Is it possible to predict list overruns in a NHS day surgery unit?

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Abstract

Aim: To investigate the factors that predict list overruns in a National Health Service (NHS) day surgery unit.

Methods: Multivariate logistic regression was used to investigate the independent influence of operating list size, late starts, individual personnel and session factors on general surgical list overruns.

Results: 30%(627/2092) of all ambulatory general surgical lists performed over a 7 year period overran. Regression modelling revealed that operating list size was the main predictor of overruns in this context($p<0.001$). Individual surgeons($p<0.001$) and late-starting lists($p<0.001$) also influenced whether overruns occurred but to a lesser degree.

Discussion: Reducing overruns in NHS ambulatory centres is desirable. Achieving this through reduced list size requires local prioritisation between opposing operational targets.

Keywords: Overrun; Operating list; Theatre utilisation; Day surgery unit.

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Introduction

Efficient use of allocated theatre time involves the maximisation of list utilisation as well as the prevention of list overruns. Attempts to enhance list utilisation often results in overruns [1,2]. The expense associated with under utilised theatre lists across National Health Service (NHS) Trusts is clear and has been highlighted in a recent Audit Commission publication [3]. Overrunning lists also lead to financial penalties but these are less easy to quantify. Specifically, in the short term overruns can lead to significant staff overtime costs. A recent investigation into day surgery services across the NHS by the Healthcare Commission has found that high levels of overtime are worked in many UK day surgery (DS) units and this is associated with high additional costs [4]. More importantly, staff absenteeism and recruitment difficulties are major problems amongst NHS theatre departments. National shortages of theatre staff were highlighted in both the Audit Commission publication as well as a high profile Modernisation Agency document entitled the *Step Guide to improving operating theatre performance* [5]. Overruns are a commonly cited cause of theatre staff discontent and are a possible contributory factor towards the recruitment problems cited above. A recent investigation into DS staffing levels by the Healthcare Commission determined that one in ten units were using bank or agency nursing to meet more than 10% of its staffing needs [4]. In a minority of units agency staff were being used to meet half of their total staffing requirements.

There may be potential financial and managerial advantages to limiting overruns if this can be achieved without concomitant falls in theatre usage. The true cost of an overrun can only be quantified against the opposing operational goal of maximising surgical throughput. At present little is known about the causes of operating list overruns in the NHS setting let alone their genuine cost to the NHS. An understanding of the aetiology of list overruns in the DS setting might facilitate operational decision makers to limit their occurrence.

Study Aim

The aim of this study was to examine the factors that led to overruns on general surgery operating lists in a London NHS DS unit.

Methods

Data methods

The study data comprised all elective day case (DC) procedures performed at a London Teaching Hospital between April 1997 and April 2004. Prospectively entered theatre data were retrieved from the hospital theatre database (*Surgiserver © McKennon systems*) and aggregated into operating lists. The principal outcome measure was whether a list overrun had occurred. Overruns were defined to have occurred when drape removal from the last patient on the list occurred after the scheduled session finish time. Database variables were consequently recoded into list, session and personnel factors (see below). The latter, in addition to operating list size, represented the overrun predictors investigated in this study.

A scoring system for operating list size

A scoring system was developed from all database procedures to quantify the size of general surgery operating lists. Specifically, *case scores* (units) were assigned to the *Office of Population, Censuses and Surveys - Classification of Surgical Operations and Procedures - 4th Revision (OPCS-4)* codes on the basis of the historical median case duration of all database procedures that had been assigned to the corresponding code. The case score represented the procedure median duration (in seconds) divided by 30. For example, the case score of a day surgery primary inguinal hernia repair was 106 units. This numerical value represented the median duration (in seconds)/30 of all historical database procedures that had been performed in the day surgery department (by all surgeons who had performed this procedure) and coded to the 'Primary Repair of Inguinal Hernia' OPCS code. Operating list size (the list score) corresponded to the sum of the case-scores of constituent list procedures.

Session, personnel and list factors

Operating lists were recoded according to whether they took place on ‘morning’ or ‘afternoon’ sessions. Lists were classified according to the theatre suites where surgery took place. The latter variables were termed session factors. Surgical and anaesthetic practitioners were included on an anonymous individual basis if they had performed more than 100 database procedures. Practitioners that had performed less than 100 cases were pooled into separate surgical and anaesthetic personnel categories respectively. List factors describe the extent to which operating sessions started late i.e. after the scheduled start time. Late starts in the day surgery setting were categorised according to the time delay incurred (see Table 1).

