA02	Spirocort Turbuhaler, inhalation powder, 200 µg/dose	Pack	1 pack of 100 doses
R03BA05	Flixotide "GlaxoSmithKline Ph", inhalation powder, 500 µg/dose	Pack	1 pack of 60 doses
R03BB04	Spiriva "BOEHRINGER", inhalation powder in capsules, 18 µg	Blister	1 pack of 30 blisters
R03CC02	Ventoline, infusion concentrate, 1 mg/ml	Ampoule	0 pack of 10 x 5 ml
R03CC03	Bricanyl "ASTRAZENECA, concentrate for infusion fluid, 0.5 mg/ml	Ampoule	1 pack of 10 x 5 ml
R05CB13	Pulmozyme "ROCHE", inhalation fluid for nebulizer, solution, 1 mg/ml, 75 ml	Pack *	1 pack of 30 x 2.5 ml
R05DA04	Kodein "DAK", film-coated tablets, 25 mg	Unit dose	60
R06AE07	Cetirizin "Mylan", film-coated tablets, 10 mg	Unit dose	10
S01AA01	Kloramfenikol "DAK", eye drops, solution, 0.5%, 10 ml	Bottle *	2
S01AA01	Kloramfenikol "DAK", eye ointment, 1%, 5 ml	Tube *	2
S01AA13	Fucithalmic "Leo", eye drops, suspension, 2.4 g	Pipette	2 pack of 12 disposable pipettes
S01XA20	Viscous eye drops, "Ophtha", eye drops, 10 ml	Bottle	1
V03	Alternative medication	Mixed	0
V03	Medication for projects	Mixed	0
V03A	Acute box GREEN SKS + THG + NBG	Box	1
V03AB15	Naloxon "B. Braun", injection fluid, solution, 0.4 mg/ml	Ampoule	1 pack of 10 x 1 ml
V03AB25	Flumazenil "Hameln, injection fluid, solution, 0.1 mg/ml	Ampoule	1 pack of 5 x 5 ml
V04CF01	Tuberkulin PPD RT23 "SSI", injection fluid, solution, 2 TE/dose, 1.5 ml	Capped vial *	2
V01AB	Sodium chloride "Fresenius Kabi", solvent for parenteral use, 9 mg/ml	Ampoule	0 packs of 20 x 10 ml
V01AB	Sodium chloride "Fresenius Kabi", solvent for parenteral use, 9 mg/ml	Capped vial	0 packs of 00 x 100 ml
V01AB	Sterile water Fresenius Kabi", solvent for parenteral use	Capped vial	8 box of 40 x 100 ml
V01AB	Sterile water Fresenius Kabi", solvent for parenteral use	Capped vial	0 box of 10 x 100 ml
Å	Calogen Energy dense supplement, 500 ml	Bottle	0 (1)
Å	Caroxin sugar free medical chewing gum	Pack	2 packs w/ 100 pieces of gums
Å	Clearblue Plus, pregnancy test	Pack	2 packs of 2 units
Å	Dakaryl "Lev-vel", sweetener,	Bottle	1 bottle of 250 units
Å	Handi Haler, for inhalation of Spiriva	Pack	3

Table 20. The standard stock list of the medication room at the Department of Infectious Diseases Q2 as of April 29th 2011. The list is arranged alphabetically by ATC codes. A stock of "0" is either "outside standard stock" or "storage leftovers". Susp.: Suspension. Inject.: injection. Inf.: infusion. * = stored in refrigerator. ** = stored in another room. * = stored in a drawer in another room. (65)**

10.5 Appendix 5: Specifications for OmniRx

This appendix shows a list of specifications for the OmniRx by Omnicell (Table 21).

