Does longer roster lead-time reduce temporary staff usage? A regression analysis of e-rostering data from 77 hospital units

DRAKE, Robert <http://orcid.org/0000-0003-4673-5531>

JAN
Informing Practice and Policy Worldwide through Research and Scholarship

Does longer roster lead-time reduce temporary staff usage? A regression analysis of e-rostering data from 77 hospital units

Journal:	*Journal of Advanced Nursing*
Manuscript ID	JAN-2017-0692.R2
Manuscript Type:	Original Research: Empirical research - quantitative
Keywords:	Rosters, Workforce Issues, Management, Information Technology, Nursing Theory, Technology
Category:	Nursing

Response to Reviewers comments:

Thank you for supportive feedback. All of your recommendations have been accepted and incorporated into this article. Likewise, numbers and titles have been added to all figures and tables.

IMPACT STATEMENT

Temporary staffing is a significant cost for healthcare organisations. This research supports the custom and practice presumption that roster lead-time and temporary staffing are related and late roster approval may contribute significantly to temporary staff usage levels of 37%. At longer lead-times of 4-6 weeks, temporary staff usage is reduced to a constant 15%. However, for certain types of unit and periods of seasonal variation (school holidays etc.) this relationship becomes increasingly extraneous and further research is required to investigate these circumstances. Importantly, this should be considered before mandating specific lead times across all units.

Abstract

Aims

Utilisation of temporary nursing staff is contentious and expensive. Using e-rostering data from 77 hospital units, this research investigates whether longer roster lead-times reduce temporary staff usage.

Background

It is commonly assumed that longer roster approval lead-times, the time from when a roster is approved, to when it is worked, result in better, more cost-effective rosters. Consequently, many hospitals target lead-times of six weeks, a figure recommended for the UK National Health Service (NHS) in a recent governmental review. This contrasts with the minimum lead-time advocated by New South Wales Ministry of Health, which advises a shorter lead-time of two weeks. Using data from 77 hospital units, this paper explores this assumed relationship.

Design

Using data extracted from the e-rostering system of an NHS Acute Foundation Trust, this study uses linear regression analysis to explore the relationship between roster approval lead-time and temporary staff usage. The data were captured over a period of nine months from 15th February 2016 to 23rd October 2016, a total of 693 rosters.

Results/Findings

This research suggests that late roster approval may contribute to as much as 37% of temporary staff usage, while approval 4-6 weeks prior to the roster being worked reduces this to approximately 15%. However, this is only relevant under specific conditions. Importantly, this should be considered before mandating lead times across all units.

Conclusions

This research implies that the optimum approval lead-time lies between four to six weeks, however, given other challenges, achieving this in practice may prove difficult.

Keywords

nurse, nursing, midwife, roster, scheduling, shift-work, staffing, workforce, agency, lead-time

Summary Statement

Why is this research/review needed?

- Based upon custom and practice, organisations have assumed a relationship between roster approval lead-time and the use of temporary staffing.
- There is, to date, no evidence to support this presumption
- Temporary staffing is a major portion of healthcare staff costs and evidence of a relationship with approval lead-time may be used to reduce costs

What are the three key findings?

- Rosters approved less than two weeks before being worked resulted in high temporary staff usage, but with no relationship to approval lead-time.
- Between 2-4 weeks roster lead-time is inversely proportional to temporary staff usage.
- Between 4-6 weeks lead-time, temporary staffing remains constant at approximately 15%.

How should the findings be used to influence policy/practice/research/education?

- Rosters must be approved/published at least two weeks before the roster is worked
- Where possible rosters should be approved between 4-6 weeks before the roster is worked

- The relationship between approval lead-time and temporary staffing is, statistically, less significant during periods of high annual leave demand, such as school holidays, and planning processes must reflect this.

Introduction

The global shortage of nurses (International Council of Nurses 2006), the 'casualisation' of the nursing profession (Batch 2012) and the rapid variability of ward requirements (Silvestro and Silvestro 2008) lead hospital managers in many countries to rely on temporary staff to meet service demand (Hurst and Smith 2011). From April 2012 to January 2015 demand for temporary staff within the United Kingdom (UK) National Health Service (NHS) grew from 930,000 hours/month to 1,917,000 hours/month (Addicott et al. 2015). Consequently, spending on agency staff grew by 80% between Q1 (April to June) 2011/12 and Q2 (July to September) 2013/14, and £3.3 billion across the 2014/15 financial year (Monitor 2015).

