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The Broussais Hospital staff was displeased with the medication supplying, shelving and storage methods. The future integration into the new Georges-Pompidou Hospital prompted the reinforcement of the security of medications while keeping the cost under control. This necessary evolution, however, had to be progressive, adapted to the institution and mindful of budgetary restrictions. The objective of this project was to reorganize the medication circuit through the benefits of automation in a 10-bed medical resuscitation unit.

Set-up of a Decentralized Automated Dispensing System in a Medical Resuscitation Unit

A hospital pharmacist has two missions: participating in the quality of health care and keeping health costs under control. He/she, therefore, must ensure that the medications are being used under the optimal flow and safety conditions for the patient and must provide the medications under the best usage conditions to the caregiver in order to minimize all possible risks.

However, medications in a hospital environment follow a complex circuit, since each care unit has its own specific needs, thus generating medication flows that can vary quite a bit⁽¹⁾⁽²⁾⁽³⁾.

The Broussais Hospital pharmacy provides medications to the medical resuscitation unit twice a week, according to a global distribution method.

Having analyzed the medication flow of this unit, we have researched a decentralized automated dispensing system that ensures 90% of the medication needs of the care unit, representing a useful tool in the gathering process and perfectly adapted to frequent changes in prescription and to emergency prescriptions^(4,5,6,7). We selected the Sure-Med® automated dispensing system (made by the Baxter Laboratories, who ceded their automated dispensing system branch to Omnicell, Inc.)⁽⁸⁾, then evaluated the system's cost/benefit ratio in terms of active time and value of the care unit inventory. The study lasted six months.

The medical resuscitation service is a 10-bed unit. There are 49.49 medication units per bed and per day.

The Automated Dispensing System: A Decentralized Cabinet

Sure-Med is an automated storage and dispensing system for medications that are distributed within the care unit. The decentralized cabinet in the care unit is entirely controlled by a central computer called "Sure-Med host," located in the hospital pharmacy.

Description of the Software Assisting in the Dispensing Process

Starting from a general menu, the Sure-Med host allows to print a report on the various activities of the care unit dispensing system, by date, by care unit and by medication (dispensing, returns, discards, abnormalities, inventory errors, error and alarm control).

It also allows to control the care unit dispensing system during the addition or elimination of a medication, defining the adequate stocking levels, to update the system users list, to control the cabinet commands, to save the data and to control the interface between the host and the cabinet.

Description of the Automated Dispensing System Located in the Care Unit

The Sure-Med dispensing system is a multi-drawer cabinet topped by a keyboard and a screen. Sure-Med is available in various configurations: the configuration chosen by the care unit is the "Sure-Med modular dispensing center." It consists of 24 small automatic drawers (A), 16 small automatic drawers (B), an automatic matrix drawer (C) divided into 24 compartments and one large manual drawer divided into 24 compartments, also equipped with a key.

	H (Height)	L (Length)	W (Width)
A	62.5 mm	271 mm	85 mm
B	102.5 mm	271 mm	85 mm
C	102.5 mm	414 mm	793 mm

A medication at a given dosage is allocated to each A or B drawer or each compartment of Drawer C. At the top of the cabinet is a rounded drawer that matches a type A drawer and is used to contain the unused, returned medications.

To this module, we have added an extension that is based on the same principle as the main cabinet, expanding the number of stocked reference medications.

The different functions of Sure-Med may be accessed through a personal and confidential access code, which corresponds to the access level of the code holder. From experience, we define the various access levels as: the nurse and head nurse of the care unit, the head pharmacist, the assistant pharmacist, and the pharmacy dispenser.

The automated dispensing system main menu allows:

- The pharmacy staff to replenish an existing medication, allocate or annul the allocation of a medication to a particular drawer, empty the returned-items drawer, effect a partial or total verification of the inventory, generate a report on all operations effected on the care unit dispensing system during the last 24 hours.
- The nursing staff to dispense one or more medications, return a medication, list all differences found between the inventory displayed on the screen and the actual inventory in the drawers, add, remove or modify a patient's data. Additionally, the head nurse may authorize a temporary user and carry out a partial or total inventory.

