

Exploring the relation between lean thinking and efficiency in high-volume cataract pathways

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3 **Exploring the relation between lean thinking and efficiency in high-volume cataract**
4 **pathways**
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19
20 **Abstract**
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22 **Objective** To explore the relation between process design, lean thinking and efficiency.
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24 **Design** A retrospective benchmark study using a mixed-method design.
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27 **Setting** Three eye hospitals in the United Kingdom, the Unites States of America and the
28
29 Netherlands. All are major international tertiary care and training centres in ophthalmology.
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31 **Participants** Data on all patients who underwent first eye cataract surgery in 2006 were used.
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33 **Interventions** The study related the degree to which lean thinking was incorporated in the
34
35 cataract pathway to efficiency.
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38 **Outcome measures** Six characteristics for lean thinking with high impact on process design
39
40 were evaluated: operational focus, physical lay-out, dedicated resources, cross-training, pull
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42 planning and eliminated waste. Efficiency was measured with lead times (access time plus
43
44 waiting time for surgery), average number of hospital visits and direct costs.
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46
47 **Results** Operational focus in the cataract pathways was influenced by external circumstances
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49 leading to different orientations on reducing the number of hospital visits, lead times and costs. A
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51 low number of visits per procedure was associated with employing one-stop diagnosis and pre-
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53 assessments. Shorter lead times were associated with the use of a general outpatient clinic and a
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55 dedicated cataract surgery clinic. Low costs were related to a low number of coordination actions,
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57 cross training and eliminated waste.
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59 **Conclusion** Operational focus seemed to have a stronger influence on process design and
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efficiency than other lean thinking principles. When pressed to further optimise their processes,

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hospitals can use these systematic benchmarking data to decrease the frequency of patient visits, lead times and costs.

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Introduction

Cataract, a clouding of the eye's lens, is the leading cause of curable blindness in the world.[1] Cataract surgery is the most frequently performed ophthalmic surgical procedure in many countries.[2, 3] Demand for cataract surgery is still rising, due to an aging population and an expanded life expectancy.[4] Today, limited access to cataract surgery in industrialized countries is mainly caused by outmoded and inefficient work practices.[4] As cataract surgery is a high-volume, relatively low-complex procedure, it could benefit from applying industrial principles, such as lean thinking and the focused factory concept.[5, 6] In focused factories, such as specialty hospitals, core processes are designed to optimally support delivery of a limited range of products or services.[7, 8]

Lean thinking, originally developed in Japan by the Toyota Motor Corporation in 1930, is a process-based management strategy that focuses on reducing lead times and costs by eliminating non-value added wastes.[9, 10] To smoothly align all operations of one production process, the work is organized in a so-called "one-piece flow" cell. This is a dedicated manufacturing cell, in which cross-trained staff, who can perform tasks in different technical domains, workstations and equipment are visibly arranged in the processing sequence.[11] This facilitates continuous flow of a product at a rate determined by demand and with short lead times, while wasteful activities are removed.

Several studies report that efficiency of care processes significantly improved after applying lean thinking [12-15] or the focused factory concept.[16-18] The aim of this study is to explore if the degree of applying lean principles in cataract pathways that are organized in focused factories, such as specialty eye hospitals, is related to efficiency. Therefore we conducted an international multi-centre benchmark study. We compared the process designs, using lean characteristics, of three focused cataract pathways and related these to efficiency in terms of lead times, number of hospital visits per patient and costs.

Methods

Study design and study setting

An international retrospective benchmark study with a mixed-method design was conducted to compare three cataract pathways of eye hospitals in 1) the United Kingdom (UK), 2) the United States of America (USA) and 3) the Netherlands (NL). All three hospitals are major international tertiary care and training centres in ophthalmology. They are large providers of eye care, with 260000 outpatient visits and 24000 surgical procedures per year in hospital 1, 160000 outpatient visits and 25000 surgical procedures per year in hospital 2 and 140000 outpatient visits and 13000 surgical procedures per year in hospital 3.

