# The Merits of a Robot: a Dutch Experience

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**ABSTRACT Purpose:** To determine the merits of a robot at the community pharmacy in a quasi-experiment. **Method**: The applied methods for data-collection were barcode-time measurements, direct observations, time-interval studies, and tally at a Dutch community pharmacy. The topics consisted of workload, waiting times, congestion, slack, general work, counter work, and work at the consultation room. The topics were studied in pre-test and post-test stages, each stage during six weeks. By using these topics and some additional data from the pharmacy, the economics of the robot were also assessed. **Results:** The workload decreased with 15 prescriptions per person per day. The waiting times decreased with one minute and 18 seconds per dispensing process, reducing the wait until counter contact. The day congestion decreased with one hour 27 minutes and 36 seconds, and the day slack increased with 28 minutes. The analysis of the general work showed no appreciable difference in the bulk of the care-related activities and the other activities. However, some work was re-shuffled: 7% increase at counter work and 7% decrease at logistics. Moreover, statistically significant increases were observed at counter work (5%) and robot work (4%), and significant decreases at telephone (3%) and filling work in presence of the patient (4%). The counter tally study showed a rise in care-related activities with 8%. Moreover, it also illuminated a statistically significant decrease at no information (11%) and an increase at only social (2%). The consultation room was never used during the study. The pharmacy economics of the robot showed that the robot had high estimated costs for purchase, depreciation, and maintenance: EUR 187,024 in the first year. Moreover, the robot had positive impact on waiting times, congestion, staffing, logistics, and care-related work, which was estimated on EUR 91,198 in the first year. The estimated payback time of the robot was three years. **Conclusions:** An introduction of the robot may indeed have the often supposed positive effects on pharmaceutical care. Even though the costs are high and the technical problems are present, the robot seems to be financial beneficial after three years. The robot can create space for pharmaceutical care, but it has a substantial cost.

## INTRODUCTION

Currently, there seems to be an increasing number of community pharmacies which introduce a robot in order to reduce the time spent on logistic tasks and improve the provision of care in The Netherlands.[1] Although much of the available literature deals with the merits and drawbacks of the robot introduction at the pharmacy, it is yet unknown to what extent this machine increases the care work that is done when compared with a human working system. In order to address this question the waiting times, congestion and slack, and work content were studied at a community-based pharmacy in The Netherlands. This study describes if the introduction of the robot at this pharmacy stimulated care-related activities and to what extent it is economically feasible. The objective of this study was therefore to determine the influence of the robot on the care-related work at the community pharmacy and to estimate the economic value.

Robotization of the logistic parts of the dispensing process is relatively new, but from pharmaceutical and organizational perspectives promising. The organization principle of robotization is simple: logistic tasks are transferred to a robot (filling) and to personnel with a low education (refilling stock) [1]. The efficiency advantages are supposed to be twofold: the machine works faster than humans and the refill is much simpler and can therefore be staffed cheaper. This shift of work increases the available time for pharmaceutical care at the educated staff, for instance, for a conversation at the counter or for continuing education. In this study it was investigated to what extent the work shifted towards pharmaceutical care. This principle is vulnerable as the advantages of improved efficiency may be used for other purposes, not in any way being related to pharmaceutical care.

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The earliest experiences in The Netherlands show that the advantages of robotization are indeed used for the strengthening of the implementation of pharmaceutical care [1]. However, technical failure remains a serious risk. The time to repair a robot after mechanical failures is a serious concern. Even though the robot may be opened and used as a regular stockroom, the exact location of the stock is mostly hard to find in the machine. With the regular pharmacy computer it can be done, but it remains far from ideal. For some pharmacists this has indeed been a valid argument to stop working with the robot [2] or may be the reason that a nation-wide technology take-up has failed to appear. In the scarcely available literature the merits and drawbacks of the robot introduction at the pharmacy are discussed, but their main contribution is to seek the efficiency advantages [3-6]. None of the research has studied the indirect effects: the improvement in terms of care-related activities. That is surprising because improvement of the care activities is a main argument to introduce a robot into the pharmacy. Consequently, this current study seeks to fill that gap.

First, it reports the basic costs : purchase, depreciation, and maintenance. Next, it seeks costs and benefits in combining studies of workload, waiting times, congestion, and slack with the work contents in general, at the counter, and in the separate consultation room. Finally, the study estimates the pharmacy economics of the robot. All under the condition that the pharmacist had the intention to improve pharmaceutical care at the pharmacy.

At the studied pharmacy the robot could store and manage slow, medium and fast moving items and manage stock independently. For the stock refill the robot scans and recognizes packs without manual intervention. Packs can be either randomly placed onto the shelves of the loading door in a relatively slow motion or identical items are placed on one shelf and only the first pack will be placed onto the scan station in a faster mode. On receipt of a stock request, the robot will pick a pack from its stores and deliver it via a transport system to the outlet near the counter from where the request has been made. For more than one pack of the same medication, the robot does not combine the delivery in a batch, but picks one pack at a time. When packs are loaded into the door, a security blind isolates the robot's central working area so that the robot can continue to work whilst packs are being placed into the storage door.