Specifications for OmniRx	
Ship to Denmark?	Yes
European offices	None, but collaboration with Mediq
Size (Width x Depth x Height)	72 cm x 60 cm x 200 cm (estimated)
Weight	?
Number of slots/drawers	2 to 9 in middle section 4 to 18 in middle and lower section
Sensing/detecting lid drawer	Yes
Locking lid drawer	Yes
Matrix/open drawer	Yes
Unit dose dispensing drawer	No
Single-dose drawer	Yes
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	Yes
Operating system	Microsoft Windows 7 Omnicell Software 15.0 (Integrates with HL7 systems)
Monitor	Colour touch screen
User login	User ID and password Biometric ID
Bar code scanner	Yes
Connectivity to EPJ	Possible
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	No
Automatic, randomised stock allocation	No, but easily configured if new
Bar code controlled refilling	Possible
Temperature control	Cabinet follows room temperature
Connect refrigerator?	Yes, by remote lock
Connect additional cabinets?	Yes
Computer station in pharmacy?	Yes, for monitoring and reports
Decision support	Some

Table 21. Specifications for the OmniRx by Omnicell. (68,94)

10.6 Appendix 6: Specifications for Pyxis® MedStation® 4000

This appendix shows a list of specifications for the Pyxis® MedStation® 4000 by CareFusion (Table 22).

Specifications for Pyxis® MedStation® 4000	
Ship to Denmark?	Yes
European offices	16, incl. Danish contact
Size (Width x Depth x Height)	Main cabinet: 59 cm x 69 cm x 140 cm Drawer auxiliary: 59 cm x 69 cm x 120 cm Single column auxiliary:79 cm x 72 cm x 204 cm
Weight	-
Number of slots/drawers	Many, depending on drawer types!
Sensing/detecting lid drawer	No
Locking lid drawer	Yes
Matrix/open drawer	Yes
Unit dose dispensing drawer	Yes (MiniDrawer)
Single-dose drawer	Yes (MiniDrawer)
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	No
Operating system	Older Microsoft Windows NT (Integrates with HL7 systems)
Monitor	Colour touch screen
User login	User ID and password Biometric ID
Bar code scanner	Yes
Connectivity to EPJ	Possible
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	Yes
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	No
Connect refrigerator?	Yes, by remote lock
Connect additional cabinets?	Yes
Computer station in pharmacy?	Yes, for monitoring and reports
Decision support	Some

Table 22. Specifications for the Pyxis® MedStation® 4000 by CareFusion. (69,97)

10.7 Appendix 7: Specifications for RxStation®

This appendix shows a list of specifications for the RxStation® by Cerner (Table 23).

Specifications for RxStation®	
Ship to Denmark?	Yes
European offices	UK, Ireland, France, Spain, Germany
Size (Width x Depth x Height)	4-Module Tower: 71 cm x 70 cm x 190 cm
Weight	364 kg
Number of slots/drawers	5 to 9 drawers in main tower, 8 to 16 drawers in supply tower, or combined with supply modules
Sensing/detecting lid drawer	No
Locking lid drawer	Yes
Matrix/open drawer	Yes
Unit dose dispensing drawer	No
Single-dose drawer	Yes
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	Yes
Operating system	Cerner Millennium w/ HP Oracle® database
Monitor	Colour touch screen (Pelham Sloane)
User login	User ID and password
Bar code scanner	Yes (Honeywell HandHeld Products)
Connectivity to EPJ	Possible, but could prove difficult due to closed-looped Cerner Millennium system
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	No
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	No (coming soon)
Connect refrigerator?	Yes, by remote lock
Connect additional cabinets?	Yes
Computer station in pharmacy?	-
Decision support	Some, e.g. allergy alerts

Table 23. Specifications for the RxStation® by Cerner. (82,99)

10.8 Appendix 8: Specifications for Pyxis® CIISafe™

This appendix shows a list of specifications for the Pyxis® CIISafe™ System by CareFusion (Table 24).

Specifications for Pyxis® CIISafe™ System	
Ship to Denmark?	Yes
European offices	16, incl. Danish contact
Size (Width x Depth x Height)	80 cm x 70 cm x 200 cm (estimated)
Weight	-
Number of slots/drawers	7 rooms of several shelves (main) 8 rooms of several shelves (auxiliary)
Sensing/detecting lid drawer	No
Locking lid drawer	No
Matrix/open drawer	No
Unit dose dispensing drawer	No
Single-dose drawer	No
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	No
Operating system	Older Microsoft Windows NT (Integrates with HL7 systems)
Monitor	Colour screen
User login	User ID and password
Bar code scanner	Yes
Connectivity to EPJ	Possible, but could prove difficult due to the Pyxis PARx® system.
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	No
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	No
Connect refrigerator?	No
Connect additional cabinets?	Yes
Computer station in pharmacy?	Yes, for monitoring and reports
Decision support	Some

Table 24. Specifications for the Pyxis® CIISafe™ System by CareFusion. (83)

10.9 Appendix 9: Specifications for medDispense Series

This appendix shows a list of specifications for the medDispense Series by Metro (Table 25).