This benchmark study was based on data of all patients who underwent first eye cataract surgery in 2006. We restricted the study of the cataract pathways to the period between referral to the hospital and the first review after surgery. We used data on 9195 patients in hospital 1, 8761 patients in hospital 2 and 4093 patients in hospital 3. All three hospitals provided written permission for data collection and dissemination of anonymous results of this benchmark study.

Process design of the cataract pathway

We identified the different process steps in a standard cataract pathway, based upon best practice guidelines for cataract surgery[19-23] and expert interviews with two nurse managers in hospital 1 and 2 and a specialized cataract surgeon in hospital 3 (see Box 1). During semi-structured interviews with representatives of the cataract teams, we determined the organization of these process steps in detail. A staff member of the planning department of each hospital provided data on patient volumes per activity, enabling us to identify the actual patient routes in the cataract pathways. These data were used to construct flow charts of the pathways.

Characteristics of lean thinking

Six key characteristics of lean thinking with high impact on the organization of process steps were evaluated.

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3 (1) The operational focus in a lean production process is to reduce lead times and costs by
4 removing non-value added activities".[9] Optimally, focus in a cataract pathway is on reducing
5 lead times, costs and number of hospital visits at the same time.
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9 Members of the cataract team were interviewed and direct observation was used to
10 determine the operational focus. To better understand the operational focus, we also took into
11 account the environmental context and how this context could have influenced the cataract
12 pathway. To determine an overall percentage of having a lean operational focus, we assigned
13 33% to focus on lead times, 33% to focus on costs and 33% to focus on hospital visits, and
14 enumerated the percentages of the identified focuses.
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25 (2) The physical layout of the resources in the cataract pathway should align all activities and
26 prevent delays, caused by crossing of departmental borders. Optimally, one department, located
27 in one area in the eye hospital, delivers the whole process of cataract care.
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31 Direct observation was used to identify the number of different departments and locations
32 involved in delivering cataract care. The degree to which lean thinking was applied in the physical
33 layout was set as one (ideal grouping of all activities in one department) over the number of
34 identified departments.
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42 (3) When all resources are dedicated to the cataract pathway, risk of interference from other
43 processes is minimized and delays are prevented.
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46 Members of the cataract team were interviewed to identify dedicated resources in the
47 cataract pathway. Then we analysed, using quantitative measurements, how many patients
48 received their a) diagnosis, b) pre-assessments, c) surgery and d) first review using these
49 dedicated resources. To determine an overall percentage of using dedicated resources, we
50 calculated a weighted mean of the four variables. We weighted the overall percentage by the
51 direct costs made for diagnosis (13%), pre-assessments (16%), surgery (67%) and first review
52 (4%).
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3 (4) In lean thinking, team members are trained to perform multiple tasks, as far as
4 competence allows. This cross training is presumed to reduce the number of handoffs and
5 associated risks on delays and errors. A cross-trained cataract team encloses only three staff
6 functions to conduct all activities: an ophthalmologist, a nurse and an anaesthetist.
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11 Members of the cataract team were interviewed and direct observation was used to
12 identify the number of different staff functions in the cataract care teams. The degree to which
13 team members were cross-trained was set as three (the ideal of only three cross-trained
14 functions) over the number of identified functions.
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22 (5) Pull planning is used to directly couple resources to activities when needed. Separate
23 planning and coordination between activities do not add value and can lead to delays and waiting
24 of patients or staff. Optimally, directly after cataract is diagnosed, all succeeding activities are
25 executed, so patients need only one hospital visit for the entire cataract treatment.
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31 We analysed, using the quantitative measurements, a) how many patients did not revisit
32 the hospital for formulating the surgical care plan (e.g., one-stop diagnosis) and b) how often all
33 pre-assessments were finished at the same day as the consultation for diagnosis (e.g., one-stop
34 pre-assessments). We also analysed c) how often surgery was scheduled directly after the
35 cataract diagnosis, and d) how often surgery was organized as a one-stop procedure at the same
36 day as the consultation for diagnosis (e.g., one-stop surgery).[24, 25] To determine an overall
37 percentage of applying pull planning, we calculated a weighted mean of the four variables. We
38 weighted the overall percentage by the direct costs made for one-stop diagnosis (13%), one-stop
39 pre-assessments (16%), scheduling of surgery (4%) and one-stop surgery (67%).
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51 Finally, we determined, using the quantitative measurements and interviews, the number
52 of coordination actions per patient. Each transfer from one activity to another involved one
53 coordination action. In case the patient revisited the hospital, two extra coordination actions were
54 needed, i.e., one for transferring the patient record and one for scheduling the appointment.
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3 (6) In a lean pathway all non-value added wastes are eliminated. As routine medical testing
4 for patients having local anaesthesia have not been found to reduce the incidence of intra- or
5 postoperative complications,[22] we defined all additional assessments (e.g., ECG, blood tests
6 and internist consultations) as non-value added activities. Another non-value added activity we
7 defined is the patient's visit to the hospital for a first review by an ophthalmologist, as this review
8 is no longer recommended.[26] Telephone reviews carried out by nurses provide safe
9 alternatives to reviews performed by ophthalmologists.[23]
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18 We analysed, using quantitative measurements, the number of patients who did not
19 receive any additional pre-assessments (e.g., ECG, blood tests and internist consultations) and
20 the number of patients who did not revisit the hospital for a first review by an ophthalmologist. To
21 determine an overall percentage of absence of waste, we calculated a weighted mean of the two
22 variables. We weighted the overall percentage by the direct costs made for additional pre-
23 assessments (49%) and a first review by an ophthalmologist (51%).
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33 To determine the incorporation of lean thinking in the cataract pathway, an average score for
34 operational focus, physical layout, dedicated resources, cross training, pull planning and
35 eliminated waste was calculated.
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42 *Efficiency measures*