Electronic rostering (e-rostering) offers greater transparency of the roster process (Drake, 2014a) and the opportunity to investigate characteristics of custom and practice such as the assumed relationship between roster approval lead-time and temporary staff usage. Following a review into hospital productivity, Lord Carter (2016 p23) notes that, "A firmer grip of e-rostering will reduce dependency on bank and agency staff". To this end, Carter (2016) recommends that rosters be approved/published at least six weeks in advance of being worked while, in Australia, the New South Wales Ministry of Health advocate a much shorter minimum lead-time of two weeks (NSW Ministry of Health, 2016).

For clinical staff the roster is fundamental in maintaining an acceptable work-life balance (Jamieson, Kirk and Andrew 2013) and staff find unduly short or long lead-times problematic when arranging personal affairs such as child care etc. Using data from 77 hospital units, this paper explores the relationship between roster approval lead-time and temporary staff usage. It examines the assumption that shorter lead-times result in higher staff usage, and consequently higher costs and attempts to identify an optimum lead-time that minimizes temporary staffing costs while maintaining flexibility for staff.

Background

The NHS employs two types of temporary nursing staff; bank and agency. Staff banks, managed by the hospitals, contract directly with staff to provide cover for workforce shortfalls. Bank nurses, often the hospital's own employees, have flexibility to choose from the shifts offered. The bank system is cost effective and allows hospitals to respond quickly to fluctuating demand. Bank pay rates, set by the trust, are typically 2% higher than those of permanent staff of the same grade (Hurst and Smith 2011).

Private sector agencies supply staff on a temporary basis, for a commission. Between 2012/13 and 2014/15 annual NHS spend on agency staff rose from £1.8 billion to £3.3 billion (Kleebauer 2015), of which £0.7 billion is the premium paid for agency staff above the equivalent substantive staff (NHS Improvement 2016). However, this does not include hidden costs such as hiring and processing costs, checking and payment of invoices and inducting temporary staff on the ward (National Audit Office 2006). Houseman, Kalleberg, & Erickcek, (2003) argue that rising agency costs are symptomatic of tight labour markets, with similar pressures observed in Australia, Canada, New Zealand and the U.S.A (Hurst and Smith 2011), though, additional factors have contributed to the rise in agency spend within the NHS (Monitor 2015), namely:

- Growth of demand for NHS services by an aging population
- Increased demand arising from regulations accompanying the Francis report (2013)
- A competitive market for overseas nurses resulting from a global shortage of nurses
- Public sector pay restraints resulting in increased attractiveness of agency working

Consequently, the search for cost savings through improved operational productivity has become a major priority (Carter, 2016). Based upon custom and practice, organisations have long assumed a relationship between roster approval lead-time and roster robustness, as defined by post-approval changes to the roster and levels of temporary staff required (Drake, 2014a).

Rostering is a five-stage process (fig 1), three of which occur prior to the roster being worked;

- The Request stage: Staff submit requests for specific shift types or days off. Owner: Staff
- The Planning stage: The Ward Manager accepts/rejects requests submitted during the request stage, then builds the roster around the requests. The provisional roster is then approved (1st stage approval). Owner: Ward Manager
- The Approval stage: The Senior Nurse Manager examines the roster, returning it to the Ward Manager for modification if required, and then gives approval (2nd stage). The roster is then made available to staff (published). Owner: Senior Nurse Manager

Roster lead-time is the period from roster approval to the commencement of the roster and is often stated explicitly in an organisation's Roster Policy (Drake, 2017). For example, one roster policy (Cornwall Partnership NHS Foundation Trust 2017) stipulates:

- The roster will be open to requests up to 12 weeks prior to the publishing of the roster and close 8 weeks before (p10)
- The Central Rostering team will create all rosters 6 weeks ahead of roster start date, for the manager's approval (p7)

Once a roster has been approved it is made available for staff (published) immediately. Therefore, roster lead-time and roster publication are similar and the terminology is used interchangeably.

