Time and motion studies of National Health Service Cataract Theatre lists to determine strategies to improve efficiency.

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Time and motion studies of National Health Service Cataract Theatre lists to determine strategies to improve efficiency.

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Synopsis

Time & motion studies were conducted at 4 NHS hospitals and one private hospital. There are marked differences in the running of cataract theatre sessions leading to significant differences in overall productivity.

Abstract

Aim:

To provide a quantitative assessment of cataract theatre lists focusing on productivity and staffing levels/tasks using time&motion studies.

Methods:

National Health Service (NHS) cataract theatre lists were prospectively observed in 5 different institutions (four NHS hospitals, one private hospital). Individual tasks and their timings of every member of staff were recorded. Multiple linear regression analyses were performed to investigate possible associations between individual timings and tasks.

Results:

140 operations were studied over 18 theatre sessions. The median number of scheduled cataract operations was 7(range5-14). The average duration of an operation was 10.3minutes(min)±(standard deviation(SD)4.11min). The average time to complete one case including patient turnaround was 19.97min(SD 8.77 min). The proportion of the surgeons' time occupied on total duties or operating ranged from 65.2%-76.1% and from 42.4%-56.7% respectively. The correlations of the surgical time to patient time in theatre was $R^2=0.95$. A multiple linear regression model found a significant association ($F(3,111)=32.86,p<.001$) with $R^2=0.47$ between the duration of one operation and: the number of AHPs, the number of AHP key tasks and the time taken to perform these key tasks by the AHPs.

Conclusions:

Significant variability in the number of cases performed and the efficiency of patient flow were found between different institutions. Time and motion studies identified requirements for high volume models and factors relating to performance. Supporting the surgeon with sufficient AHPs could improve surgical efficiency up to approximately double productivity over conventional theatre models.

Introduction

In 2014-15 over 370,000 cataract operations were performed by the National Health Service (NHS) in the United Kingdom (UK)¹. This was 3.7 times the number performed in 1989, with cataract surgery being the most common operation undertaken in the UK². The demand for cataract surgery is expected to rise still further with increasing life expectancy, rising population size, growing patient expectations, and an increase in age-related chronic diseases associated with cataracts, such as diabetes³. Surgeons are also conducting, and patients are being referred and presenting for cataract surgery at an earlier stage of the disease⁴. In 1990 less than 9% of eyes which underwent cataract surgery had a Snellen acuity of 6/12 or better⁴, while two decades later in the period between August 2006 and November 2010, the Royal College of Ophthalmologists' (RCOphth) National Ophthalmology Database (NOD) showed that 3%, 5% and 36% of eyes undergoing cataract surgery had preoperative Snellen visual acuities of better than or equal to 6/6, 6/9 and 6/12 respectively⁵.

With current financial constraints, the increased future demand for cataract surgery within the NHS is liable to be problematic. Meeting an ever greater demand with a constrained budget requires an improvement in efficiency while, ensuring that standards of patient care are maintained or improved. A recent report from Monitor (Department of Health) estimated that 13-20% productivity gains might be made in elective ophthalmology if practices were optimized⁶. The recently published *The Way Forwards* report (RCOphth), found a median of 7 cases scheduled per theatre list (Range 4-12)⁷. To the authors' collective experience, NHS cataract lists exist with anything between 5 and 15 patients routinely booked. Why this difference of a three-fold difference in productivity between minimum and maximum values exists in public sector cataract surgery has not received the due attention it should.

In 1911, F.W. Taylor introduced the time and motion study (TMS) as an application of the scientific method to the management of workers in order to improve productivity. Historically, TMS was applied to the manufacturing industry. However, it has also been shown to have useful applications within healthcare⁸⁻⁹. A century after the introduction of scientific management method, there is genuine interest in aggregating knowledge in healthcare workflow, inefficiencies, patient safety and quality. Among several approaches commonly used to date, TMS, which involves continuous and independent observation of clinicians' work, is generally regarded as a more reliable methodology compared to alternative approaches such as work sampling and time efficiency questionnaires^{8,9}.