## METHODS

A Dutch community pharmacy was selected based on their motivation to participate in the study, their intention to use the robot introduction for the improvement of pharmaceutical care, and because it was a best case practice. The pharmacy was in the top ten of a secret shopper study performed at well-over 500 community pharmacies by the Dutch pharmacy consultancy firm AMP [7]. The study was not designed for generalization purposes: the sample was far too small. It may therefore be regarded as a study in the context of discovery; the study was designed to reveal the impact of the robot on the performance of pharmaceutical care. The main study distinguishes care-related from other work. Care-related work was defined as the work where at least parts of the content would relate to pharmacotherapeutic consultation; with other work this link could not be established reasonably. In the study eight main topics were investigated: basic costs of the robot, workload, waiting times, congestion and slack, general work, counter work, consultation-room work, and overall economics of the robot.

The first topic was basic costs comprising initial purchase, depreciation, and maintenance and was expressed in euro (EUR). The next topic, workload was described for both periods as a precondition to perform the study: to what extent were the periods really comparable. Moreover, the main data-collection various techniques were used for five additional topics: waiting times, congestion and slack, general work, counter work, and consultation-room work. Finally, the last topic pharmacy economics of the robot were estimated with the above and additional data from the pharmacy. This allowed estimations of costs and merits of the robot during the first year and an estimation of the payback time. All data were collected during six weeks in the spring of 2004 (pre-test stage without robot) and six weeks in the autumn of 2005 (post-test stage robot). Each topic was studied during two weeks per stage.

Firstly, the basic costs comprised initial purchase, depreciation, and maintenance. The data were reported by the pharmacy and the costs were calculated in euro. The total write-down term was ten years in which the cost will be equally distributed in yearly chunks. The pharmacy had a maintenance contract, which included the costs for reparations in case of mechanical troubles. The costs of this contract were reported.

Secondly, the workload was defined as the mean number of prescriptions handled per person per day. It was used as a rough indication of how busy it was during both periods. The calculation was based upon the total number of prescriptions and the total fulltime pharmacist equivalence (FTE) for the team. The FTE gives expression to the number of full time and part time pharmacy staff occupied at the pharmacy during the study, including pharmacists and pharmacy assistants. The pharmacists counted the number of prescriptions and FTE each day during six weeks.

Thirdly, the waiting times were defined as the time patients had to wait in the waiting area and at the counter. These data were collected with barcode-time measurements. The measurements were patient oriented: the times the patient had to wait in the waiting area and at the counter. With direct observations all patients were linked to a unique barcode number on a list which, when registered, was linked to the time. This produced two time periods: a waiting time until the first counter contact and a waiting time after the first counter contact.

Fourthly, congestion was when four or more patients were present in the waiting area and slack was when no patients were present. For both issues direct observations were made in the waiting area. Each time when four or more patients waited or when no patient was waiting, the period from start until end was registered. Waiting times, congestion, and slack were studied in the first two weeks of each measurement period and were expressed in hours, minutes, and seconds (hh:mm:ss).

Fifthly, general work was defined as all the work at the pharmacy. For these work measurements pocket-size machines were used. The machines made a sound signal, roughly four times an hour in a randomly produced time interval. Each time when the machine made a sound signal, the staff member registered in eleven categories what she or he did. These eleven categories comprised care-related work and general work. The care-related work was: counter care, counter other, conversation room, telephone, computer work, ex tempore preparations, and home delivery work. The definitions in this category were: counter care: advice on medication, medical aids or disease; counter other: helping patients at the counter, not being couter care; conversation room: all conversations in this room; telephone: all telephone conversations; computer work: prescription-related computer work, not at the counter; ex tempore preparations: preparing or making medicine at the pharmacy; and home care work: all tasks in relation with the home care. The general work was filling work in and out patient presence, logistical work, office work, robot problems, and other. The definitions in this category were: filling work in patient presence: collecting the medication in presence of the patient; filling work out of patient presence: collecting the medication without the presence of the patient; logistical work: ordering and handling medical goods; office work: stock mutations, claims, expiry dates control, and quality system; robot work: work to fix technical problems or malfunctioning of the robot; other: all other activities at the community pharmacy. This measurement was made in the middle two weeks of each measurement period.