A brief web search uncovered 43 publically available NHS Roster Policies that stipulated specific approval lead-times, though the duration varied markedly between hospital trusts (table 2). However, despite this perceived wisdom, little evidence has, to date, been offered to support this assumption. Nonetheless, Carter (2016) cites a rostering improvement project at Portsmouth Hospitals NHS Trust (a 'trust' is an organisational entity within the NHS that may include several hospitals) that resulted in a reduction of 7,000 hours of agency usage.

Consequently, a specific recommendation of the Carter Review (2016) is that rosters be approved and published six weeks in advance of being worked to reduce dependency on temporary staffing.

The Study

Aims

This paper explores the relationship between roster approval lead-time and temporary staff usage. In this paper, we explore the relationship between roster approval lead-time and temporary staff usage. We also examine the assumption that shorter lead-times result in higher staff usage (and, consequently, higher costs) and attempt to identify an optimum lead-time that minimises temporary staffing while maintaining flexibility for staff.

Design

Using data extracted from the HealthRoster e-rostering system, this study uses the linear regression facility of SAS Enterprise Guide 9.4, a statistical analysis tool, to explore the hypothetical relationship between roster approval lead-time and temporary staff usage.

Sample

This research uses data from an NHS Acute Foundation Trust, comprising four hospitals, all using a common e-rostering system. The study is based upon roster data from 77 units across the organisation. To avoid selection bias all units using the e-rostering system were included in the sample, however, at the time the data were collected, some units were less familiar with the e-rostering system than others. The sample contains nine 28-day rosters. The first roster began on Monday 15th February 2016 and the final concluded on Sunday 23rd October 2016, a total of 693 rosters.

Data Collection

For each roster, the approval lead-time (in weeks) and the percentage of temporary staff used were captured within the e-rostering system. It is important to note that the data for

temporary staff is a consolidation of both bank and agency staff and offers no insight into the proportion of each individually.

The original roster is likely to incur changes due to staff sickness, absenteeism or changes on the ward. This may result in vacant shifts that must be filled by temporary staff. Once the actual roster, including all changes, has been worked and finalized, the amount of temporary staff, as a percentage of the total number of shifts on the roster, is calculated. The data are then exported into SAS Enterprise Guide directly from the 'Roster Statistics' report generated by the e-roster system.

Ethical Considerations

The study utilized consolidated, ward-level data and was approved by the executives of the organisation involved. The details of both the organisation and the units discussed have been anonymized throughout this research. No data regarding any individual staff member was used in this research.

Data Analysis

Of the original sample size of 693 rosters, 25 rosters contained no data. These were associated with units that began using the e-rostering system during the research period and consequently had less than nine weeks' data. Another 20 rosters had approval lead-times of zero, where rosters had failed to be approved prior to the roster start date. Finally, 12 rosters had lead-times greater than six weeks. Further investigation showed that these rosters had been approved incorrectly. These 57 rosters were also removed from the sample. Consequently, the final research sample size was 636 units. While, each of these units presented a unique combination of roster rules and demand variations, the roster approval process and the need to fill vacant shifts remained common to all.

Validity and Reliability/Rigour

Data collection took place more than a year after the implementation of the e-rostering system. However, as the deployment was consecutive, some unit staff were more

experienced in using the system. Moreover, the technological experience of unit staff was variable. Consequently, some staff were still learning the details of the e-rostering system at the beginning of the data collection period. The data gathered were taken from the same period for all units.

Results

The results of the regression analysis, based upon a sample of 636 rosters, imply correlation between temporary staff usage and roster lead-time such that:

% Temporary Staff Usage = -0.048 Roster Approval Lead-time (weeks) + 0.372 (fig.2)

While the R^2 value for the analysis is low (0.21), possibly due to the uniqueness of each unit, the model appears to confirm the relationship between roster lead-time and temporary staffing. Certainly, these results are sufficiently encouraging to merit further research, given that late roster approval may contribute to 37% of temporary staff usage. Equally, early approval of rosters may offer the opportunity to reduce this figure appreciably. Approval four weeks in advance of roster start date reduces this to 18%, while approval six weeks earlier may reduce it to less than 9%.