Installation in the Care Unit

Flow Study before Setup

This study has allowed us to select the type of automated dispensing system most adapted to the needs of the care unit. We have analyzed the consumption and flow of the reference medications over a six-month period.

The following have been evaluated, without considering the form of the medications:

- The number of reference medications used.
- The number of units used.

The care unit cabinet is entirely controlled by a central computer located in the pharmacy.

We have computed the reference medication turnover from one month to the next.

Finally, we have weighed the advantages of both centralized and decentralized automated systems. We have calculated, in function of the flow (type and number of medication units), the various lengths of time needed by the nursing staff to gather the medications (care unit cabinet) and by the pharmacy staff to prepare

them, on the assumption that a decentralized dispensing system is set up in the care unit versus the assumption that a centralized dispensing system has been installed in the ATC 212 pharmacy (Baxter).

Preliminary Steps Before Set-up

Setting up the Sure-Med automated dispensing system required several preliminary steps:

- Listing all possible Sure-Med users and giving them a personal password, adapted to their position.
- Training all personnel involved (nurses, doctors and pharmacists) in the use of the automated dispensing system. For the initial trials, small colored pills were at first placed in the Sure-Med drawers and next non-narcotic pills to practice the most common functions, such as "dispensing a medication" or "taking back a medication." All observations were noted to ensure that the narcotic drugs are installed under the best of conditions.
- Selecting the narcotic drugs to be placed in the Sure-Med (according to a narcotics list made up jointly each year by the Department Head, the pharmacist and the Director of the institution).

Installation in the Resuscitation Service

→ *Selection of Inventory:* It was decided, in a first phase, to only stock injectable and oral, non-refrigerated, low volume products, selected from the Type I and Type II lists of the care unit. Next, maximum and minimum quantities were assigned to each of the 124 products, based on the average daily consumption of the care unit. We have determined a minimum stocking level (emergency quantity) that must trigger the restocking process and a maximum stocking level serving as reference value at the time of restocking, as well as the dispensing system stocking plan:

- Reference medications requiring a lot of space in the matrix drawer (several easy-to-select compartments of different sizes).
- Reference narcotic medications in separate drawers.
- In all partitioned drawers, the distinction is made between oral and injectable forms of medications.

During the study, these stocks have undergone several qualitative and quantitative reevaluations.

→ *Restocking Methods:*

Twice a week, the stocker notes on the host (in the pharmacy) the reference medications to be restocked and the information on returns, if any. The dispenser gathers the medications from the pharmacy shelves and goes to the care unit dispensing system. In the care unit, the dispenser removes the medications from the return drawer (before restocking). He then checks the content of all reference medication drawers against the theoretical inventory displayed on the host, by means of a "partial inventory verification" function. In case of discrepancy, he alerts the head nurse of the fact, who notes it on the control sheet. When he restocks the narcotics, he asks the head nurse or the department head to sign the narcotics slip, which is then filed at the pharmacy.

→ *Task Distribution:* The dispensers are responsible for the restocking circuit, from noting the state of the inventory to restocking each drawer, which includes unwrapping, gathering and transporting the supplies and verifying the content of the drawers.

The care unit supervisor is responsible for researching the cause of stock discrepancies and entering the solution on the screen.

Economic Simulation

Our work has consisted in analyzing the economic and cost factors, and then evaluating the cost/benefit ratio of the care unit with the Lotus 1-2-3 software prepared by Mrs. Genelle⁽⁹⁾

Economic Factors

The economic factors consist of a decrease in nursing hours and the optimization of the medication inventory control.

→ *Decrease in nursing hours*

We have computed the nursing hours gained as compared to the old system.

→ *Optimization of the medication inventory control*

Optimizing the inventory allows better control with a decrease in losses due to expiration or pilferage. The limited size of the dispensing system forces a streamlining of the list of medications

The automated dispensing system main menu allows the nursing staff to add to, subtract from or modify a patient's data.

available in the care unit. Furthermore, control is optimized due to the system configuration.

