

Impact of a 5S lean intervention on resources use: A quasi-experimental study

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Abstract

Objective: To evaluate the potential effect of a 5S lean intervention on redundant movements, finding of products and nurse-reported efficiency.

Design: A quasi-experimental design was applied using predefined outcome measures (step counts, time measured finding of products) and staff-reported quality of patient-care.

Setting: Two geriatric wards of az Maria Middelaers, a 631-bed general hospital in Ghent, Belgium.

Study participants: A pilot study was set up with 37 participants. Half of them took part respectively in the experimental (5S lean intervention) and control (non-intervention) group. All of them completed a questionnaire before and after the intervention. In addition, movements (by means of total number of steps) and time to find products were measured.

Implementation: The implementation was executed by means of a Rapid Improvement Event with nurses, staff and persons working in the distribution department and the lean 5S technique (focusing on Sorting, Straightening (or stabilizing), Sweeping (or shining), Standardizing and Self-discipline (or sustaining). Intervention effects were measured three weeks following implementation.

Results: The intervention group reported higher satisfaction with a large effect size for the logical arrangement and on the availability of products on the chariot compared to the control group. There was no significant difference between both groups on the step counts and, on the time, measured finding products.

Conclusion: The lean intervention was able to have an impact on some staff ratings of quality of patient care. Future studies with a combination of outcome measures seem indicated.

Introduction

Globally the healthcare system is under pressure due to increasing costs and high expectations. More than 30% of all general hospitals (private and public) in Belgium are loss-making [1]. Reducing unnecessary costs and optimizing hospital services might provide more financial respite and additional space for investment [1,2].

Lean management (LM) refers to the thinking, principles and methods of the Toyota Production System that aimed to preserve and add more value and performance and eliminate 'non-value activities' or waste [2-7]. Research demonstrated a strongly potential of lean premises [6,8-13] with quality improvement in the automotive and manufacturing industries [11].

Up till now lean studies in hospitals are not as frequent as in the industry. In addition, the available healthcare studies resulted in low quality evidence [3,11], such as non-significant results or results without controlling for spontaneous improvement using a before-after study design [2,10,13]. Only few studies examined the effect of lean management using a control group in a quasi-experimental design. In addition, different outcome measures make healthcare studies difficult to compare.

To conclude the application of lean management to healthcare sector has been limited [2,3], and the effectiveness of lean interventions in hospitals has been questioned [11].

Aim of the present study

There is a lack of rigorous and higher quality studies to find out if lean works in hospital settings [11]. This study aims to help to fill this gap by conducting a quasi-experimental lean intervention on a geriatric ward from a private hospital in Ghent.

Another aim of this study was to combine key outcome measurements and to investigate whether hard outcome measures (digital counting of steps and observation and registration of searching time) differed from the results of the staff self-reports (questionnaires on staff reported work satisfaction).

Up till now, no study used a quasi-experimental design with rapid improvement event approach and a combination of measures. This paper aims to add in this way to the body of knowledge concerning the impact and effectiveness of lean in healthcare settings.

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Method

Design and setting

A pretest-intervention-posttest with a control group and lean-intervention group design was used. The three-phased study was performed on two geriatric wards of a 631-bed private hospital in Ghent, Belgium. Both geriatric wards of the hospital were comparable to be sure that the lean intervention effects could not be attributed to other changes over time. Randomly one ward was chosen as intervention group.

All participants volunteered to participate to the study. The most experienced participant worked there for 37 years. The least experienced participant just started (*Mdn* = 9, *IQD* =19). Of the participants 54 % worked full time and 25 % worked 4/5.

During the pretest primary outcome measures on redundant movements, finding of products and nurse-reported efficiency were collected.

The lean intervention focused on the use of care carts. To enhance the sustainability [2], staff members in the 5S lean-intervention group were involved in the application of lean thinking, using a Rapid Improvement Event (RIE) approach where they looked together (after primary outcome measures were taken) and under supervision of the first author at their actual performance and on how they could manage and improve efficiency and staff satisfaction.

After the intervention phase the impact of the intervention (in the intervention group) and of the changes over time without intervention (in the control group) were tested with the same outcome measures on redundant movements, finding of products and nurse-reported efficiency as in the pretest.

All outcomes of both groups were blinded. Appropriate statistics were used for data analysis. Non-parametric Mann-Whitney U and χ^2 tests were used. Effect sizes ($r = Z / \sqrt{n}$) for comparisons using Mann-Whitney U tests, Medians (*Mdn*) and Interquartile Distance (*IDQ*) were reported

Instruments

The information of a questionnaire on nurse-reported efficiency, step recording (of movements) and observation (of finding of products) were combined in this study as outcome measures.

The questionnaire was developed and validated to assess staff reported work satisfaction, based on existing literature [10] enriched with two observations by the first author for two morning shifts at the hospital and conversations with stakeholders. The questionnaire comprised information about the respondents (how long do you work in the hospital, in what shift do you work).