In order to provide a quantitative assessment of the efficiency of cataract surgery across several UK hospitals, we conducted TMS investigations at several different institutions and settings. These included weekend waiting list initiative sessions, the provision of NHS cataract surgery in the private sector, as well as routine cataract surgery lists in NHS hospitals. In particular we focused on surgical time, surgeon tasks within and outside theatre, patient throughput, staffing levels of allied health care professional (AHPs) and their key tasks and

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timings. By analyzing these variables and investigating correlations between them, we hope to provide greater awareness of different models of practice, to identify important factors leading to differences in the individual number of cataract operations per theatre session and provide information to improve surgical productivity while maintaining high levels of patient safety. To the authors' knowledge, there are no previous examples of such TMS investigations of cataract surgery with a public health setting in the literature.

Confidential: For Review Only

Methods

Continuous observation TMS of 18 routine four hour cataract theatre sessions, was undertaken in 5 different hospitals and settings. These settings included two district general hospitals, two teaching hospitals, a weekend waiting list initiative theatre session in an NHS hospital, a dedicated high volume theatre list in an NHS hospital and an NHS cataract surgery list in a private hospital (table 1). The five institutions studied were the BMI Southend Private Hospital, Norfolk and Norwich NHS Foundation Trust, Guy's & St Thomas' NHS Foundation Trust, Southend University Hospital NHS Foundation Trust and West Suffolk NHS Foundation Trust. A consultant ophthalmic surgeon or associate specialist performed all lists, no lists were designated teaching lists. All patients were listed for only routine cataract surgery and all surgeries were conducted by phacoemulsification with intraocular lens insertion under local anaesthesia. All cases were unilateral. The number and type of AHPs supporting each individual theatre list was recorded (table 1).

Institution	1.	2.	3.	4.	5
Type of theatre list studied	Routine theatre list	Routine theatre list	A. Routine theatre list B. Weekend initiative list C. Dedicated high volume list	Routine theatre list	NHS patients receiving surgery at adjacent private institution
Number of sessions observed	4	4	A. 2 B. 2 C. 2	2	2
Median number of operations scheduled / list	6	6	A. 7.5 B. 9 C. 13.5	7	13
Total number of cases studied	23	22	A. 14 B. 16 C. 27	12	26
Percentage of operations cancelled on the day (%)	4.2%	8.3%	A. 6.67% B. 11.1% C. 0	14.3%	0
Allied health care professionals	3 nurses	3 nurses, 1 HCA	A. 3.5 nurses, 1 ODP B. 3 nurses, 1 HCA C. 4 nurses, 1 HCA, 1 ODP, 1 medical secretary	3 nurses	2 nurses, 1 HCA, 1 ODP

Table 1. Details of cataract theatre lists studied. (HCA = Health care assistant. ODP = Operating Department Practitioner)

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Each list had been observed prior to undergoing TMS investigation in order to identify preliminary staffing models and tasks (tables 1 and 2). Agreement analysis was used to define the list of tasks and then a basic model for each setting was set up and used as a template to observe and time the steps of every defined task (table 2). Each list was observed by one or two ophthalmologists (HWR, JM). Each observer used a template Excel spreadsheet (Microsoft Corp, Redmond, WA) with specifically designed macros to facilitate the prompt and accurate recording of tasks and their timings.

Noting the start and finish times of some of the key tasks was self-explanatory, while other tasks required specific moments agreed upon in advance in order to maintain reproducibility. Surgical start and end times were regarded at the point of insertion or removal of lid speculum. Patient entry time was defined as the time from patient entry into theatre until final positioning for surgery had been achieved. Patient exit time was defined as the time from removal of lid speculum to patient exiting the theatre. Start and end of scrubbing were regarded as the opening of the tap and finishing the gowning process. The start and end of the safety checklist were recorded once the first member of staff began speaking until the last member of staff had finished speaking. The start of the scrub nurse clearing up from the case was the time when the first instrument was passed out or dismantled once the lid speculum had been removed. The end of clearing time was recorded once the scrub nurse re-entered the theatre from the sluice, having disposed of all equipment and waste. The cause and duration of any unexpected delays greater than 5 minutes were recorded.