Sixthly, counter work was defined as all work at the counter. For these work measurements registration lists were used to allow tally. After each counter contact with the patient, the staff member qualified the nature of the conversation, also in eleven categories. These eleven categories also comprised care-related work and general work. The care-related work was: brief medication browse, first-time dispensing, second-time dispensing, instruction, medication surveillance, medication counseling, self care, and information about disease or life style. The definitions in this category were: brief medication browse: a quick scan of the medication together with the patient, first-time dispensing: conversation about a first dispense of a certain drug; second-time dispensing: follow-up conversation about the second dispense of a certain drug; instruction: instruction on patient skills to take medication or to use medical aids, e.g. diabetes injection or COPD inhaler; medication surveillance: conversation about the comparison of new medicine with medication history; medication counseling: conversation about medication use or optimization of it; self care: OTC counseling and other conversations about the use of nonprescription medication; and information about disease or lifestyle: conversation about patients' disease or lifestyle. The general work was: only social, other, and no information. The definitions in this category were: only social: conversation about patients' personal situation; other: all other counter conversations; no information: only dispensing medicine. This measurement was made in the last two weeks of each measurement period.

Seventhly, consultation-room work was defined as all work in the separate consultation room. For these work measurements registration lists were also used to allow tally. After each consultation, the staff member qualified the nature of the conversation in six categories. These six categories also comprised care-related work and general work. The care-related work was: first time use, instruction, medication counseling, and information about disease. The definitions in this category were: first time use: conversation about a first use; instruction: instruction on patient skills to take medication or to use medical aids, e.g. diabetes injection, COPD inhaler or incontinence products; medication counseling: conversation about medication use or optimization of it; and information about disease: conversation about patients' disease. The general work was: only social and other. The definitions in this last category were: only social: conversation about patients' personal situation; and other: all other conversations in the consultation room. This measurement was also made at the pharmacy in the last two weeks of each measurement period. The results between the situations without a robot and with a robot were compared.

Finally, the overall economics were defined as the costs and merits that were caused by the robot introduction. In these analyses the basic and additional costs and benefits were combined and compared in order to allow an estimation of the merits in the first year. These financial estimations of changes comprised extra work to overcome robot flaws, filling and logistical work, counter work, workload, waiting times, congestion and slack, and pharmaceutical care. First, the extra work that had to be done by the pharmacy staff in order to overcome technical failure of the robot was derived from the general work study. These results were combined with the data on the available FTE from the workload study and the average year salary reported by the pharmacy and resulted in an estimation of the personnel costs to solve the technical problems. Second, a similar approach was used for an estimation of the costs of changes in logistics and counter work. Next, an estimation of the costs of changes in workload was made with the data on the workload study and the average year salary. Fourth, an estimation of the costs of changes in the waiting time was based upon the results of the waiting time study, in combination with reports from the pharmacy about the mean number of patients per week, the number of weeks per year, the working hours per year per person, and the average year salary. Fifth, an estimation of the costs of changes in congestion and slack were based upon the results of the congestion study, in combination with the number of weeks and working hours per year per person and the average year salary, as reported by the pharmacy. Sixth, an estimation of the costs of changes in pharmaceutical care was calculated with the counter work study. By combining these results with the mean capacity utilization for counter work in the new situation and the average year salary as reported by the pharmacy, the merits were calculated. Consequently, with the results from above methods the total estimated costs and merits could be calculated for the first year. Finally, and based upon the results of methods from above, the payback time was estimated.

## STATISTICAL ANALYSIS

The comparison between the two situations for the topics work load, waiting times, congestion, and slack were population measurements. Therefore, a statistical test if the reported difference was the result of chance alone (if there is really no difference in the population from which you drew your sample) is not relevant [8]. Be reminded that the sample for the above topics equals the population in the period described. Consequently the analyses of these topics were restricted to descriptive statistics. In contrast, the comparison between the two situations for the topics general work, counter work, and work at the consultation room were samples. Consequently, both descriptive statistics and the Mann-Whitney U test were used to determine significant differences. Given the relatively small sample size in the data matrix (day frequencies per cell) and the fact that all observations have higher than ordinal scales the Mann-Whitney U test is a good choice [9-11]. The Mann Whitney U test is the most widely-used non-parametric test for determining the significance of the difference between two groups. In each analysis the pre-test and post-test groups were compared as being independent samples. The test hypothesis was $H_0$: when there is no difference between pre test and post test (or more exactly formulated: it tests whether the major part of the population A (on the basis of pre-test sample a) equals the main part of population B (on the basis of post-test sample b), in this case with an $\alpha$=.05). If the calculated p-value $\leq$.05 $H_0$ will be rejected and it will be assumed that the differences between the pre test and post are significant. The comparison

was made with the rough data: the observed frequencies per day per item in each cell.

## RESULTS

Table 1 describes the basic costs of the robot. Tables 2-6 compare the situation of the pharmacy without and with a robot for the topics workload, waiting times, congestion and slack, general work, and counter work. There is no table for the consultation-room work since no consultations were made during this study: the room was never used. Tables 7-8 deal with the cost and merits of the robot and the payback time. Be reminded that the data in table 1 were based upon initial pharmacy reports, table 2 were based upon measurements during six weeks, tables 3-6 upon two weeks per stage, and tables 7-8 upon a combination of all of the above.