Statistical Analysis
Multivariate logistic regression models were used to evaluate the relative influence of list volume, list factors (i.e. late starts), session factors (i.e. session type, theatre suite) and theatre personnel (i.e. surgeons and anaesthetists) on the predisposition of theatre lists to overrun. A binary approach to overruns was employed as the study end point (i.e. no overrun or overrun). The details of how test variables (i.e. list, session and theatre factors) were sub-categorized are described in Table 1. Logistic regression models were constructed by entering influential unifactorial risk factors into the model. Stepwise regression was used to evaluate individual predictors. Criteria were set so that variables were excluded from the model if their probability of influence was low ($P>0.1$). The mean ($\pm$ standard deviation) and median (Q1-3, n) were recorded for test variables where appropriate. For all tests of significance, $P<0.05$ was considered statistically significant.

Results

Operating list characteristics
Throughout the study period 8,314 operations were carried out on 2,092 general surgery lists in the day surgery (DS) centre. Nearly all (99.2%) procedures were performed on 4-hour sessions. In total, 61.6%, 29.8% and 7.7% of database operations were performed under general anaesthesia, local infiltration and sedation respectively. The descriptive characteristics of the operating lists performed in the DS department throughout the study period are described in Table 1. The sub-categories of list, session and personnel factors are described in accordance with the categories included in the regression analyses.

Theatre list overruns
In the day surgery department 30% (n=627) of all study theatre lists overran to some extent. The median length of list overrun was 25 minutes (42 – 12 minutes, n=627). In total, 3,046 (36.6%)

Table 1 A summary of general surgical operating list characteristics in the DS department between 1997 & 2004.

Operating list factors	**Day Surgery (DS)**
Operating list volume	
Mean hourly productivity i.e. list score units per hour (SD)	78.48(26.15)
Session factors	
Session type	
Percentage of operations performed on Morning lists (n)	38.2%(3226)
Percentage of operations performed on Afternoon lists (n)	61.1%(5083)
No. of theatre suites	5
Personnel factors	
Surgeons	
Total number of surgeons coded on database	133
No. of surgeons with >100 database procedures	16
Percentage of total cases performed by surgeons with>100 cases (n)	79.3% (6594)
Anaesthetists	
Total no. of Anaesthetists’ coded on database	246
No. of anaesthetists with >100 database procedures	10
Percentage of total cases performed by anaesthetists with>100 cases (n)	23. 9% (1983)
List factors	
Late-starts	
Median (Q1-Q3, n) late start in minutes	32 (17-48, 2,087)
n(%). DS operations on lists where Late start <30 minutes	996 (47.61%)
n(%). DS operations on lists where Late start is 30-60 minutes	870 (41.59%)
n(%). DS operations on lists where Late start is > 60 minutes	221 (10.56%)

operations performed in the day surgery department were on lists that overran. Of these operations 1736 (20.8% of total) and 1310 (15.7% of total) cases were on lists that overran by less than 30 minutes and more than 30 minutes respectively. The distribution of degree (time in seconds) of list overruns and underruns for all day surgery cases is illustrated in Chart 1.

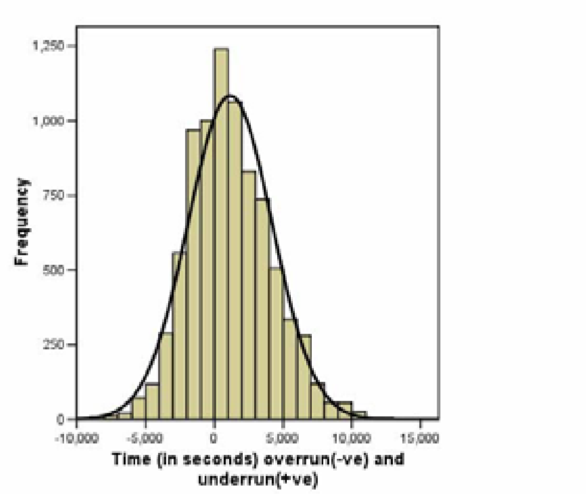

Chart 1 Frequency of theatre list overruns and under runs (in seconds) in the day surgery department between 1997 and 2004.

The multivariate logistic regression model was constructed by entering list size and influential session, personnel and list factor covariates into the model. Table 2 highlights the strength of individual list, session and personnel predictors within the model. The Odds Ratio (OR + 95% Confidence Interval for the OR) is given for each predictor as well as the level of significance of the predictor within the model.

The overall predictive power of the model was 77.1%. The percentage of underruns and overruns correctly predicted by the model was 86.6% and 60% respectively. Analysis of the relative influence of predictors within the model (i.e. the magnitude of the change in –2 Log likelihood statistic when the predictor is removed from the model) revealed that the size of an operating list is the principal determinant of whether it overruns or not (Table 3). Surgeons also demonstrated an independent influence on list overruns. Their ability to predict overruns was greater than that of all factors other than operating list size. With the exception of session type the predictive power of the other covariates within the model was significant but modest.