The data were then analysed at increasing lead-time intervals; < 2 weeks, < 3 weeks etc. (table 2). At less than two weeks, the analysis showed no correlation, possibly due to small sample size. As lead-time increased, the correlation became increasingly significant and the predictive capacity of the model more robust. This optimised at 4.3 weeks (R^2= 0.25) and then began to decline steadily. Since the maximum lead-time of the sample was six weeks, the nature of this decline beyond that duration remains unknown, though, in practice, few units approve the roster beyond this time (Drake, 2014b).

Calculating the average temporary staff usage for rosters approved at different lead-time durations is quite revealing (table 3). From extremely short lead-times (< 1 week) to lead-times of four weeks, usage deceases, almost linearly, from 38.3% to 15%. However, for

lead-times of four weeks or more temporary staff usage is constant at approximately 15%. This suggests that there is a portion of temporary staffing, in this case 15%, that is unrelated to lead-time.

Given the data included nine roster periods, from January to August, this offered an opportunity to explore possible implications of seasonal variations on the lead-time/temporary staffing relationship (table 4). Periods 3 and 5, those with highest significance, correspond to rosters that did not coincide with school holidays. Conversely, the whole of period 7 coincides with school summer holidays and the R^2 for this period is not significant. In practice, Ward Managers anticipate more staff booking holidays during this period and subsequently plan their roster further in advance. Those periods immediately following the school summer holiday (periods 8 and 9) result in lower values of R^2, possibly due to staff without children of school age taking holidays during a later, cheaper, period. These trends are to be expected as the rostering robustness of many units is tested during school holidays as staff struggle to balance the needs of work and family.

In summary, this research supports the custom and practice assumption that roster lead-time and temporary staffing are related. However, this relationship is less meaningful during periods of high annual leave, such as school holidays. Between lead-times of 4-6 weeks, temporary staff usage remains constant at 15%, implying that other factors, beyond lead-time, influence temporary staffing.

Discussion

The findings of this research appear to support, in part, custom and practice, showing correlation between approval lead-time and temporary staff usage. However, the relationship is rather more nuanced than it appears.

Approval lead-times of less than two weeks

Statistically this component of the relationship is the least significant and, consequently, the most unpredictable. Thus, units that fail to approve rosters in advance, or have lead-times of less than two weeks, are likely to require disproportionately higher levels of temporary staff. While hospital policies and systems stress the importance of roster approval, the implications of subsequent roster publication are less considered. Prior to roster planning, staff may request specific shifts and/or days off, often more than three months in advance of the roster being worked. The number of requests allowed per roster vary from hospital to hospital, the lowest being two and the highest being eight per roster (Drake, 2017). Nevertheless, only when staff have access to the published roster can they see the dates/times that they are committed to work. Consequently, for many, the period following publication is spent negotiating 'swaps' with their colleagues to reconcile their roster with personal commitments. Successfully negotiating these reciprocal arrangements involves a considerable amount of time and stress (Moorhead 2003) and is a common cause of tension on wards (Wise et al. 2007). Accordingly, lead-time must be sufficient for staff to negotiate, and get approved, personal roster changes. In circumstances where lead-times are short, staff may resort to sickness and absenteeism in lieu of 'swaps', thereby increasing the demand for temporary staffing. Within the sample, only 45 rosters (7%) had lead-times less than two weeks and four units accounted for more than 50% of these rosters. These four units averaged temporary staffing levels of 42%

Approval lead-times of two to four weeks

As lead-time increases, the relationship with temporary staffing becomes statistically more significant and the use of temporary staff declines. However, while two weeks is regarded by some as an acceptable lead-time (NSW Ministry of Health 2016), this research suggests that this may still result in high levels of temporary staffing since rosters with lead-times of two weeks used approximately 10% more temporary staff than those with lead-times of four weeks.

Approval lead-times of four to six weeks

Assuming the 43 roster policies shown table 1 are representative of the whole NHS, most organisations (84%) aim for lead-times between four to six weeks. Using the results of the linear regression, % Bank and Agency Usage = -0.048 Roster Approval Lead-time (weeks) + 0.372, temporary staffing at four weeks is predicted to be 18%, and at six weeks to be 8.4%. However, table 3 implies that, at lead-times between four to six weeks, temporary staffing remains constant at approximately 15%.