43 To evaluate efficiency of the cataract pathway, we used quantitative measurements to analyse
44 average lead times, average number of hospital visits per patient and average direct costs. Lead
45 time was split in access time to the hospital and waiting time for cataract surgery. Access time
46 was defined as the number of days between contacting the hospital and the first consultation.
47 Waiting time for surgery was defined as the number of days between the first consultation and
48 the surgery.
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57 We analysed the average number of hospital visits per patient and determined how many
58 patients visited the hospital once. Because one-stop surgery is not a very common procedure yet,
59 we also determined how many patients visited the hospital twice.
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3 The direct costs were estimated using activity based costing.[27, 28] We broke down the
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5 cataract pathway in activities. For each activity, we determined activity costs. Members of the
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7 cataract team were interviewed to identify the responsible team member(s) and the allocated time
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9 for executing each activity. We devised a standard cost per team member, based upon the Dutch
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11 hourly wages in Euro's (€). To calculate the activity costs, we multiplied the standard cost of the
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13 responsible team member(s) with the allocated time. To determine the total costs, we used the
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15 quantitative measurements and flow charts of the cataract pathways and established how many
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17 patients underwent each activity and multiplied this number with the corresponding activity costs.
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19 To determine the average direct costs per patient, we divided the total costs by the number of
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21 included patients.
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27 *Data collection*

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29 A staff member of the planning department from each hospital collected the quantitative data
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31 from the hospitals' databases, conform a protocol, specifying details on definition and
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33 measurement of all variables. One of the researchers (LK) verified whether the data was
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35 collected conform protocol.
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38 The same researcher (LK) visited each hospital for a two-week period, observed the
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40 different process steps in the cataract care process and conducted semi-structured interviews
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42 with two nurse managers, one manager of the planning department, three cataract surgeons,
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44 three nurses and two administrative staff members. The questions covered the organization of
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46 work in the cataract pathway, operational focus, environmental context, physical layout of the
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48 cataract pathway, allocation of resources and reasons for not applying lean thinking. Directly after
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50 the interview, an interview report was written, describing the cataract pathway. One day after the
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52 interview, a second meeting was arranged to validate the process description and obtain
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54 approval on the interview report. After the case visit was finished, the process description was
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56 sent by email to the responsible nurse manager to validate the final content.
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Results