Discussion

Optimal theatre performance involves the full and productive usage of allocated theatre time without incurring list overruns. In reality the greater the surgical volume that is attempted on a given list, the greater the chance that an overrun will occur [1]. The relative cost, or negative value, attributed to an overrun depends largely on the given operational targets desired by the managers of a specific DS unit. In centres where waiting lists are problematic under used theatre time represents a greater cost than a list overrun. In contrast, in units where overtime costs and staffing problems are significant a greater emphasis on limiting theatre overruns is required.

The results of this study confirm that, within the context of general surgery day case lists, the strongest determinant of whether an overrun occurs is the size of the list that is undertaken. Although this appears obvious, the factors that govern the ultimate size of an operating list can be complex in the setting of an NHS day surgery centre. In NHS DSUs operating lists are mostly scheduled by clerical staff. Many surgeons often have little direct involvement with routine day surgery list planning. The presence of waiting lists presents a surplus of scheduling opportunities. Individual operating sessions are planned through estimation of an appropriate number of cases, taking case complexity and clinical urgency into account. A tendency towards over booking lists can arise for two reasons. Firstly, pressures associated with lengthy waiting lists generate attempts to achieve a greater operative output per session. Also over booking of lists is sometimes carried out by clerical staff in order to compensate for patients who fail to attend for procedures. Where compensatory over scheduling occurs erratic operative list volumes often ensue.

List scoring, as described in this study, is a time based quantification tool that was used as a marker of operative volume. Its potential advantage over the empirical use of total procedure numbers (i.e. case load) or cumulative procedure duration is that it reflects both quantitative as well as complexity aspects of theatre output. The principal weakness of list scoring is that, as it is based on the OPCS-4 procedure classification, some codes are not specific to individual operations. Instead these codes represent categories where related interventions are amalgamated. Arguably some degree of heterogeneity of individual procedure complexity and duration exists within such categories.

Many investigators have noted that historical procedure times can offer practical assistance regarding theatre scheduling. Broka and co-workers determined from a prospective analysis of theatre usage that the recorded occupancy times (ROTs) of theatres correlated strongly with the predicted occupancy times (POTs) that were taken from the historical surgeon specific median procedure durations [6]. When they used the historical procedure data for theatre list planning they demonstrated significant reductions in numbers and duration

Table 1 The model power when significant variables are removed. The strength of individual predictors is denoted by the Change in –2 Log Likelihood statistic of the model when the given predictor is removed from model.

Model variable	Model Log Likelihood	Change in –2 Log Likelihood	df	Sig. Of the Change
Late start	-4224.4	361.9	2	0.000
List volume	-5124.1	2161.3	1	0.000
Theatre	-4067.3	47.7	4	0.000
Anaesthetist	-4100.1	113.2	10	0.000
Surgeon	-4304.5	522.0	16	0.000

Table 2 Multi-factorial logistic regression model for overruns in the day surgery department.
Reference predictor subcategories are denoted by (reference). P-values are included for all covariates.