In addition to defining each key task and its reproducible start and finish, a series of quotients were defined as follows and produced for each setting. The efficiency quotient was defined as the proportion of time that the surgeon was engaged in a task (total surgeon time spent productive/total time)¹⁰. The surgery quotient was defined as the proportion of time that surgery was occurring (total surgical time/total time). The theatre utilisation quotient was defined as the utilisation of the maximum available theatre time (time between start of first and end of last case/4 hours)¹¹.

Statistics

Data is presented as non-parametric and parametric as appropriate. Differences between the groups were analyzed with ANOVA one-way test where appropriate. Linear regression models were calculated to estimate the key factors effecting the time to perform the surgery, and the time an individual patient spent in theatre. Descriptive statistics was used to calculate averages and standard deviation of the performances in each list. IBM SPSS Statistics for Windows (Version 22.0. Armonk, NY: IBM Corp) was used to perform the analysis.

Results

TMS of 140 individual cataract operations were prospectively recorded during 18 NHS cataract theatre sessions. All cataract operations were performed with phacoemulsification. All operations were under local anaesthesia. All operations were unilateral. No operations were combined procedures or required additional procedures outside small-incision phacoemulsification cataract extraction and intraocular lens insertion. The details of each theatre session can be seen in table 1.

Timings from each theatre list can be seen in table 2 and figure 1. The reason and duration of any unscheduled delays can be seen in table 3. Mapping of the workflow of the 2 highest volume theatre lists can be seen in figures 2 & 3.

The median number of operations per 4 hour theatre session was 7 (range 5 - 14). The mean time to perform a cataract operation was 10.3 minutes (min) (standard deviation (SD) 4.11 min). The mean time to complete one case including patient turnaround was 19.97 min (SD 8.77 min). The mean surgical scrub time was 1.86 min (SD 0.77 min). The mean time to complete pre-procedure WHO checklist was 0.55 min (SD 0.52 min). The mean time to complete post procedure paper/computer work was 1.77 min (SD 1.35 min). The mean time for patients to enter theatre to being positioned for surgery was 2.28 min (SD 1.88 min). The mean time from patient entry to start of operating was 4.56 min (SD 1.49 min). The mean time for patient to exit theatre from removal of lid speculum was 1.90 min (SD 1.00 min). The mean duration of patients' time in theatre was 17.07 min (SD 7.30 min). The mean time in between cases was 4.12 min (SD 2.78 min). The correlations of the surgical time to patient time in theatre was $R^2=0.95$. The correlation between surgical time and number of cases scheduled was $R^2 = 0.696$.

The minimum number of AHPs (nurses/health care assistants/operating department practitioners) allocated to a theatre list in this study was 3. The majority of AHPs in this study were registered nurses. The two theatre lists with the greatest number of cases scheduled had either 4 or 7 AHPs (Table 4). There was a moderate correlation between number of AHP and number of cases scheduled ($R^2=0.489$). If only the public healthcare settings were included (institutions 1, 2, 3A, 3B and 3C and 4) and we excluded the one private institution under taking NHS operations (institution 5), where practices may differ from the NHS, the correlation between number of AHP and number of cases scheduled was much higher ($R^2=0.823$). However, if we remove the institution with the highest number of AHP per case (3C) from the analysis, the correlation became not significant ($R^2=0.13$).