The operational focus in the cataract pathways was distinctively influenced by external circumstances leading to different orientations on reducing lead times, number of patient visits and costs. Hospital 1 (43% lean characteristics in pathway) focused on reducing the number of visits and realized the lowest average number of 3.0 visits per patient and the lowest direct costs per patient (€205) (Table 1). This hospital implemented one-stop diagnosis for all patients and one-stop pre-assessments for nearly half of their patients (n=4376, 48%) (Figure 1). To further align activities in their cataract pathway, hospital 1 cross trained ophthalmic nurses to conduct biometry, schedule the surgery and conduct a same-day review after surgery (Box 2). The 109 days lead time just matched the National Health Service '18-week pathway' objective that stated that nobody should wait longer than 18 weeks after referral to hospital treatment. Nurse managers mentioned that waiting times for surgery slightly decreased the past years due to efforts to achieve this objective. However, they did not experience strong incentives to further reduce waiting times.

Hospital 2 (29% lean characteristics in pathway) operated in a competitive environment with a fee-for-service system. Therefore they focused on direct access to the cataract pathway and realized a lead time of 15 days (Table 1). Ophthalmologists did not reserve any of their outpatient slot capacity for specific patient groups and operated most patients (n=7366, 84%) in a cataract surgery clinic (Figure 1). Furthermore, during the consultation ophthalmologists conducted the biometry and scheduled the surgery, leaving patients only to finish their pre-assessments before undergoing surgery. Ophthalmologists told us that they were aware of redundant procedures in the cataract pathway (Box 2). These were mainly prompted by fear of malpractice claims.

Hospital 3 (33% lean characteristics in pathway) was facing a shortage of ophthalmologists and nurses in a cost-competitive environment and focused on decreasing costs (€220 per patient). This hospital selected for each activity the lowest skilled employee, resulting in a fragmented pathway (Figure 1). More than 16 coordination actions were needed to deliver cataract care to one patient (Table 1). Nurse managers mentioned that coordinating care was

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3 difficult, as each activity was conducted in another department, with different opening hours and
4 an independent capacity planning. A cataract surgeon mentioned that regularly, when general
5 ophthalmologists or residents, admitted patients for cataract surgery, details of the refractive aim
6 of the surgery were not registered. Patients then needed to revisit the cataract surgeon to
7 formulate the surgical care plan (Box 2).
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14 None of the hospitals offered one-stop surgery to their patients (Table 1). They were risk-
15 averse for having under-utilization of expensive resources for an elective surgical procedure.
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17 Nurse managers in hospital 1 and 3 mentioned that they experienced that elderly cataract
18 patients appreciated a little time between the decision for surgery and the surgery itself, so they
19 could arrange their personal lives for the surgery and the first postoperative days.
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27 Discussion