All these savings have a positive impact on the "medication" budget.

Cost factors

The cost factors include the cost of equipment and personnel.

→ *Equipment cost:* Cost of purchasing the automated dispensing system and the data processing system (equipment and software).

→ *Personnel expenses:* Managing the cabinet entails a transfer of tasks from the nursing to the pharmacy staff, consequently, it is necessary to expand the pharmacy work force.

Flow Studies

This study allows us to learn to know the needs of the care unit and, therefore, to select the most effective automated system.

→ We have evaluated, without considering the form of the medication (table 1):

- The number of reference medications used:
Over six months: 448 reference medications
Monthly average: 166 reference medications
- The number of units used:
Monthly average: 14,846 units
Per day: 619
Per day and per patient: 49.5 units

Our conclusions:

- The medication diversification is relatively low and the ratio of oral forms is weak (2,484 units per month);
- The prescriptions are not very stable over time;
- There is a need to trace the blood-derived medications and the narcotics;
- A large number of narcotic units are being used.

Table 1

Number of Units Dispensed per Medication Month

No. Units/month	January	February	March	April	May	June	Monthly Avg.	Daily Avg.	In %
Dry oral	2,539	2,568	3,066	2,301	2,108	2,321	2,484	103	16.7%
Injectable	9,145	7,192	8,470	9,789	10,993	6,326	8,653	361	58.2%
Massive solutions	1,503	2,518	1,614	1,754	1,695	1,376	1,743	73	11.7%
Other forms	2,242	1,926	2,010	2,053	2,075	1,492	1,966	82	13.2%
Total all forms	15,429	14,204	15,160	15,897	16,871	11,515	14,846	619	100.0%

→ We have computed the reference medication turnover for one month as compared to the following month (Table 2). The analysis shows the following:

- An average of 61.5% of the medications used during the month is used again during the next two months. There have not been 384 new medications in a six-month period. The entire pool is relatively stable, but we must consider the fact that certain medications reappear regularly every two or three months.
- Prescriptions depend a great deal on the clinical and biological variations occurring in the patients and are, therefore, unstable in the long run. Medications must be very rapidly available.

→ Finally, we analyzed the arguments in favor of both automated systems (Diagrams 3 and 4):

- In the centralized ATC automated dispensing system, the proportion of oral medications is low, and automated dispensing is not possible due to time limits which are not compatible with the frequent daily and nightly prescription changes;
- The installation of the Sure-Med automated dispensing system by itself is then justified by the need to trace the blood-derived medications and narcotics in the relatively high number of units consumed;
- In both hypotheses, the full-vacuum Medimath system remains a system that allows the management of massive solutions, antiseptics and all collective usage medications that are regularly used in the care unit and that are excluded from the automated dispensing system;
- The nursing hours spent to gather the medications and pharmacy hours spent performing all tasks necessary to manage the cabinet (Diagram 4) encourage the use of a decentralized system. The theoretical pharmacy and nursing hours gained is 16.5%.
- Under these circumstances, there is no advantage in automating the medication dispensing process with a centralized ATC-type dispensing system.

System Cost/Benefit Analysis

Using Lotus 1-2-3[®], we were able to analyze the cost/benefit ratio of the system set-up as compared to the existing global dispensing system.

The data were as follows:

- Number of beds: 10
- Number of pharmacist full-time equivalent (FTE): 0.16
- Number of pharmacy dispenser FTE: 0.16
- Average value of the care unit cabinet supplies: FF 81,200.00

We evaluated equipment and personnel costs, then computed the savings on supplies and nursing hours.