This suggests that other factors, beyond lead-time, impact temporary staffing. One of these is sickness and absenteeism. In 2014-15, average sickness absence was approximately 4% (Office for National Statistics 2017) - indeed Carter (2016) suggests this may be closer to 6%. Much of this is unplanned and, given that 31% of justifications for sickness absence are minor, short-term illnesses (Office for National Statistics 2017), these are assigned after the roster has been approved, therefore, necessitating temporary staff regardless of lead-time. This presents a rather more nuanced view than that presented in Carter (2016) and McIntyre (2016), who seek to mandate a fixed, six-week lead-time. Furthermore, while organisations may aspire to long lead-times, how achievable this is in practice is debateable. For example, the organisation providing the data for this research requires a 6-week lead-time, but only three rosters of the whole 636 sample met this requirement (though 236 rosters were approved with a lead-time of four weeks).

Approval lead-times and other factors

While the evidence suggests correlation between lead-time and temporary staffing, the significance of this relationship varies considerably, month by month, depending upon seasonal factors such as school holidays (table 4). Rosters covering periods without school holidays corresponded to higher correlations between lead time and the use of temporary staffing, while those rosters that included holidays showed lower correlations. In many cases staff experience problems arranging school holiday care due to the limited number of

approvals for leave at those times. Indeed, while many apply for leave 12 to 24 months in advance (Skinner et al. 2011), those who are unsuccessful, faced with difficult choices, may choose to be absent.

The relationship between lead-time and temporary staffing is also influenced by the type and demand pattern of the unit. For example, elective care wards, dealing with planned surgery, have much greater visibility of present and future patient demand. Conversely, within the sample, four units accounted for more than 50% of rosters with lead-times less than two weeks. These four units included two theatre units, an acute medical unit and unit with high vacancy rates. These units showed no relationship between lead-time and temporary staffing. Similarly, the relationship showed less significance on those units with irregular demand patterns, many of which used temporary staffing to manage short-term peaks and troughs (Houseman, Kalleberg and Erickcek 2003).

Consequently, while the general findings of this research suggest that lead-times of 4 to 6 weeks may result in lower temporary staff costs, this may only be relevant under specific conditions. For certain types of unit and periods of seasonal variation (school holidays etc.) this relationship becomes increasingly extraneous and further research is required to investigate these circumstances. Importantly, this should be considered before mandating specific lead times across all units.

Limitations

This study is based upon data from a single NHS trust comprising four hospitals. Accordingly, without further investigation, these results may not be generalizable across other hospitals and organisations.

Conclusion

Based upon custom and practice, organisations have long championed a relationship between roster approval lead-time and temporary staff usage - shorter lead-times result in

higher staff usage, and consequently higher costs. While this research provides some evidence to support that claim, it seems that the relationship is rather more refined. Rosters approved less than two weeks before being worked resulted in high temporary staff usage, but with no relationship to approval lead-time. This equates to a 'chaotic' phase during which staff desperately attempt to reconcile the roster with their personal circumstances, possibly resorting to sickness and absenteeism as a final resort.

Between 2-4 weeks roster lead-time is inversely proportional to temporary staff usage and reflects the assumed relationship between these two variables. However, beyond four weeks' lead-time the relationship enters a 'plateau' phase in which longer lead-time has negligible effect on staffing. At this stage, other factors, such as sickness, absenteeism, type of unit and patient demand pattern define the lower limit of temporary staff usage. Consequently, this research implies that the optimum approval lead-time lies between four to six weeks.

References

ADDICOTT, R., et al. (2015). *Workforce planning in the NHS*. London, The Kings Fund.

BATCH, M. (2012). *Communication and the Casualisation of Nursing: A Critical Ethnography (Doctoral dissertation)*.

BURGESS, J., HENDERSON, L. and STRACHAN, G. (2007). Work and family balance through equal opportunity programmes and agreement making in Australia. *Employee Relations*, **29** (4), 415-430.

CARTER (2016). *Operational productivity and performance in English NHS acute hospitals: Unwarranted variations*. [online]. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499229/Operational_productivity_A.pdf

CORNWALL PARTNERSHIP NHS FOUNDATION TRUST (2017). *E-roster Policy*. [online]. Last accessed 10 June. http://www.cornwallfoundationtrust.nhs.uk/documentslibrary/cornwallfoundationtrust/policies/staffing/recruitmentandworkforce/er00113validation.pdf

DRAKE, R. G. (2017). eRoster Policy: Insights and implications of codifying nurse. *Health Informatics Journal*,.