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29 None of the three hospitals focused on reducing lead times, number of patient visits and costs at
30 the same time. Hospital 1 incorporated the most lean characteristics in the cataract pathway and
31 realized the lowest number of visits and costs. Hospital 2 incorporated the least lean
32 characteristics in the cataract pathway, but realized the shortest lead time. Hospital 1
33 incorporated pull planning and cross training to reduce visits and costs. Hospital 1 had a long, but
34 stable lead time for several years, suggesting balance between demand and supply. From a lean
35 perspective, they only needed to reduce the backlog of waiting patients to operate a cataract
36 pathway with a significantly shorter lead time. Hospital 2 employed general consulting hours and
37 a high-volume dedicated cataract surgery clinic and immediately finished all process steps
38 related to ophthalmologist's time, i.e., conducting biometry, formulating surgical care plan and
39 scheduling surgery, to avoid delays and to achieve short lead times.
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53 All three hospitals employed a high-volume dedicated cataract surgery clinic and a
54 general outpatient clinic. Hospital 1 and 3 employed a cataract outpatient clinic because cataract
55 surgeons can accurately prepare patients for surgery, compared to general ophthalmologists who
56 do not or less frequently perform cataract surgery. But most cataract patients were referred
57 without a preliminary diagnosis of cataract. We found that only ophthalmologists and properly
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3 trained optometrists can sufficiently diagnose cataract. As a result, the majority of cataract
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5 patients were diagnosed and admitted for cataract surgery at general consulting hours. We argue
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7 that the initial outpatient consultation acts as a decoupling point in the cataract pathway. Open
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9 access should be most important when aiming for short lead times. This pleads for both (shared)
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11 general and (dedicated) cataract outpatient clinics.
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14 None of the hospitals provided one-stop surgery for their patients. One-stop surgery
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16 requires optometrists and general practitioners who can accurately predict the need for cataract
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18 surgery when referring patients for this procedure.[25] A potential problem is waste of operation
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20 room capacity when there is a shortfall of patients admitted for surgery on the day.[24] All three
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22 hospitals provided these reasons explaining why they did not organize one-stop surgery.
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25 In accordance with Lansingh, Carter and Martens the cataract pathways in the UK and the
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27 Netherlands were more cost-effective than the cataract pathway in the USA.[29] The fee-for-
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29 service system in the USA seems to encourage physicians to treat more patients[30] and to
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31 execute redundant activities, such as internist consultations for all patients.[22] Apart from
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33 redundant activities, coordination actions also unnecessarily increased costs. This study showed
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35 that a more integrated pathway as in the UK, with less need for coordination, resulted in lower
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37 direct costs compared to a fragmented pathway as in the Netherlands that employed the lowest
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39 skilled employee for each activity, conform the idea of the traditional assembly line.
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42 A restriction of the study is the limited number of cases. To increase understanding of the
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44 relation between cataract pathways and efficiency in different environmental contexts, we
45
46 recommend conducting a larger multi-centre longitudinal benchmark study. The methodology
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48 described in this study could be feasible to use in such a large study. Added value of this study is
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50 the specification of six lean characteristics. Further research to applications of lean thinking in
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52 healthcare could help to expand the characteristics that should be found in lean pathways.
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55 In conclusion, operational focus seemed to have a stronger influence on process design
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57 and resulting efficiency than other lean thinking principles. When pressed to further optimise their
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59 processes, hospitals can use these systematic benchmarking data to decrease the frequency of
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patient visits, lead times and costs.

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Table 1 Efficiency and characteristics of lean thinking in the cataract pathways of three eye hospitals for first eye cataract surgery in 2006.