Institution	1	2	3A	3B	3C	4	5
Average time of surgery utilized per session (range)	172.7 (160.03, 180.1)	160.97 (142.61, 176.7)	169.23 (163.87, 174.6)	163.13 (142.7, 182.57)	198.5 (185, 212.3)	122.35 (110.53, 134.17)	210.92 (194.5, 247.33)
Theatre utilization quotient	71.7%	67.1%	70.4%	67.9%	82.7%	50.8%	87.9%
<i>Theatre utilization quotient (assuming no cancellations)</i>	74.8%	73.2%	75.4%	76.4%	82.7%	59.3%	87.9%
Efficiency Quotient	66.0%	65.2%	66.4%	71.9%	76.1%	65.6%	75.8%
Surgery Quotient	53.2%	42.4%	44.0%	42.9%	52.9%	56.1%	56.7%
Average patient time in theatre (S.D.)	26.74 (5.13)	22.27 (5.1)	17.23 (2.77)	12.84 (2.32)	11.88 (1.4)	19.16 (4.96)	10.06 (4.13)
Average time between cases (S.D)	3.75 (1.98)	7.1 (3.67)	6.17 (2.43)	4.9 (56)	1.53 (0.7)	1.4 (1.12)	3.4 (1.4)
Average time from patient entering theatre to start of operation (S.D)	8.65 (3.12)	6.67 (2.72)	2.86 (1.18)	2.87 (0.58)	2.45 (2.2)	5.25 (1.98)	1.43 (0.88)
Average time for patient to exit theatre after operation (S.D.)	2.1 (1.1)	3.2 (1.03)	2.05 (0.65)	1.93 (0.4)	1.25 (0.3)	2.53 (1.03)	1.08 (0.48)
Average surgical time (S.D.)	15.98 (3.93)	12.4 (2.8)	10.63 (2.53)	8.1 (0.6)	7.43 (1.47)	11.43 (2.61)	7.55 (3.38)
Average time surgeon spends on paperwork (S.D.)	0.87 (0.37)	3.7 (1.45)	1.85 (0.93)	1.88 (0.62)	0	0	0.95 (0.42)
Average surgeon scrub time (S.D)	2.33 (0.75)	2.32 (1.1)	1.92 (0.57)	1.98 (0.78)	1.43 (0.4)	1.43 (0.37)	1.6 (0.53)
Average nurse scrub time (S.D)	2.4 (0.8)	2.13 (0.7)	3.77 (1.28)	2.85 (0.97)	2.95 (0.33)	2.4 (1.07)	1.47 (0.8)
Average nurse time to prepare scrub trolley (S.D)	4.98 (1.55)	4.1 (1.4)	7.95 (0.88)	8.03 (1.72)	7.17 (1.5)	5.6 (1.9)	5.27 (1.53)
Average nurse time to prepare phacoemulsification machine (S.D)	2.72 (2.72)	4.18 (1.8)	3.15 (1.05)	2.82 (0.65)	2.6 (0.65)	3.9 (1.37)	2.07 (0.8)
Average nurse time to clear equipment (S.D)	3.68 (0.68)	3.48 (1.07)	5.35 (1.53)	4.93 (1.47)	6.37 (1.03)	7.5 (2.08)	3.48 (2.07)
Average time spent on WHO checklist (S.D)	0.65 (0.27)	0.67 (0.17)	0.7 (0.27)	0.45 (0.15)	0.27 (0.1)	0.52 (0.18)	0.73 (1.08)
Total number of key tasks performed by AHP per case	11	11	12	12	15	12	18
Average time taken to complete key tasks by AHP per case (S.D)	9.95 (6.56)	19.9 (4.15)	26.57 (2.3)	26.3 (3.15)	29.67 (3.44)	29.43 (4.89)	28.7 (6.1)
Average scheduled team break time	Nurses - staggered break, no break for surgeon	Nurses - staggered break, no break for surgeon	14.72	18.2	20.5	No breaks (relatively short theatre session)	37.8

Table 2. Task durations in minutes from common tasks across the institutions studied