**Table 1.** Basic costs of the robot

| Items | Costs |
|---|---|
| **Purchase (initial cost)** | EUR 150,000 |
| **Maintenance cost (yearly cost)** | EUR 9,000 |
| **Depreciation (yearly cost)** | EUR 15,000 |

Table 1 deals with the costs for the initial purchase, depreciation, and the costs for maintenance in euro. The initial purchase was EUR 150,000 and with a total write-down term of ten years in which the cost will be equally distributed in chunks of EUR 15,000 yearly. For maintenance cost the pharmacy had a contract, which included the costs for reparations in case of mechanical troubles. The contract costs EUR 9,000 per year.

Table 2 deals with the workload and shows that the number of prescriptions dispensed was 546 less in the post-test stage, but still comparable. It presents the sum, mean and standard deviation for the number of prescriptions and team fulltime equivalence (FTE). Moreover, it presents the mean and standard deviation for the prescriptions per person per day. The table shows that the FTE was much higher in the post-test stage, a mean of 1.7 staff members extra per day. As a consequence the workload, expressed in the mean number prescriptions handled per person per day, was much lower at the post-test stage than at the pre-test stage; respectively 53 and 68 prescriptions. A decrease in the workload of 15 prescriptions per person per day.

**Table 2 Workload**

| **Pharmacy situation** | **Without robot** | | |
|---|---|---|---|
| **Measures Items** | **Sum total** | **Mean** | **Standard deviation** |
| Number of prescriptions | 14410 | 480 | 108.9 |
| Total fulltime pharmacist equivalence | 213 | 7.1 | 1.3 |
| Prescriptions per person per day | | 68 | 18.6 |
| **Pharmacy situation** | **With robot** | | |
| **Measures Items** | **Sum total** | **Mean** | **Standard deviation** |
| Number of prescriptions | 13864 | 462 | 89.9 |
| Total fulltime pharmacist equivalence | 263 | 8.8 | 1.5 |
| Prescriptions per person per day | | 53 | 15.2 |

Table 3 deals with the waiting times and presents the mean waiting time and standard deviation. The table shows that the total waiting time decreased with one minute and 18 seconds per dispensing process. Patients had well-over a minute shorter waiting time until counter contact. The waiting time after counter contact remained relatively stable. All standard deviations were lower in the situation with the robot. Less waiting times differed from the mean, indicating that the different waits were more comparable in duration.

**Table 3 Waiting times**

| **Pharmacy situation** | **Without robot (n=1578)** | |
|---|---|---|
| **Measures (hours:minutes:seconds) Items** | **Mean** | **Standard deviation** |
| Waiting time until counter contact | 00:05:11 | 00:05:14 |
| Waiting time after counter contact | 00:02:59 | 00:00:57 |
| Total waiting time | 00:08:10 | 00:03:38 |
| | **With robot (n=1515)** | |
| **Measures (hours:minutes:seconds) Items** | **Mean** | **Standard deviation** |
| Waiting time until counter contact | 00:03:48 | 00:04:10 |
| Waiting time after counter contact | 00:03:04 | 00:00:31 |
| Total waiting time | 00:06:52 | 00:03:28 |

Table 4 comprises the observed congestion and slack. It presents the cumulative observed time periods and frequencies of congestion and slack, the mean and frequencies per day, and the standard deviation. The table shows that the sum total congestion decreased with more than 15 hours per two weeks and the frequency dropped with almost 50%, from 238 to 121 observed congestion time intervals. As a consequence, the mean congestion decreased with one hour 27 minutes and 36 seconds per day and the observed daily frequencies were halved. The table also shows that the sum total slack increased with more than 4 hours per two weeks and the frequency rose with almost 20%, from 175 to 210 observed slack time intervals. Therefore, slack increased with 28 minutes per day and the observed frequencies were comparable: three more per day. The standard deviations were also comparable: it decreased slightly at congestion and increased slightly at slack.

Table 5 deals with the general work at the pharmacy. It presents the cumulative observed frequencies per item, the mean per day, the percentage per item as part of all observed frequencies, the standard deviation, and statistical significant differences. The table shows that there was no appreciable difference in the proportion between the care-related activities and other activities with the introduction of the robot. The study comprised 2665 registrations in the pre-test and 3143 registrations in the post-test spread in two weeks each. The proportion of care-related activities was 1039 registrations (39%) in the pre-test and 1179 registrations in the post-test (38%). The proportion of other activities was 1626 registrations (61%) in the pre-test and 1964 registrations in the post-test (62%). Consequently, it is argued that the general work in the situation with the robot was for 38% care-related (39% without robot) and for 62% not-care-related (61% without robot).