Moreover, the health-related quality of work was assessed in the questionnaire with five Likert scale items (e.g., I totally disagree (1) /I totally agree (5)). The items covered aspects of logical arrangement, user friendliness, availability, facility and absence of redundant steps.

On the same questionnaire the frequency of searching material (ones each shift, 2 or 5 times in a shift, more than 5 times in a shift) and the mean time searching material (1-10 minutes, 11-15 minutes, 16-30 minutes, more than 30 minutes) was asked for. In addition, two open ended questions were included to give the respondents the possibility to describe the positive points and the points of improvement in their current work.

Prior to the study, the instrument was tested in a pilot study in order to determine its usefulness for this purpose and the sensitivity in measuring individual differences. Analyses showed that nurses could handle the instrument well. Nurses were interviewed after the test on their given answers and all of them referred to the constructs aimed to assess. In addition, an expert on lean was consulted in order to increase lean-related value of the study.

Step counts took place before (primary outcome measure) and after (posttest) the intervention phase. Over the course of two weeks a digital counter recorded the steps at both teams. The Omron Walking style 2.0 step counter was chosen, after a tryout on four persons.

There were 114 registrations of the steps set during a shift (65 registration in the intervention group, 49 registrations in the control group) as baseline and primary outcome measure before the 5S intervention took place. After the intervention steps were monitored during 110 shifts, with 57 registrations in the intervention group and 53 in the control group. Outcomes were blinded (only participant numbers were used).

Parallel to the monitoring of steps and fulfilling of questionnaires observations/time measurement took place. Participants had to search for five randomly chosen items on the care chariot. Time was registered in line with the study of Pedley and colleagues [14] with a stopwatch. Outcomes were analyzed blinded.

Lean 5S intervention

The lean 5S technique aimed to capture the following five processes: Sorting, Straightening (or stabilizing), Sweeping (of shining), Standardizing and Self-discipline (of sustaining).

In the phase of Sorting all redundant items were removed from the bandage and linen chariots. In the Straightening phase the system was restructured with visual reminders and every item was given a fixed place on the chariot. The sweeping and shining referred to the cleaning and removing of dirt on the chariots. Standardizing referred to the creation of routines and standardized ways to use products on the chariots. The last phase was the phase of self-discipline to continue and sustain the improved situation.

A Rapid Improvement Event (RIE) approach was used, with care takers and staff members as well as people from the distribution looking together in the intervention group at their actual performance and how they could manage and improve efficiency.

The effect of the changes over team was monitored for three weeks in the two teams.

Results

Before (phase 1) and after (phase 2) the intervention, predefined outcome measures (step counts, time measured finding of products) and staff-reported quality of patient-care were gathered.

Phase 1 : pretests

The nurse reported efficiency was assessed with a questionnaire in the experimental (5S lean intervention) and control (non-intervention) groups before the intervention took place.

There were no significant differences on the report of the logical arrangement, user friendliness, availability and facility between both groups. In the intervention group the nursing staff however reported significantly more (with a small effect size $r = - 0.41$) to have the feeling

to set more redundant steps than in the control group ($U = 34.50, p = .049$) before the intervention took place. For the Medians (*Mdn*) and Interquartile Distance (IQD) we refer to Table 1.

On the same questionnaire both groups did not differ in self-reported frequency ($\chi^2 (2) = 0.88, p = .642$) nor in time ($\chi^2 (3) = 0.91, p = .823$) spent searching material, so both groups rated themselves comparable on efficiency in finding of products before the 5S lean implementation.

Secondly, there were 114 registrations of the steps set during a shift as baseline and primary outcome measure before the 5S intervention took place. Step counts (Table 1) were not significantly different ($p = .587$) in the experimental group and control group

Finally, time measured to find five products on the chariot before the intervention (Table 1) differed significantly between both groups ($p = .032$), with the intervention group needing more time to find the products, indicating less efficiency.

Phase 2 : post-tests

After the 5S lean intervention in the experimental group, information from questionnaires, step recording and time measurement were gathered again in the experimental and control group. The information was blinded.

On the questionnaire for staff-reported quality of patient-care (Table 1), there were statistically significant differences between the intervention and control group on two direct outcomes with a large effect size ($r > .05$), namely on the report of the logical arrangement ($U=27.00, p = .013, r=-0.52$) and on the availability ($U=16.00, p = .002, r=-0.65$) of products on the chariot. After the Lean intervention there were no statistical significant differences between the intervention and control group on facility ($U=40.50, p = .103, r=-0.34$), user friendliness ($U=51.00, p = .353, r= -0.19$) and on the reduction of redundant steps ($U=61.00, p = .894, r=-0.03$) rated by the staff as parameters of quality of patient-care.

Secondly there were step counts during 110 shifts, revealing no significant ($U=1271.50, p = .117, r= -0.15$) differences between both groups after the lean intervention. These results did not confirm that

this 5S lean intervention could promote the elimination of ‘non-value activities’ or waste by reducing redundant movements. In both groups less, steps were counted in the posttest, meaning that the reduction of movements might be attributed to changes over time (Table 1).