	Hospital 1 n=9195	Hospital 2 n=8761	Hospital 3 n=4093
EFFICIENCY			
Lead time in days ¹	109.2	15.0	91.0
- Access time ¹	31.5	0.0	25.0
- Waiting time for surgery ¹	77.7	15.0	66.0
Number of hospital visits/patient ¹	3.0	3.6	3.2
- Patients with 1 hospital visit ¹	0 (0%)	0 (0%)	0 (0%)
- Patients with 2 hospital visits ¹	4376 (48%)	0 (0%)	1274 (31%)
Estimated direct costs/patient ²	€ 205	€ 243	€ 220
LEAN CHARACTERISTICS			
% Lean thinking characteristics incorporated in process design ^{2,3}	43%	29%	33%
1. Operational focus			
Focus ³	Decrease patient visits	Reduce lead time	Reduce costs
Environmental context ³	Difficult accessible location; 18 week pathway	Fee-for-service	Shortage of nurses and ophthalmologists
2. Lean physical lay-out			
- Number of departments ³	17%	13%	11%
- Different departments involved in delivering cataract care ³	6 outpatient clinic cataract clinic pre-assessment clinic general OR ward cataract surgery clinic	8 outpatient clinic private clinic private primary care centre pre-admission testing area internist general OR ward cataract surgery clinic	9 outpatient clinic cataract clinic pre-assessment clinic laboratory biometry dept. internist general OR ward cataract surgery clinic
3. Dedicated resources for:⁴			
a) Diagnosis ²	62%	56%	47%
b) Pre-assessments ²	8160 (89%)	0 (0%)	580 (14%)
c) Cataract surgery ²	0 (0%)	0 (0%)	0 (0%)
d) First review ²	6309 (69%)	7366 (84%)	2630 (64%)
	9195 (100%)	0 (0%)	2497 (61%)
4. Cross-trained care team			
- Number of staff functions ³	60%	50%	38%
- Different staff functions involved in delivering cataract care ³	5 ophthalmologist anaesthetist nurse ECG technician lab assistant cataract coordinator	6 ophthalmologist anaesthetist nurse ECG technician lab assistant internist	8 ophthalmologist anaesthetist nurse ECG technician lab assistant ophthalmic assistant internist planning coordinator OR
5. Pull planning⁵			
a) One-stop diagnosis ¹	24%	22%	13%
b) One-stop pre-assessments ¹	9195 (100%)	8761 (100%)	1373 (34%)
c) Direct scheduling of surgery ¹	4376 (48%)	2523 (29%)	1794 (44%)
d) One-stop surgery ¹	8160 (89%)	8761 (100%)	1846 (45%)
	0 (0%)	0 (0%)	0 (0%)
Coordination actions/patient ²	8.5	13.8	16.3
6. Eliminated waste⁶			
- No additional assessments ¹	61%	0%	55%
- No first review in hospital ¹	1839 (20%)	0 (0%)	1584 (39%)
	9195 (100%)	0 (0%)	2906 (71%)

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Legend table 1: ¹ Data source: quantitative data; ² Data source: quantitative data and interviews; ³ Data source: observations and interviews; ⁴ Weighted mean (diagnosis: 13%; pre-assessments: 16%; surgery: 67%; first review: 4%); ⁵ Weighted mean (one-stop diagnosis: 13%; one-stop pre-assessments: 16%; direct scheduling surgery: 4%; one-stop surgery: 67%); ⁶ Weighted mean (additional pre-assessments: 49%; first review in hospital by an ophthalmologist: 51%)

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Box 1 Process steps in a standard cataract pathway.**Diagnosis**

Cataract patients are referred to an ophthalmologist by their general practitioner or an optometrist, usually with symptoms of gradual blurring of vision. The ophthalmologist performs an ophthalmic examination to confirm the diagnosis of visually significant cataract and ensures the patient wishes to undergo surgery.

Pre-assessments

Ultrasound biometry is conducted to predict the correct lens implant power. The ophthalmologist formulates a surgical care plan including details on the implant lens, the refractive aim of the surgery and type of anaesthesia.

The nurse conducts a health check to assess if the patient is able to cooperate with the surgical procedure. An anaesthetist conducts a preoperative screening to evaluate the risk associated with anaesthesia and surgery. Additional assessments are performed, when required by the patients' general health (e.g., electrocardiogram (ECG), blood tests, and an internist consultation).

Cataract surgery

The current standard of cataract surgery in the developed world is phacoemulsification with intraocular lens implantation, which is typically performed under local anaesthesia as a same-day, outpatient procedure.

First review

One day after surgery, a review is conducted to identify any early-postoperative complications.

Box 2 Organization of the cataract pathways in the three eye hospitals for first eye cataract surgery in 2006.