However, on the detailed level the results show some interesting statistically significant differences. First, the results show a significant increase of 5% in the observed activities at counter other (without robot: 7%; with: 12%) and of 4% at robot work (without robot: 0%; with: 4%); both having a calculated p-value of less than .01. Second, the results show a significant decrease of 3% at telephone work (without: 6%; with: 3%) and of 4% at filling work in patient presence (without robot: 8%; with: 4%); both also having a calculated p-value of less than .01. Third, it is interesting to mention that other changes are remarkable, even though they are not statistically significant. The counter work, including the categories counter care and counter other, has increased with 7% (without robot: 12%; with: 19%). Moreover, the filling work, including the categories filling work in patient's presence and filling work out of patient's presence, has decreased with 8% (without robot: 22%; with: 16%).

Table 6 deals with the counter work at the pharmacy. It presents the cumulative observed frequencies per item, the mean per day, the percentage per item as part of all observed frequencies, the standard deviation, and statistical significant differences. The table shows that the care-related activities have risen (without robot: 71%; with: 79%). The study comprised 1197 counter registrations in the pre-test and 1052 counter registrations in the post-test spread in two weeks each. The proportion of care-related activities was 855 registrations (71%) in the pre-test and 827 registrations in the post-test (79%). The proportion of other activities was 342 registrations (29%) in the pre-test and 225 registrations in the post-test (21%). Consequently, it is argued that the counter work in the situation with the robot was for 79% care-related (71% without) and for 21% not-care-related (29% without).

However, again on the detailed level the results show some interesting differences which were statistically significant. First, the results show a very relevant and statistically significant decrease in the observed activities at no information (without robot: 26%; with: 15%). Second, the results show a significant increase at only social (without: 0%; with: 2%). Both differences were having a calculated p-value of less than .01. Third, it is also interesting to mention that another important changes was registered, even though it was not statistically significant. The brief medication browse has increased with 6% (without: 51%; with: 57%).

Table 7 shows the estimated costs and merits of the robot in the first year. The costs of the robot comprised initial purchase, depreciation, maintenance, and extra work to overcome technical failure of robot. Earlier, we have learned from table 1 that the yearly costs associated with the initial purchase were EUR 150,000, with depreciation EUR 15,000, and with maintenance EUR 9,000. Moreover, the extra work that had to be done by the pharmacy staff in order to overcome technical failure of the robot comprised an increase of 4% of the total FTE in the new

**Table 4 Congestion and slack**

| Pharmacy situation | Without robot | | | | | With robot | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Measures (hours:minutes:seconds)** | **Sum total** | **Frequency** | **Mean** | **Frequency** | **Standard deviation** | **Sum total** | **Frequency** | **Mean** | **Frequency** | **Standard deviation** |
| **Items** | | | | | | | | | | |
| Congestion (four or more patients waiting) | 34:15:04 | 238 | 03:25:30 | 24 | 00:15:50 | 19:39:00 | 121 | 01:57:54 | 12 | 00:11:22 |
| Slack (no patients waiting) | 09:15:55 | 175 | 00:55:36 | 18 | 00:03:21 | 13:56:00 | 210 | 01:23:36 | 21 | 00:04:10 |

**Table 5 General work**

| Pharmacy situation | Without robot | | | | With robot | | | | Significance * p-value≤.05 **p-value≤.01 |
|---|---|---|---|---|---|---|---|---|---|
| **Measures** | **Sum total** | **Mean** | **Percentage of total number of activities** | **Standard deviation** | **Sum total** | **Mean** | **Percentage of total number of activities** | **Standard deviation** | |
| **Items** | | | | | | | | | |
| Counter care | 141 | 14.1 | 5% | 10.9 | 224 | 22.4 | 7% | 7.2 | |
| Counter other | 197 | 19.7 | 7% | 8.1 | 383 | 38.3 | 12% | 12.5 | ** |
| Conversation room | 1 | 0.1 | 0% | 0.3 | 3 | 0.3 | 0% | 1.0 | |
| Telephone | 166 | 16.6 | 6% | 6.1 | 99 | 9.9 | 3% | 5.0 | ** |
| Computer work | 289 | 28.9 | 11% | 10.6 | 231 | 23.1 | 7% | 5.1 | |
| Ex tempore preparations | 41 | 4.1 | 2% | 4.1 | 42 | 4.2 | 1% | 3.5 | |
| Home delivery work | 204 | 20.4 | 8% | 7.9 | 197 | 19.7 | 6% | 14.9 | |
| **Subtotal care-related activities** | 1039 | 103.9 | 39% | 10.4 | 1179 | 117.9 | 38% | 25.0 | |
| Filling work in patient presence | 215 | 21.5 | 8% | 8.4 | 111 | 11.1 | 4% | 7.5 | ** |
| Filling work out of patient presence | 375 | 37.5 | 14% | 18.9 | 375 | 37.5 | 12% | 20.9 | |
| Logistical work | 168 | 16.8 | 6% | 5.9 | 149 | 14.9 | 5% | 8.9 | |
| Office work | 55 | 5.5 | 2% | 3.2 | 168 | 16.8 | 5% | 18.7 | |
| Robot work | 0 | 0.0 | 0% | 0.0 | 120 | 12.0 | 4% | 12.3 | ** |
| Other | 813 | 81.3 | 31% | 22.4 | 1041 | 104.1 | 33% | 26.1 | |
| **Subtotal other activities** | 1626 | 162.6 | 61% | 46.0 | 1964 | 196.4 | 62% | 58.1 | |
| **Total activities** | 2665 | 266.5 | 100% | 43.4 | 3143 | 314.3 | 100% | 70.0 | |