Specifications for medDispense Series	
Ship to Denmark?	Yes
European offices	The Netherlands, Danish contact by phone
Size (Width x Depth x Height)	Base 72: 81.91 cm x 58.08 cm x 138.43 cm Base 45: 53.97 cm x 58.08 cm x 138.43 cm Base 25: 53.97 cm x 58.08 cm x 138.43 cm
Weight	-
Number of slots/drawers	25 to 72 per cabinet
Sensing/detecting lid drawer	No
Locking lid drawer	No
Matrix/open drawer	No
Unit dose dispensing drawer	No
Single-dose drawer	Partly (single linear)
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	No
Operating system	Software by contractors (Integrates with HL7 systems)
Monitor	Colour touch screen
User login	User ID and password Biometric ID
Bar code scanner	Yes
Connectivity to EPJ	Possible
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	Yes
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	No
Connect refrigerator?	Yes, by remote lock
Connect additional cabinets?	Yes
Computer station in pharmacy?	Partly, auxiliary unit necessary
Decision support	Some

Table 25. Specifications for the medDispense Series by Metro. (86,90)

10.10 Appendix 10: Specifications for ServeRx™

This appendix shows a list of specifications for the ServeRx™ by MDG Medical (Table 26).

Specifications for ServeRx™	
Ship to Denmark?	Yes
European offices	UK
Size (Width x Depth x Height)	70 cm x 70 cm x 200 cm (estimated)
Weight	-
Number of slots/drawers	Up to 108 small drawers, 54 large drawers, or
Sensing/detecting lid drawer	No
Locking lid drawer	Yes
Matrix/open drawer	Yes
Unit dose dispensing drawer	No
Single-dose drawer	No
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	Yes, in SmarTrays
Operating system	MDG Foundation Software Suite (Integrates with HL7 systems)
Monitor	Colour touch screen
User login	User ID and password
Bar code scanner	Yes
Connectivity to EPJ	Possible, through Microsoft BizTalk
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	No
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	Yes, refrigerated module
Connect refrigerator?	Yes
Connect additional cabinets?	Yes
Computer station in pharmacy?	No
Decision support	Some

Table 26. Specifications for the ServerRx™ by MDG Medical. (70)

10.11 Appendix 11: Specifications for AcuDose-Rx

This appendix shows a list of specifications for the AcuDose-Rx by McKesson (Table 27).

Specifications for AcuDose-Rx	
Ship to Denmark?	Unlikely, mainly U.S. market
European offices	France, the Netherlands, UK
Size (Width x Depth x Height)	Large main cabinet: 63 cm x 74 cm x 145 cm Small main cabinet: 63 cm x 60 cm x 75 cm Medication tower: 62 cm x 69 cm x 199 cm
Weight	Large main cabinet: 325 to 525 kg Small main cabinet: 80 to 180 kg Medication tower: 210 kg
Number of slots/drawers	8 slots for standard height drawers 16 slots high capacity drawers
Sensing/detecting lid drawer	Yes
Locking lid drawer	Yes
Matrix/open drawer	Yes
Unit dose dispensing drawer	Yes
Single-dose drawer	No
Space for unit doses in drawers	Yes
Space for original packs in drawers	Yes
Guiding lights	Yes
Operating system	Connect-Rx® (Integrates with +85 pharmacy systems)
Monitor	Colour touch screen
User login	User ID and password Biometric ID
Bar code scanner	Yes
Connectivity to EPJ	Possible
Automatic recording of medication transactions	Yes
Automatic stock monitoring	Yes
Automatic re-ordering	Yes
Automatic loading	No
Automatic, randomised stock allocation	No
Bar code controlled refilling	Yes
Temperature control	Some, wireless monitoring of devices
Connect refrigerator?	Yes, by remote lock. Refrigerator can also be inserted into bottom section of medication tower.
Connect additional cabinets?	Yes
Computer station in pharmacy?	No
Decision support	Yes

Table 27. Specifications for the AcuDose-Rx by McKesson. (67)