Hospital 1, n=9195

When patients were referred to hospital 1, the referrer sent a referral letter to the booking centre. A member of the booking centre booked patients who were under suspicion of suffering from cataract on a cataract consulting hour (n=3341, 36%). Because the hospital was located in a difficult accessible city centre, their cataract patients, with an average age of 70 years, faced long travel times to reach the hospital. Patients that were diagnosed with cataract in the general outpatient clinic (n=5854, 64%) were directly (and if capacity was available (n=4819, 52%)) referred to the cataract outpatient clinic.

Following the outpatient consultation in the cataract clinic, a nurse in the shared pre-assessment clinic conducted the health check and biometry and booked an admission date for surgery (n=8160, 89%). Patients were seen by an anaesthetist (if available) and received additional pre-assessments if required by the patient's health and if capacity was available. In case pre-assessments were not finished, patients (n=4819, 52%) received a separate appointment.

Most patients were operated in a cataract surgery clinic (n=6309, 69%). Patients that underwent surgery under general anaesthetics or that suffered from severe (ocular) comorbidities were operated in the general operating room (n=2886, 31%).

Two hours after surgery, a nurse inspected the operated eye for any early-postoperative complications, after which the patient was discharged (n=9195, 100%).

Hospital 2, n=8761

Most cataract patients (n=8047, 92%) received their diagnosis outside the hospital in a private outpatient clinic. After the diagnosis, ophthalmologists conducted the biometry, formulated the surgical care plan and booked the admission date for surgery (n=8761, 100%).

Most patients (n=5099, 58%) visited a Primary Care Centre outside the hospital to receive their health check, an internist consultation (for their medical clearance) and additional pre-assessments if required. The hospital offered private patients (n=2523, 29%) the possibility of same-day testing. The other 1139 patients (13%) visited the pre-admission area in the hospital to receive their pre-assessments. Forty-eight hours before surgery, the anaesthetist screened the patient record to assess the anaesthetic risk.

At the day of surgery all patients (n=8761, 100%) received an extra health check by a nurse. To avoid potential liability, all patients received an internist consultation and were seen by an anaesthetist. Most patients (n=7366, 84%) were operated in a cataract surgery clinic. Patients that underwent surgery under general anaesthetics or that suffered from severe (ocular) comorbidities were operated in the general operating room (n=1395, 16%).

The day after surgery, the ophthalmologist inspected the operated eye for any early-postoperative complications in the private outpatient clinic (n=8047, 92%) or the outpatient clinic inside the hospital (n=714, 8%).

Hospital 3, n=4093

Most cataract patients (n=3513, 86%) received their diagnosis in the general outpatient clinic.

Hospital 3 organized walk-in sessions in their pre-assessment clinic, to give patients their health check, an admission date for surgery and additional pre-assessments the same day (n=1794, 44%). An ophthalmic assistant conducted the biometry in a different department outside the pre-assessment clinic. When walk-in capacity of the (shared) pre-assessment clinic was already fully booked, patients (n=2299, 56%) received a separate appointment. The hospital started to integrate formulating the surgical care plan in the initial consultation, so they could offer patients a one-stop diagnosis (n=1373, 34%). Cataract surgeons discussed the refractive aim of the surgery with the 2720 other patients (66%) in a separate appointment.

Most patients (n=2630, 64%) were operated in a cataract surgery clinic. Patients that underwent surgery under general anaesthetics or that suffered from severe (ocular) comorbidities were operated in the general operating room (n=1463, 36%).

The day after surgery, either a nurse conducted a telephone review, enabling patients (n=2497, 61%) to stay at home, or the ophthalmologist inspected the operated eye for any early-postoperative complications in the hospital (n=1187, 29%). Another 409 patients (10%) were instructed to call the hospital in case they had a red eye or pain (e.g., self review).

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3 **Figure legends**
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7 **Figure 1** Flow charts of the cataract pathways in the three eye hospitals for first eye cataract
8 surgery in 2006.
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11 Fat line: main patient route.

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13 Blocks with dotted lines: patient not in hospital.