**Table 6 Counter work**

| **Pharmacy situation** | **Without robot** | | | | **With robot** | | | | **Significance * p-value≤.05 **p-value≤.01** |
|---|---|---|---|---|---|---|---|---|---|
| **Measures**<br><br>**Items** | **Sum total** | **Mean** | **Percentage of total number of activities** | **Standard deviation** | **Sum total** | **Mean** | **Percentage of total number of activities** | **Standard deviation** | |
| Brief medication browse | 614 | 61.4 | 51% | 17.8 | 601 | 60.1 | 57% | 14.5 | |
| First time use | 130 | 13.0 | 11% | 7.6 | 116 | 11.6 | 11% | 4.5 | |
| Second time use | 21 | 2.1 | 2% | 1.4 | 31 | 3.1 | 3% | 2.8 | |
| Instruction | 6 | 0.6 | 1% | 1.0 | 7 | 0.7 | 1% | 1.1 | |
| Medication surveillance | 2 | 0.2 | 0% | 0.4 | 8 | 0.8 | 1% | 1.1 | |
| Medication counseling | 10 | 1.0 | 1% | 1.1 | 11 | 1.1 | 1% | 1.1 | |
| Self care | 68 | 6.8 | 6% | 3.9 | 49 | 4.9 | 5% | 3.3 | |
| Information about disease or lifestyle | 4 | 0.4 | 0% | 1.0 | 4 | 0.4 | 0% | 0.7 | |
| **Subtotal care-related activities** | 855 | 85.5 | 71% | 25.8 | 827 | 82.7 | 79% | 20.6 | |
| Only social | 2 | 0.2 | 0% | 0.4 | 26 | 2.6 | 2% | 3.1 | ** |
| Other | 26 | 2.6 | 2% | 2.2 | 40 | 4.0 | 4% | 4.3 | |
| No information | 314 | 31.4 | 26% | 12.9 | 159 | 15.9 | 15% | 8.7 | ** |
| **Subtotal other activities** | 342 | 34.2 | 29% | 13.8 | 225 | 22.5 | 21% | 13.3 | |
| **Total activities** | 1197 | 119.7 | 100% | 25.9 | 1052 | 105.2 | 100% | 25.8 | |

situation (based on tables 2 and 5). Based on the average year salary reported by the pharmacy (EUR 37,000 salary) this extra work was estimated on EUR 13,024 per year.

The merits of the robot comprised decreases of workload, waiting time, and congestion; and an increase of slack. Moreover, a decrease of filling and logistical work and increases of counter work and pharmaceutical care were observed. The calculated weighted decrease of workload was .3 FTE (based on table 2); by combining this result with the average year salary this merit was estimated to be EUR 11,100 per year. The decrease of waiting time was one minute 18 seconds per patient (.022 hours), and which is derived from table 3. Based on the mean number of 644.5 patients per week, 52 weeks per year and 1600 working hours per year per person, and the average year salary, as reported by the pharmacy, the merits of the decrease of waiting time were estimated on EUR 17,050 per year. The decrease of congestion was one hour 27 minutes and 36 seconds per day (7.3 hours per week), and which is shown in table 4. Based on the number of weeks and working hours per year per person, and the average year salary, the merits of the decrease of congestion were estimated on EUR 8,778 per year. The increase of slack was 28 minutes per day (2.3 hours per week), and which is shown in table 4. Based on the number of weeks and working hours per year per person, and the average year salary, the merits of the increase of slack were estimated on EUR 2,766 per year.