Table 2

Evolution of Reference Medication Changes Medication per month

Number of References = No. of ref.	January	February	March	April	May	June	Avg.
Total No. of ref. used during the month	182	210	213	192	189	193	197
No. of ref. used the month before		119	134	127	115	118	123
		56.7%	62.9%	66.1%	60.8%	61.1%	61.5%
% of ref. used from the six-month supply		27.1%	30.5%	28.9%	26.2%	26.9%	27.9%
No. of new refs. compared to previous month		91	79	65	74	75	77
		50.0%	37.6%	30.5%	38.5%	39.7%	39.3%
No. of unused refs. from previous months		63	76	86	77	71	75
		34.6%	36.2%	40.4%	40.1%	37.6%	37.8%
No. of unused refs. from six-month supply	266	238	235	256	259	255	252
	60.59%	54.2%	53.5%	58.3%	59.0%	58.1%	57.3%

The automated dispensing system forces a streamlining of the list of medications available in the care unit.

Equipment Cost

The system purchase price is FF 195,000.00, including the main system and an extension.

Pharmacy Staffing Cost

- Number of pharmacy dispenser FTE: An additional 0.16 as compared to the present situation
- Average annual salary: FF 200,000.00
- Supplementary dispenser personnel costs: average of FF 32,000.00 per year
- Number of pharmacist FTE: An additional 0.16 as compared to the present situation
- Average annual salary: FF 350,000.00
- Supplementary pharmacy personnel costs: average of FF 56,000.00 per year
- **Supplementary pharmacy personnel costs: average of FF 88,000.00 per year.**

Investment in Materials	Total Cost (FF)	Depreciation	Annual Payment
Data Processing System	36,000	3 years	12,000
Main Dispensing System	124,000	5 years	24,800
Extension	83,000	5 years	16,600
Total	230,000		53,400

Inventory Savings

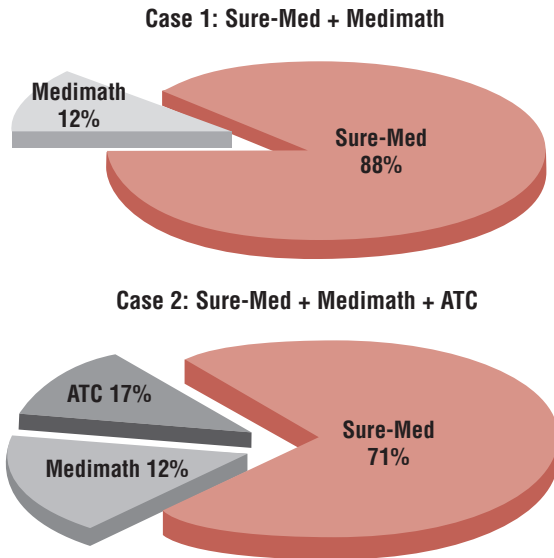
The impact of the automated dispensing system on inventory control was measured by computing the value of the stocks for the same products before and after installing the Sure-Med.

Value before installation amounts to FF 81,200.00.

The filled automated dispensing system is valued at FF 57,871.00.

Diagram 1

Dispensing medications per system in case of simple or combined automation



The savings on immobilization cost is estimated at FF 23,329.00, i.e., 28.73% of the initial value.
 Average value of the inventory per cabinet: FF 82,200.00
 Average value of estimated inventory: FF 57,871.00
 Inventory Savings: FF 23,329.00
Inventory savings during first year: FF 23,329.00.

Savings in Nursing Hours

The automated dispensing system clearly saves hours gathering the various medicating products and makes the process easier, quicker and safer as compared to the traditional pharmacy cabinet. The care unit has taken advantage of the system to change its organizational methods: there is no longer a stock of medications in the patient's room and the advance preparation of the medications needed daily is no longer required. The speed at which different medications required for the patient's care can be gathered has helped to improve administrative quality. The nursing hours dedicated to activities linked to the medications may be reduced by 126.76 hours/month (ordering, storing, expired and returned medications, narcotics control and decreased medication gathering time).