Institution 1		Institution 2		Institution 3B		Institution 5	
Reason for delay	Time	Reason for delay	Time	Reason for delay	Time	Reason for delay	Time
Waiting for next patient from day case unit	5.88	Instrument error	6.52	Patient vasovagal episode	10.3	Waiting for next patient from day case unit	6.0
Surgeon examining staggered patients	9.5	Equipment error	5.17			Waiting for next patient from day case unit	5.75
Waiting for next instrument trolley to be ready	7.43	Surgeon required to see patient in clinic	13.23				
Surgeon out of theatre	8.75	Surgeon late for theatre due to clinic overrun	28.17				
Surgeon examining staggered patients	08.32	Surgeon reviewing latecomer	7.35				
		Waiting for next patient from day case unit	10.5				
		Waiting for next patient from day case unit	8.95				
Total	39.88		79.88		10.3		11.75

Table 3: The reason and duration, in minutes, of any unscheduled delays.

Setting	Number of allied health professionals	Median number of cataracts scheduled/session
1	3	6
4	3	7
2	4	6
3A	4.5	7.5
3B	4	9
5	4	13
3C	7	13.5

Table 4. Staffing levels associated with number of cases scheduled

Multiple linear regression models

A multiple linear regression model was calculated to predict the time to perform one operation based on three factors: i) the number of AHPs, ii) the number of key tasks performed by AHPs and iii) time taken to perform these key tasks by AHPs. A significant regression was found ($F(3,111) = 32.86$ $p < 0.001$) with an R^2 of 0.47. All the three factors were significant predictors of the time to perform a surgery. In particular the surgical time decreases by 0.95 min for each additional AHP involved, by 0.39 min for every additional task performed by AHP, and by 0.19 min for each additional minute spent by AHP performing tasks.

An ANOVA-one way was performed to control for the effect on surgical time by: i) the number of AHPs, ii) the number of key tasks performed by AHPs and iii) time taken to perform these key tasks by AHPs. There was a significant effect ($p < 0.001$) of all the factors as follows: i) $F(1,113) = 35.12$, $p = 0.001$, ii) $F(1,113) = 53.43$, $p = 0.001$; iii) $F(1,113) = 42.23$, $p = 0.001$ (figure 4).

A similar multiple linear regression model was calculated to predict the effect of the same three factors i) the number of AHPs, ii) the number of key tasks performed by AHPs and iii) time taken to perform these key tasks by AHPs on the total patient time in theatre. Factors ii and iii were significant predictors of the time an individual patient spent in theatre i.e. the total time to complete one surgical case. The model was significant ($F(2,116) = 43.18$ $p < 0.001$) with an R^2 of 0.43. The length of patient time in theatre decreased by 0.76 min for each task performed by AHPs and by 0.19 min for each minute spent by AHPs to perform their tasks.

An ANOVA-one way was performed to control the effect on the total patient time in theatre by i) the number of AHPs, ii) the number of key tasks performed by AHPs and iii) time taken to perform these key tasks by AHPs. There were significant effects of factors ii and iii ($F(1,117) = 43.97$, $p < 0.001$) (figure 4).

Discussion

This study adopted a TMS approach to evaluate the efficiency of public sector cataract surgery in the UK. We observed a significant variance in the running of cataract theatre lists at five different UK institutions, the most striking of which is the number of patients scheduled per list, which ranged from medians of 6 to 13.5. From the perspective of the public healthcare sector, it is imperative to maximize the efficiency of elective surgery while maintaining quality and safety⁶. The average duration of a cataract operation was 10.3 min and the total time including pre- and post- procedure preparation and patient turnaround was 19.97 min. It could be expected therefore that at least 12 operations could be completed in a 4 hour session and yet the median number of cases booked to a theatre list of 7 is much less. Based on the results of this TMS, one could expect that an increase in 70% efficiency might be possible. Whether this is an achievable target and why it is not currently being realized is a matter of conjecture, but certainly it highlights the great need to identify possible factors necessary to improve the efficiency of NHS cataract surgery.

It was interesting to document that the sessions (3C and 5) providing the highest median number of cases per list (13, 13.5) and highest theatre utilization and efficiency quotients, had the longest duration of staff breaks, suggesting that these units have discovered how to 'work smarter, not harder' (table 2, figure 1, figures 2 and 3). This strongly suggests that by changing working practices efficiency can be improved without increasing individual staff workload.