DRAKE, R. G. (2014b). The nurse rostering problem: From research to reality. *Journal of Advanced Nursing*, **70** (4), 800-810.

DRAKE, R. G. (2014a). The 'robust' roster: exploring the nurse roster process. *Journal of Advanced Nursing*, **70** (9), 2095-2106.

FRANCIS, R. (2013). *Report of the Mid Staffordshire NHS Foundation Trust Public Enquiry*. London, Stationary Office.

HOUSEMAN, S. E., KALLEBERG, A. L. and ERICKCEK, G. A. (2003). The role of temporary agency employment in tight labour markets. *Industrial and Labour Relations review*, **57**, 105-127.

HURST, K. and SMITH, A. (2011). Temporary nursing staff - cost and quality issues. *Journal of Advanced Nursing*, **67** (2), 287-296.

INTERNATIONAL COUNCIL OF NURSES (2006). *The global nursing shortage:Priority areas for intervention*. [online]. http://www.icn.ch/images/stories/documents/publications/GNRI/The_Global_Nursing_Shortage-Priority_Areas_for_Intervention.pdf

JAMIESON, KIRK and ANDREW (2013). Work-Life Balance: What Generation Y Nurses Want. *Nurse Leader*, **11** (3), 36-39.

KEELING, K.B. and PAVUR, R.J. (2011). Statistical accuracy of spreadsheet software. *The American Statistician*, **65** (4), 265-273.

KLEEBAUER, A. (2015). Hunt's schedule for cutting agency spend is too ambitious, warns unions. *Nursing Standard*, 10 June, 8.

MINOGUE, V. and WELLS, B. (2016). Managing resources and reducing waste in healthcare settings. *Nursing Standard*, **30** (38), 52-60.

MONITOR (2015). *Price caps for agency staff: impact assessment*. [online]. www.gov.uk/government/uploads/system/uploads/attachment_data/file/468469/Impact_assessment_-_agency_rules.pdf

MOORHEAD, A. (2003). Managing flexible working time arrangements: Negotiations between mothers and managers in a Canberra hospital. *Labour and Industry*, **14** (1), 95-105.

NATIONAL AUDIT OFFICE (2006). *Improving the Use of Temporary Nursing Staff in NHS Acute and Foundation Trusts*. London, The Stationary Office.

NHS EMPLOYERS (2017). *Reducing agency spend.* [online]. Last updated 31 March. www.nhsemployers.org/your-workforce/plan/agency-workers/reducing-agency-spend

NHS IMPROVEMENT (2016). *Agency rules*. [online]. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510391/agency_rules__23_March_2016.pdf

NHS IMPROVEMENT (2016). *Evidence on clinical staff shortages*. [online]. https://improvement.nhs.uk/uploads/documents/Clinical_workforce_report.pdf

NSW MINISTRY OF HEALTH (2016). *Rostering Resource Manual version 2.1*. [online]. www.health.nsw.gov.au/Performance/Rostering/

OFFICE FOR NATIONAL STATISTICS (2017). *Sickness absence in the labour market: 2016*. [online]. Last accessed 10 June. www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/sicknessabsenceinthelabourmarket/2016

SILVESTRO, R. and SILVESTRO, C. (2008). Towards a model of strategic roster planning and control: an empirical study of nurse rostering practices in the UK National Health Service. *Health Services Management Research*, **21**, 93-105.

SKINNER, N., et al. (2011). An in-depth study of Australian nurses' and midwives' work-life interaction. *Asia Pacific Journal of Human Resources*, **49** (2),.

WISE, S., et al. (2007). Controlling working time in the ward and on the line. *Employee Relations*, **29** (4), 352-366.