- Number of nursing hours gained each year: 1,521 hours
- Average hourly cost: FF 96
- Number of nurse FTE saved: 1,521 divided by 39 hours over 52 weeks = 0.75
- **Savings in nursing hours per year: FF 146,016**

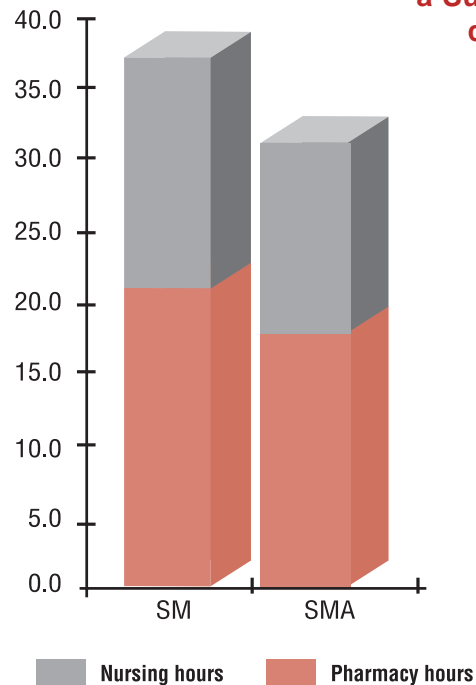
A Positive Cost/Benefit Ratio

Advantages of the automated dispensing system:

- **Increased security:** The Sure-Med system may allow the avoidance of certain medicating errors. The nurses and head nurses are released of all administrative procedures linked to the restocking process, since the circuit operates under optimal security conditions. Indeed, the cabinet was small and a nurse could easily confuse two medications or two doses of a same medication. This risk has now been eliminated, since each different form of narcotic or medication is stored in a drawer. The stocker regularly checks the inventory, thus decreasing the risk that a medication is out of stock and representing one more safety factor to the patient.

Diagram 2

Comparison of nursing and pharmacy hours in the Sure-Med system by itself and a Sure-Med/ATC combination



Comparison	SM	SMA	Difference in hours	% Difference
Pharmacy hours	21.1	17.6	-3.4	-16.2%
Nursing hours	16.5	13.7	-2.8	-16.7%
Total hours	37.6	31.4	-6.2	-16.5%

- Saving time: A study of the circuit time required has proven that the Sure-Med, through its logical storage method, its forced inventory control and its method of rapidly gathering medications, saves nurses time.
- The automated dispensing system can be easily and progressively installed within a hospital; it can function via the network or independently.

However, the automated dispensing system does have some disadvantages:

- It does not prevent medicating errors. It registers them and alerts the staff so they can take corrective measures.
- It does not meet all of the care unit needs: large volumes, medical devices and collective-use medications are excluded.
- It requires that the pharmacy staff invest some time with the care unit, which, in the end, does not represent an inconvenience.

Consequently, the cost/benefit ratio appears to be positive for all parties involved in the circuit in terms of increased security, inventory control and decreased nursing hours, contributing to the quality of health care. Furthermore, this system allows conformance to the laws on narcotics control. It may also prove to be a useful tool in the framework of the PMSI, providing access to the therapy cost per patient, thus allowing a closer analysis of the patient populations.

System Cost/Benefit Ratio

Cost (in Francs)	Year 1	Year 2	Year 3	Year 4	Year 5
Investment in Equipment					
Data Processing	12,000	12,000	12,000	0	0
Main automated dispensing system	24,800	24,800	24,800	24,800	24,800
Extension	16,600	16,600	16,600	16,600	16,600
Total for Equipment	53,400	53,400	53,400	41,400	41,400
Pharmacy Staff					
Pharmacist	56,000	56,000	56,000	56,000	56,000
Pharmacy Dispensers	32,000	32,000	32,000	32,000	32,000
Subtotal Staff	88,000	88,000	88,000	88,000	88,000
Total	141,400	141,400	141,400	129,400	129,400
Savings (in Francs)					
Nursing Staff	146,016	146,016	146,016	146,016	146,016
Drug Consumption					
Inventory	23,329	0	0	0	0
Total	169,345	146,016	146,016	146,016	146,016
To Conclude					
Cost	141,400	141,400	141,400	129,400	129,400
Savings	169,345	146,016	146,016	146,016	146,016
Balance	27,945	4,616	4,616	16,616	16,616
Total saved over 5 years = FF 70,409					

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