Finally, time to find five products was measured in 13 nurses after the 5S lean intervention took place in the experimental group (Table 1). Two nurses no longer were active on the unit and did not participate in the posttest. The results revealed no significant differences ($U=7.00, p = .177$) between the experimental and control group in the posttest. Both groups were faster to find the five products in the posttest compared to the primary outcome pretest measure. The Intervention group evolved with a difference score of - 32.50 sec, whereas the control group evolved with a difference score of -9 sec. However, the formal statistical test was not significant, so the data could not support the claim that the lean intervention could promote more effectiveness in healthcare .

Discussion

The existing studies about lean interventions in healthcare are lacking or low in methodological quality [11]. The aim of this study was to fill in this gap with a quasi-experimental design, a rapid improvement event approach and a combination of predefined outcome measures (step counts, time measured finding of products and staff-reported quality of patient-care).

The results revealed that lean resulted in higher satisfaction ratings with a large effect size on the logical arrangement and availability of products on the chariots. However, there was no significant improvement of nurse-reported facility, user friendliness and reduction of redundant movements. In addition, there was no significant step reduction (assessed with the digital registration of steps). However, although not significant on the formal statistical test, in the intervention group they were 32.50 sec. faster and so more effective than in the pretest, whereas the control group was only 9 seconds faster to find five randomly selected products in the posttest.

Thus, the study demonstrated some impact and effectiveness of the lean intervention on worker satisfaction in a hospital setting. However, in line with previous studies [2] and with the systematic literature review of Moraros and colleagues [11] the results also confirmed that

Table 1. Nurse-reported efficiency, redundant movements and efficiency of findings products in geriatric wards

	Intervention group <i>Med (IQD)</i>	Control group <i>Med (IQD)</i>	
Pretest			
Nurse-reported efficiency			
Logical arrangement	3 (2)	3 (2)	$U = 65.00, p = 1.000$
User friendliness	3 (3)	3 (2)	$U = 43.50, p = .158$
Availability	2 (3)	2 (1)	$U = 57.00, p = .558$
Facility	4 (3)	4 (2)	$U = 61.00, p = .747$
Redundant steps	3 (3)	2 (2)	$U = 34.50, p = .049*$
Step counts	5782 (10949)	5367 (7184)	$U = 1497.50, p = .587$
Time registration	106.50 (2153.47)	40.00 (1334.91)	$U = 6.00, p = .032*$
Posttest			
Nurse-reported efficiency			
Logical arrangement	4 (2)	3 (2)	$U = 27.00, p = .013*$
User friendliness	4(2)	4 (3)	$U = 51.00, p = .353$
Availability	4 (3)	2 (1)	$U = 16.00, p = .002*$
Facility	4 (3)	3 (2)	$U = 40.50, p = .103$
Redundant steps	2 (2)	3 (3)	$U = 61.00, p = .894$
Step counts	5482 (6350)	5095 (8193)	$U = 1271.50, p = .117$
Time registration	73.00 (1376.57)	31.00 (1654.30)	$U = 7.00, p = .177$

stating that 'the lean message is 100% positive' seems a bit of a stretch, since the lean intervention group only differed from the control group on two aspects of self-reported staff satisfaction in healthcare. The present data did not support the claim of quality promotion assessed with the three other staff rated aspects and there was no evidence for the lean premises and the reduction of waste measured with digital step recorders or time registration.

In addition, the study revealed that the measurement of a lean implementation effects might not be 'bias free' since predefined outcome measures such as step counters and time measurements of the finding of products gave different results than staff-reported quality reports. Perhaps questionnaires are more sensitive to smaller effects compared to time registrations and digital step counters. A combination of measures and more rigorous high-quality research is required to understand these incongruent findings.

All studies have limitations. First it should be acknowledged that sample size is a limitation of the present study. Obviously sample size is not a problem for significant differences. However, when analyses have insufficient power and were not significant (e.g., for facility as aspect of work satisfaction or staff morale and for time registration as effectiveness), a risk of type 2- or β -mistakes (concluding from the cohort that there were no differences although in reality there were differences in the population) cannot be excluded. Additional research with larger groups of participants is indicated. Second, the results of this study should be interpreted with care since the analyses are based on a Rapid Improvement Event and a very short period of 5S-lean implementation. It might be so that a longer period of implementation or lean without RIE might lead to other results. Additional research should focus on such intervention studies and also pay attention to the sociotechnical aspects [3] of lean implementations.

However, the overall conclusion is that a short lean intervention combined with a rapid Improvement Event approach in a hospital seems to be able to generate some positive and significant results with large effect sizes on the ratings of the health-related quality of work [15].

Conclusion

The study revealed some impact and effectiveness of a 5S-lean intervention to improve the worker satisfaction on the logical arrangement and availability of products on a chariot in a geriatric ward form a hospital. In addition, the study demonstrated the need for further quasi-experimental studies with larger samples and a combination of outcome measures to explore what aspects of lean interventions actually work in healthcare settings.

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