This assumption is supported by the observation that institutions 4 and 5 share the same population, yet there are noticeable differences between the TMS of their theatre sessions, especially in terms of median number of cases per list (7 versus 13), theatre utilization quotient (50.8% versus 87.9%) and efficiency quotient (65.6% versus 75.8%) (table 2). As patient demographics should be similar at these two settings, differences in practice and efficiency presumably arise from internal organization of the cataract theatre lists rather than external factors.

In considering the TMS of the surgeons, it is important to recognize that the theatre session is not an independent entity. Rather, differences in theatre practices often stemmed from factors outside the theatre itself, such as in the day case ward/clinic. For example, at 1 and 4, the surgeons performed slit-lamp examination and marked all patients on the day of surgery, at 2 the surgeon met the patients and marked them, at 3A/B/C the surgeon met the patient, marked and consented them, while at 5 (which had the highest theatre utilization quotient and second highest median number of cases at 13) all such tasks were performed by staff on the day-case unit. This suggests that utilizing AHPs to undertake some of the duties of the surgeon outside theatre, might be an important factor in improving efficiency by ensuring that the surgeon spends as much in theatre as possible during each allocated 4 hour cataract surgery session. This is supported by the observation that institution 1 (with a joint lowest median number of cases of 6 and an efficiency quotient of only 66%) was the only unit in which there was staggered patient arrival and surgeon

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performing pre-operative examination, leading to a time relating to these duties of 26.57 min out of theatre during the 4 hour sessions (tables 2 and 3). Similarly, at institution 2 (joint lowest median number of cases of 6 and efficient quotient of 65.2%), the surgeons spent 48.75 min outside the operating theatre due to out-patient clinic overrun and the need to see patients on the day case ward (figure 1, tables 2 and 3). Clearly to achieve optimum efficiency it is imperative for the surgeon to be available within theatre to undertake the surgery rather than performing duties outside. Whether this best achieved by AHPs performing such outside duties instead of the surgeon as at institution 5, or ring fenced time before the theatre session itself is a matter of conjecture.

Some units allowed patients to arrive on a staggered basis for their convenience and reduced overall patient waiting time (1, 3A/B/C, 5), while the remainder requested that all patients were present for the pre-theatre ward round. As such practices did not affect the overall median number of cases or efficiency quotients (table 2), it seems a reasonable approach to stagger arrival times for patient convenience, provided protocols are introduced to avoid surgeons spending time out of theatre, as at institution 5.

Based on our observation, a minimum of 4 AHPs appear to be required to provide a high volume service, however this criterion was met at all settings other than 1 and 4 (table 4). Increasing the number of cases towards the goal of high volume lists may require either/both an increase in the number of AHPs (i.e. 3C) or a change in working practice (i.e. 5). It is our experience that in addition to the scrub nurse and circulating AHP, at least two AHPs are required to be able to clear up from the previous case and, more importantly, prepare for the subsequent case so there is only a minimal wait between cases. This is achieved at institutions 3C and 5 (this lists with the highest volumes of patients treated per session) with 18.92min and 22.63min of AHP preparation time respectively before the patient even enters theatre (figures 2 and 3). Ideally, the gap between cases needs to be minimized to the time it takes to escort the patient out and in, perform the World Health Organization (WHO) checklist, and for the surgeon to rescrub. In this series the length of time from the end of one case to the start of the next ranged from 5.92 to 16.8 min.