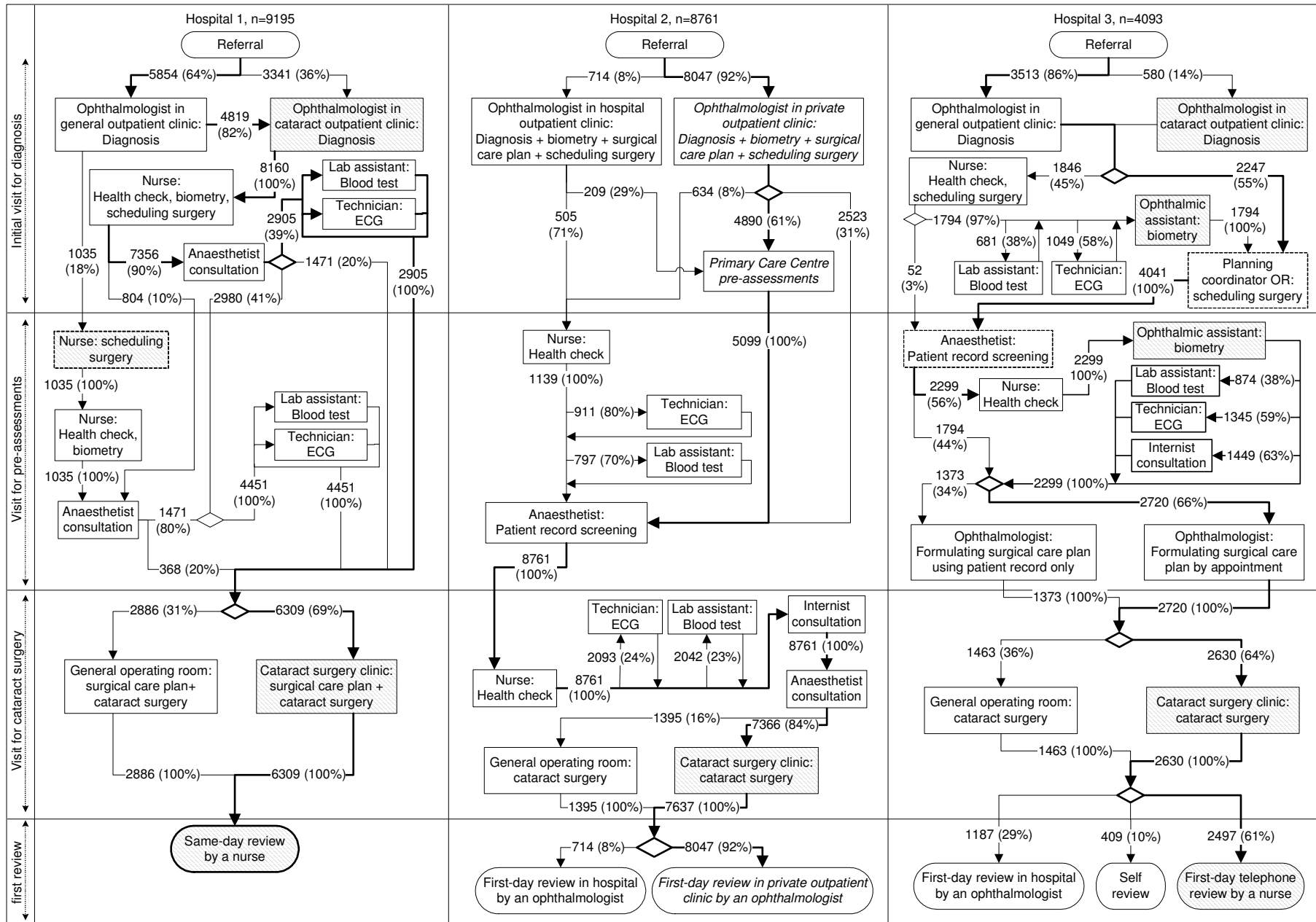
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15 Blocks with striped pattern: dedicated resource.

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18 Italic: activities outside hospital.
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