							95.0% C.I. for OR	
Model constant	**Beta**	**S.E.**	**Wald**	**df**	**p-value**	**OR**	**Lower**	**Upper**
*Constant**	-5.061	0.151	1116.255	1	0.000	0.006		
List volume (list-score)	0.014	0.000	1414.230	1	0.000	1.015	1.014	1.015
Session factors								
Session type categories					NS			
AM list (reference)								
PM list								
Theatre type			47.287	4	0.000			
Theatre 1	-0.631	0.121	26.998	1	0.000	0.532	0.420	0.675
Theatre 2	-0.458	0.088	26.913	1	0.000	0.632	0.532	0.752
Theatre 3	-0.763	0.165	21.468	1	0.000	0.466	0.338	0.644
Theatre 4	0.021	0.155	0.018	1	0.895	1.021	0.753	1.383
Theatre 5 (reference)					1.000			
Personnel factors								
Surgeons			459.942	16	0.000			
Surgeon 1	0.754	0.150	25.172	1	0.000	2.125	1.583	2.852
Surgeon 2	-1.223	0.176	48.478	1	0.000	0.294	0.209	0.415
Surgeon 3	-0.266	0.107	6.228	1	0.013	0.767	0.622	0.945
Surgeon 4	-0.692	0.221	9.820	1	0.002	0.501	0.325	0.772
Surgeon 5	-1.524	0.283	28.994	1	0.000	0.218	0.125	0.379
Surgeon 6	0.003	0.191	0.000	1	0.988	1.003	0.690	1.457
Surgeon 7	-1.808	0.117	239.628	1	0.000	0.164	0.130	0.206
Surgeon 8	-1.116	0.258	18.760	1	0.000	0.328	0.198	0.543
Surgeon 9	-0.754	0.204	13.719	1	0.000	0.470	0.316	0.701
Surgeon 10	-1.240	0.187	44.157	1	0.000	0.289	0.201	0.417
Surgeon 11	-0.473	0.120	15.620	1	0.000	0.623	0.493	0.788
Surgeon 12	0.303	0.130	5.483	1	0.019	1.354	1.051	1.746
Surgeon 13	-0.415	0.131	10.037	1	0.002	0.660	0.511	0.854
Surgeon 14	-0.159	0.250	0.405	1	0.524	0.853	0.523	1.392
Surgeon 15	-0.475	0.142	11.126	1	0.001	0.622	0.471	0.822
Surgeon 16	0.976	0.175	30.996	1	0.000	2.653	1.882	3.741
Surgeon 'others' (reference)					1.000			
Anaesthetists		105.749	10 0.000					
Anaesthetist 1	-0.396	0.231	2.934	1	0.087	0.673	0.428	1.059
Anaesthetist 2	-0.332	0.214	2.402	1	0.121	0.717	0.471	1.092
Anaesthetist 3	-0.247	0.153	2.622	1	0.105	0.781	0.579	1.053
Anaesthetist 4	0.275	0.238	1.329	1	0.249	1.316	0.825	2.099
Anaesthetist 5	0.975	0.163	35.718	1	0.000	2.652	1.926	3.652
Anaesthetist 6	0.861	0.210	16.856	1	0.000	2.364	1.568	3.566
Anaesthetist 7	0.542	0.181	8.993	1	0.003	1.719	1.206	2.449
Anaesthetist 8	-1.285	0.256	25.242	1	0.000	0.277	0.168	0.457
Anaesthetist 9	0.252	0.207	1.474	1	0.225	1.286	0.857	1.932
Anaesthetist 10	-0.622	0.206	9.141	1	0.003	0.537	0.359	0.804
Anaesthetist 'others' (reference)					1.000			
List factors								
Late start categories			341.221	2	0.000			
<30 minutes (reference)					1.000			
30-60 minutes	0.988	0.066	226.310	1	0.000	2.685	2.361	3.054
> 60 minutes	1.650	0.103	256.025	1 0.000	5.210	4.256	6.377	

of list overruns. Franklin Dexter and colleagues from the University of Iowa have published extensively on this issue [7- 10]. They have demonstrated that, despite the error associated with the variability of case duration, mean case length and turnover times offer a practical method of estimating the session duration requirement for a series of elective operations. Although statistical modelling techniques might offer theoretical advantages and have been advocated by some investigators [11,12], Dexter et al suggest that use of simple mean historical times can suffice for managerial decision making even when surgeon specific historical procedure times are not available and generalised historical data is applied instead [7, 13].

Late starting operating lists are common in the ambulatory setting. This problem is certainly not exclusive to theatre units in the NHS [14]. The study finding that late starting lists are significant predictors of list overruns was to some extent expected. The degree of influence that they had on overruns was not anticipated as one might expect a late start to result in a cancellation rather than an overrun. In the context of ambulatory surgery it is possible that staff feel a duty towards list completion when lists are started late, even at the expense of overrunning. Unexplainable factors appear to contribute towards the differing influence of individual personnel such as surgeons and anaesthetists on list overruns. The data suggests large differences in the likelihood of overruns occurring when specific personnel are considered. Some elements of these differences might be attributable to the case mix of individual consultant's operating lists. Differing personality types amongst teams of surgeons and anaesthetists might also account for varying tendencies towards case cancellations where an overrun seems likely. One might expect an excess of overruns to occur on afternoon lists. The principal constraint to overruns on morning lists being that theatre suites need to be vacated in time for the start of the afternoon session. In this study no independent influence was noted between session type and overruns.

The burden of theatre list overruns on theatre staff in the NHS is probably considerable. Future studies will need to attempt to quantify the true cost of list overruns in NHS DS departments. Whilst the pressure to reduce waiting lists persists, achieving high productivity from theatre units will be prioritised and list overruns will remain a secondary consideration. Simple measures directed towards the prevention of late starts and ensuring that listed patients attend for their operations should serve to provide reliable consistent list volumes that offer high list productivity whilst making overrunning less likely.

Conclusion

Overruns are associated with significant financial costs and low staff morale. The true extent of these costs is difficult to define. This study demonstrates that the size of an operating list is the principal determinant of whether it will overrun its allocated duration. Avoidance of overruns is obviously desirable but it could result in a consequent reduction in theatre productivity if list size is limited. Where overruns occur consistently and simple measures, such as the avoidance of late starts, has failed to limit this problem, conflict arises between opposing operational aims. Under these circumstances decision-makers need to prioritise between achieving a higher service output and the relevant local costs associated with overruns.

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