Between the institutions the average surgical time varied from 7.43 to 15.98 minutes. This variation may reflect different case mix or differences between surgeons with some being faster/more experienced than others. The surgeons in lists 3C and 5 have a national reputation of excellence and are known for their expertise and surgical skills and this may have created outlying results. However, despite this the correlation between AHP numbers and tasks was strong and means that efficiency can be improved for those that do not have exceptional surgical skills. The correlation between surgical time and number of cases scheduled was $R^2 = 0.696$, suggesting that factors such as surgical experience and case mix are likely to have a part to play in cataract surgery efficiency. However, we found significant correlation between the time undertaken to perform cataract surgery and the number of AHPs, the number of key tasks performed by AHPs and the time taken to perform these key tasks by AHPs ($p<0.001$). This was confirmed by ANOVA-one way testing, suggesting that

alteration of the number of AHPs supporting a cataract surgery list and surgeon, their duties and their total time performing tasks, is strongly associated with and can indeed influence the time to perform individual cataract surgery (figure 4). Similarly, a strong correlation, confirmed by ANOVA-one way testing, was found between the number of key tasks performed by AHPs and the time taken to perform these key tasks by AHPs on the total patient time in theatre ($p < 0.001$). Such correlations appear to high-light the importance of AHPs and their designated tasks in the development of high volume NHS cataract surgery.

Concerning institution 5, which appeared to be an outlier in terms of correlation of number of AHPs with efficiency, these results might be explained by the fact that this was a private institution with different working practices from public health sector settings and there were direct financial incentives for the numbers of patients treated which it could be assumed positively influence productivity. Most importantly, whilst the number of AHPs supporting the cataract theatre list at institution 5 was 4, the number of key tasks performed by AHPs per case was much higher at 18 than any other organization (table 2). At site 5, it clearly appeared that AHPs were undertaking many of the tasks performed by the surgeons at other institutions, which ensured that the surgeon was spending far more time in theatre undertaking surgery than at any other institution. As such this unit could optimize surgical productivity and theatre utilization. Indeed the results at institution 5 strongly support our correlations concerning the importance of AHPs, their roles and tasks they undertake, in optimizing cataract surgical list efficiency. It appears that expansion of the role of AHPs in the public sector health setting to incorporate some the non-surgical roles currently undertaken by the surgeon, as well as the maintenance of adequate AHP staffing levels is vital to optimize cataract surgery efficiency.

There was generally an under-utilization of the full 4 hour (240 min) theatre session. Average theatre utilization was 70.11% (range 50.8% to 87.9%) and was 73.9% (range 59.3% to 87.9%) when extrapolated to take into account the cancelled operations. The reasons for delayed start of theatre sessions included the surgeon being delayed by an overbooked clinic or administrative duties on the day case ward (table 3). Pre-operative examination of surgical patients and associated duties (patient marking, confirmation of consent, etc.) is an integral part of the surgical process, but duration should be minimized to maximize potential surgical time. However, in the interests of patient safety, it is not suggested that the target for theatre utilization should be 100% due to the possibility of a case taking longer than expected or the event of a surgical complication, albeit the risks of surgical complications in cataract surgery is generally low ($< 5\%$)⁵.

The current study does have a number of limitations. Firstly, it focused on single independent consultant or associate specialist surgeon theatre sessions and not on training lists with junior doctors. Clearly there is a need to balance the desire for high volume services and the promotion of high quality provision of training for the next generation of surgeons. However, if sufficient high volume can be achieved in single surgeon lists, this can then we believe reduce the pressure of service provision in lists with junior trainees. Indeed, given the increased future

demand for cataract surgery within the NHS (as discussed above), there is a great need for senior trainees as future consultant surgeons to have exposure to high volume models of cataract surgery.

Secondly observations were made based on a relatively small number of observed sessions (eighteen). To our knowledge this is the first TMS of its kind in cataract surgery. TMS are, by their nature, very labour intensive. Historically, TMS would often require one observer for each person studied which would, of course, introduce great difficulty (logistical and financial) in studying a cataract theatre session. However, we have found that through the use of Macros on Microsoft Excel, we were able to record timings for all staff involved with a theatre session with no more than 2 observers. This would be the first example of TMS of cataract theatre sessions published, which we feel is of great importance, especially in understanding differences in productivity within state-funded healthcare systems. Clearly, however, there is scope for future research incorporating greater numbers of operations at more institutions which may facilitate analysis of a greater number of factors and less risk of chance findings.