**Table 7 Estimated costs and merits of the robot in the first year**

| Items | Costs in first year | Merits in first year |
|---|---|---|
| Initial purchase | EUR 150,000 | |
| Depreciation (EUR 150,000 purchase/10 years) | EUR 15,000 | |
| Maintenance | EUR 9,000 | |
| Extra work to overcome technical failure of robot (.04 robot work*8.8 FTE*EUR 37,000 salary) | EUR 13,024 | |
| Decrease of workload (.3 FTE*EUR 37,000 salary) | | EUR 11,100 |
| Decrease of waiting time ((.022 hours*644.5 patients*52 weeks)/1,600 hours)*EUR 37,000 salary | | EUR 17,050 |
| Decrease of congestion ((7.3 hours*52 weeks)/1,600 hours)*EUR 37,000 salary | | EUR 8,778 |
| Increase of slack ((2.3 hours*52 weeks)/1,600 hours)*EUR 37,000 salary | | EUR 2,766 |
| Decrease of filling and logistical work (.07 filling and logistical work*8.8 FTE*EUR 37,000 salary) | | EUR 22,792 |
| Increase of counter work (.07 counter work*8.8 FTE*EUR 37,000 salary) | | EUR 22,792 |
| Increase of pharmaceutical care (.08 care related work at the counter*2 FTE counter assistants*EUR 37,000 salary) | | EUR 5,920 |
| **Total** | **EUR 187,024** | **EUR 91,198** |

The decrease of filling and logistical work and the increase of counter work were both 7% of the total FTE in the new situation (tables 2 and 5). Based on the average year salary these merits were estimated on EUR 22,792 each, per year. The increase of pharmaceutical care is shown in table 6 and was a total increase of 8% of care-related activities. By combining this increase with a mean capacity utilization of two FTE for counter work in the new situation and the average year salary as reported by the pharmacy, this merit was estimated on EUR 5,920 per year. Consequently, the total estimated costs were EUR 187,024 and the merits were EUR 91,198 in the first year.

Table 8 shows the estimated payback time of the robot, based on the estimations of table 7. Within this line of thought the break even point was passed after three years. At that time the merits were EUR 12,522 higher than the costs.

**Table 8 Estimated payback time of the robot**

| | Costs | Merits |
|---|---|---|
| **Year 1** | EUR 187,024 | EUR 91,198 |
| **Year 2** | EUR 224,048 | EUR 182,396 |
| **Year 3** | EUR 261,072 | EUR 273,594 |

## DISCUSSION

Be reminded that this study included eight main topics: basic costs of the robot, workload, waiting times, congestion and slack, general work, counter work, consultation-room work, and overall economics of the robot. All topics will be discussed briefly and converge in a general conclusion about the merits of the robot in this Dutch pharmacy.

Firstly, the basic costs of the robot were determined on EUR 174,000 in the first year. The costs are high and support the idea that the robot is expensive and has substantial depreciation and maintenance costs.

Secondly, the workload was higher in the pre test without robot than in the post test with robot. In the robot situation each staff member handled 15 prescriptions less a day. This may have affected at least parts of the results of the study. However, if all other things are kept equal, the total pharmacy working systems needs 6.8 FTE in stead of 7.1 FTE to dispense the observed 14,410 prescriptions of the pre test (table 2). The robot working system needs .3 FTE less for staffing in a situation with a robot; estimated on EUR 11,000.

Thirdly, the waiting times have decreased with one minute and 18 seconds per dispensing process; estimated on EUR 17,050. On one hand, it has reduced the 'nasty' waiting times before counter contact. These are the times during which the patient is not yet being helped and that have the potential to lead to impatience, frustration and annoyance [12]. On the other hand, it has kept the good 'waiting' time after counter contact stable. These are the times during which the patient is helped and that have the potential to lead to a pharmacotherapeutic consultation.

Fourthly, the other efficiency advantages at congestion and slack were also very important. The observed congestion was reduced with one hour, 27 minutes and 36 seconds and the observed slack was increased with 28 minutes; with half and similar frequencies respectively. Both benefits were estimated on EUR 11,544. As a consequence, each day 16% of the opening hours became normal in stead of stressful, creating more time to have a conversation. The stressful moments were also less frequent: 12 in stead of 24 a day. It also meant that each day 5% of the opening hours became silent, creating time to do other work. These peaceful moments were comparable, but slightly more frequent: 21 in stead of 18 a day.

Fifthly, the time-interval studies of the general work showed a 7% increase of the counter work and the 4% decrease of the filling work in the presence of the patient. These results suggest that the observed efficiency advantages were actually used for the provision of care. Although robot introduction produces significant negative side effects of costs and technical failure, these positive effects at the general work are also of considerable importance. At first sight the time-interval studies showed that the work has 'just' been re-shuffled: there was no appreciable difference in the proportion between the care-related activities and the other activities. However, with a detailed analysis of the care-related activities positive effects were observed at counter work, exactly at the place where a care-oriented pharmacist would wish them to have: a 7% increase at counter work; estimated on EUR 22,792. Moreover, it also illuminated a 9% decrease at telephone, computer work, and home delivery work where at least parts of the work content will also have related to other work content, and therefore not completely being care-related. Because the care and other activities were so intermingled, we did not calculate these benefits in financial terms. Within the other activities the main outcome of the re-shuffling was dimming effects on filling and logistical work: a 7% decrease; also estimated on EUR 22,792. However, there was also a 4% increase at robot work to overcome technical problems; estimated on EUR 13,024. In the overall results of the time-interval studies, the 7% increase at counter work, the 7% decrease of filling and logistical work, and the 4% increase of robot work were found to be the most important effects of the robot introduction, mainly because of their statistical significance and their relation with the implemented logistical changes.