It is also of note, that results from the five hospitals participating in this study, incorporated a mixture of academic centres and district general hospitals, with both rural and urban populations. They were chosen carefully to reflect a broad spectrum of environments. However, this study does not claim to represent universal provision of cataract services across the UK. We did not evaluate any models of surgical provision, including patients having surgery under sedation or general anaesthetic (GA). However, the vast majority of cataract surgery performed with the UK is undertaken under topical/local anaesthesia^{1,5} and the aim of this study was to focus on the delivery of high volume services, wherein GA cases are unlikely to feature. Furthermore, it was assumed that all theatre teams were experienced with cataract theatre lists and familiar with working with each other. Indeed during the course of the TMS nothing was observed to the contrary.

Finally although the focus of this study was the efficiency of cataract surgery, the metrics of the quality of the surgery, such post-operative visual acuity, post-operative complications, post-operative refraction and patient satisfaction were not evaluated. It is important to remember that the quality of any aspect of cataract surgery and overall patient satisfaction should never be compromised to enhance efficiency. To further investigate this, we are currently investigating patient satisfaction and patient reported outcomes in high volume cataract models.

Conclusion

This current TMS study, high-lights the huge variation in the efficiency of cataract surgery, within the NHS. It suggests that by providing sufficient levels of AHP staffing and expanding the roles of AHPs to minimize patient turnover time

and most importantly undertake some of the non-surgical tasks currently performed by surgeons during cataract theatre sessions when ideally they should be mainly concentrating on operating, productivity in cataract surgery and theatre utilization could be significantly improved in the public sector.

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Legends for figures in the text

Fig1. Diagram of model summarising the results of the time motion studies.
Fig 2. Model of workflow of staff duties at Institution 3C.
Fig 3. Model of workflow of staff duties at Institution 5.
Fig 4. Represents the significant relationships identified by ANOVA. The average time to perform the surgery was equal to 10.25. The average time to perform the case was equal to 14.08. Section A: shows the relationship between the time to perform the surgery and number of AHPs. Section B: shows the relationship between the time to perform the surgery and number of tasks performed by AHPs. Section C: shows the relationship between the time to perform the surgery and the time spent by AHPs to perform their tasks. Section D: shows the relationship between the time to perform the case and number of AHPs. Section E: shows the relationship between the time to perform the case and the time spent by AHPs to perform their tasks.

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Figure 1. Diagram of model summarising the results of the time motion studies.

338x190mm (300 x 300 DPI)

Figure 2. Model of workflow of staff duties at Institution 3C.

254x190mm (300 x 300 DPI)

Figure 3. Model of workflow of staff duties at Institution 5.

254x190mm (300 x 300 DPI)

Fig 3. Represents the significant relationships identified by ANOVA. The average time to perform the surgery was equal to 10.3. The average time to perform the case was equal to 19.97.

Section A: shows the relationship between the time to perform the surgery and number of AHPs.

Section B: shows the relationship between the time to perform the surgery and number of tasks performed by AHPs.

Section C: shows the relationship between the time to perform the surgery and the time spent by AHPs to perform their tasks.

Section D: shows the relationship between the time to perform the case and number of AHPs.

Section E: shows the relationship between the time to perform the case and the time spent by AHPs to perform their tasks.

Fig 4. Represents the significant relationships identified by ANOVA. The average time to perform the surgery was equal to 10.25. The average time to perform the case was equal to 14.08. Section A: shows the relationship between the time to perform the surgery and number of AHPs. Section B: shows the relationship between the time to perform the surgery and number of tasks performed by AHPs. Section C: shows the relationship between the time to perform the surgery and the time spent by AHPs to perform their tasks. Section D: shows the relationship between the time to perform the case and number of AHPs. Section E: shows the relationship between the time to perform the case and the time spent by AHPs to perform their tasks.

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