Sixthly, counter-tally studies showed a rise in care-related activities with 8%; this merit was estimated on EUR 5,920 per year. Moreover, it also illuminated an important increase at brief medication browse (6%) and social conversations (2%), and a very important decrease at counter contacts where no information was provided (11%), although only the latter two were statistically significant. In the overall results of the counter-tally studies therefore the 11% decrease in the counter contacts where no information was provided and the 2% increase of social conversations were the most important effects of the robot introduction, because of their statistical significance and their relation with the implemented logistical changes. However, only the 8% increase in care-related activities was calculated in financial terms because it is believed to represent the major shift in work at the counter.

Seventhly, the consultation-room work was never performed during the study: the room was unused. This is remarkable because the separate room is generally accepted as a pre-condition that allows the provision of pharmaceutical care in The Netherlands.

Eighthly, the overall economics of the robot support the idea that the robot is expensive, has substantial maintenance cost, and makes the pharmacy working system more vulnerable, as it is liable to have troubles. The estimated expenses per year were EUR 187,024 in the first year and EUR 37,024 in the years after. However, the robot also has substantial benefits at the topics of workload, waiting time, congestion and slack, logistics, counter work, and pharmaceutical care. The estimated benefits per year were EUR 91,198 in the first year and after. If we combine these results we can derive that the financial pay-back time of the robot was three years.

The results suggest that the robot is expensive, but also that it improves efficiency of the pharmacy work, and by doing so, may

actually support a transition in the work at the pharmacy from logistics to care. The advantages in terms of efficiency and pharmaceutical care are very promising. But what explains the efficiency advantages?

Firstly, the changes in the nature of the filling work were strong at this pharmacy. In the situation without a robot the filling work was a separate working station on another location. The staff had to move their and back, creating time disadvantages. In the situation with the robot, the product outlet was only steps away from the counter eliminating most of these disadvantages, which could in turn be used for patient contact.

Secondly, the human search process in the regular supply closet was eliminated at this pharmacy. The robot delivered the stock request in its outlet transforming the search into a stop-and-go action. Consequently, the work could be done more easily, creating a shorter wait and more space for conversations at the counter, and being accountable for a main part in the observed positive effects at the care-related activities.

Proximity of stock in the counter area and replacement of human with nonhuman technology for specific logistic tasks may indeed be a good design principle for many pharmacies, and it may in fact also have general applicability. However, be reminded that these positive effects for pharmaceutical care remain vulnerable. They only hold under the condition ceteris paribus. If the pharmacist decides to keep the staffing stable, which was done at this pharmacy, the available workforce is reallocated to other work. But to what other work? Scientifically there is no guarantee that the time advantage really is a change for the better for pharmaceutical care. Robotization can also be used easily for a sole cost-reduction of staff expenses, for instance, at times of financial setback or staff shortage in the labor market. In this view the robot must also be regarded as a substantial financial investment in which the recovery of the cost plays an important role. Cheaper low educated staff may actually replace parts of the educated pharmacy staff, without any benefits for pharmaceutical care. Whichever way one looks at it, money and care remain communicating vessels. The strong interdependencies between economics and pharmaceutical care could drive pharmacists or other decision-makers into sole cost-reduction. To what extent the robot actually improves pharmaceutical care will always depend on the intentions and qualities of the individual pharmacist and on the business context. As such, robotization has the potential to advance pharmaceutical care in the pharmacy, but its actual contribution can only be determined when the reallocation of human resources is known.

## CONCLUSIONS

The study has shown that the introduction of a robot, when combined with increased staffing, has important drawbacks which should not be ignored, but it also has interesting merits.

On one hand, the observed drawbacks of the robot remain the high initial costs, depreciation, maintenance costs, and new robot work to overcome problems of technical failure. Hence, the estimated pharmacy expenditures were EUR 187,024 in the first year.

On the other hand, the observed merits of the robot consist of positive impact on waiting times, congestion, staffing, logistics, and care-related activities. In terms of the general work the study revealed more counter work and less filling work. In terms of the counter work it was shown that in general more care-related activities were present at the pharmacy. Finally, less counter contacts without information were observed and more social conversations. The estimated merits were EUR 91,198 in the first year. In combining the costs and merits, the estimated payback time of the robot was three years.

This all leads to the conclusion that an introduction of the robot may indeed have the often supposed positive effects on pharmaceutical care. Even though the costs are high and the technical problems are present, the robot seems to be financial beneficial after three years. So, if the robot is combined with an intention of the pharmacist to improve pharmaceutical care it can create space for pharmaceutical care. New studies should illuminate if these observations hold in a larger sample size in using pre-test and post-test stages.

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