Lead Time (weeks)	No. Roster Policies
2	1
4	21
5	1
4 to 6	2
6	12
6 to 8	2
8	4

Table 1: Duration of roster lead-times as specified in 43 roster policies

	Roster Approval Lead Time				
	< 2 weeks	< 3 weeks	< 4 weeks	< 5 weeks	6 weeks
R^2	0.013	0.137	0.201	0.232	0.212
Standard Error	0.174	0.138	0.107	0.098	0.097
Sample (n)	46	105	326	562	636
$Coefficient_{Lead\ Time}$	-0.043	-0.076	-0.062	-0.058	-0.048
$p\text{-value}_{Lead\ Time}$	0.459	<0.001	<0.001	<0.001	<0.001

Table 2: The impact of increasing lead-time on the robustness of the regression model

Roster Lead Time	% Temp Staff Usage (Avg.)	Sample size (rosters)
0.0 - 0.9 weeks	38.3	12
1.0 - 1.9 weeks	33.1	33
2.0 - 2.9 weeks	23.6	59
3.0 - 3.9 weeks	19.3	221
4.0 - 4.9 weeks	15.0	236
5.0 - 5.9 weeks	14.3	72
6.0 or more weeks	14.9	3

Table 3: Average temporary staff usage at increasing lead-time weekly intervals

Roster Period	Roster Start Date	Sample Size	R^2	Coeff.$_{\text{Lead Time.}}$	p-value $_{\text{Lead Time}}$
1	15/02/2016	70	0.210	-0.052	<0.001
2	14/03/2016	72	0.200	-0.057	<0.001
3	11/04/2016	69	0.321	-0.069	<0.001
4	09/05/2016	71	0.219	-0.049	<0.001
5	06/06/2016	70	0.356	-0.060	<0.001
6	04/07/2016	76	0.300	-0.042	<0.001
7	01/08/2016	69	0.067	-0.026	0.031
8	29/08/2016	72	0.190	-0.046	<0.001
9	26/09/2016	67	0.166	-0.039	<0.001

Table 4: Analysis of roster periods

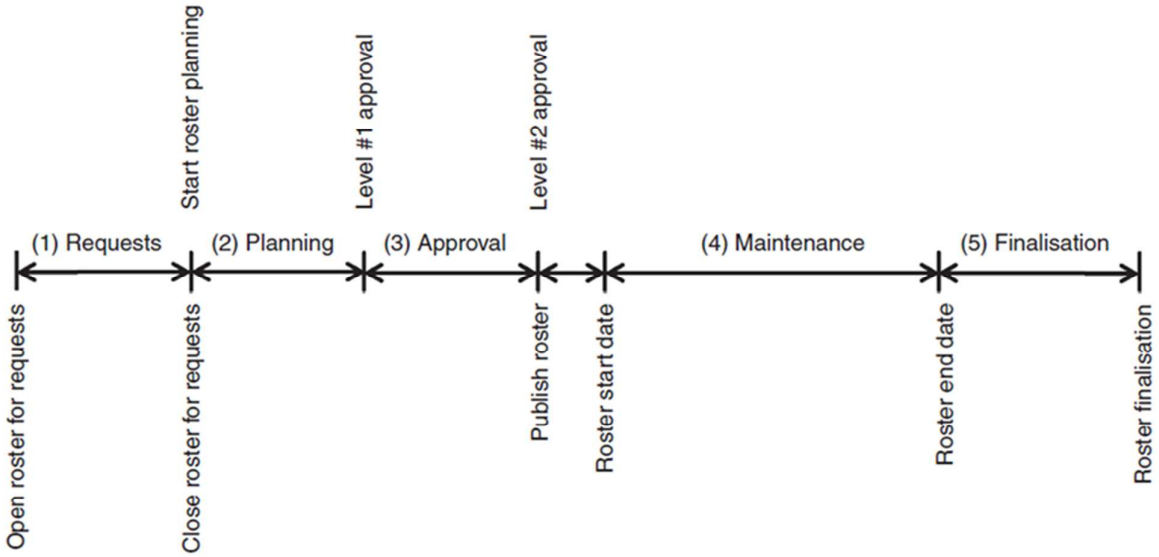

Figure 1: The roster process (Drake 2014a)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.60710	1.60710	170.55	<.0001
Error	634	5.97425	0.00942		
Corrected Total	635	7.58135			

Root MSE	0.09707	R-Square	0.2120
Dependent Mean	0.18635	Adj R-Sq	0.2107
Coeff Var	52.09141		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.37166	0.01470	25.28	<.0001
Full Approval Lead Time (Wks)	1	-0.04772	0.00365	-13.06	<.0001

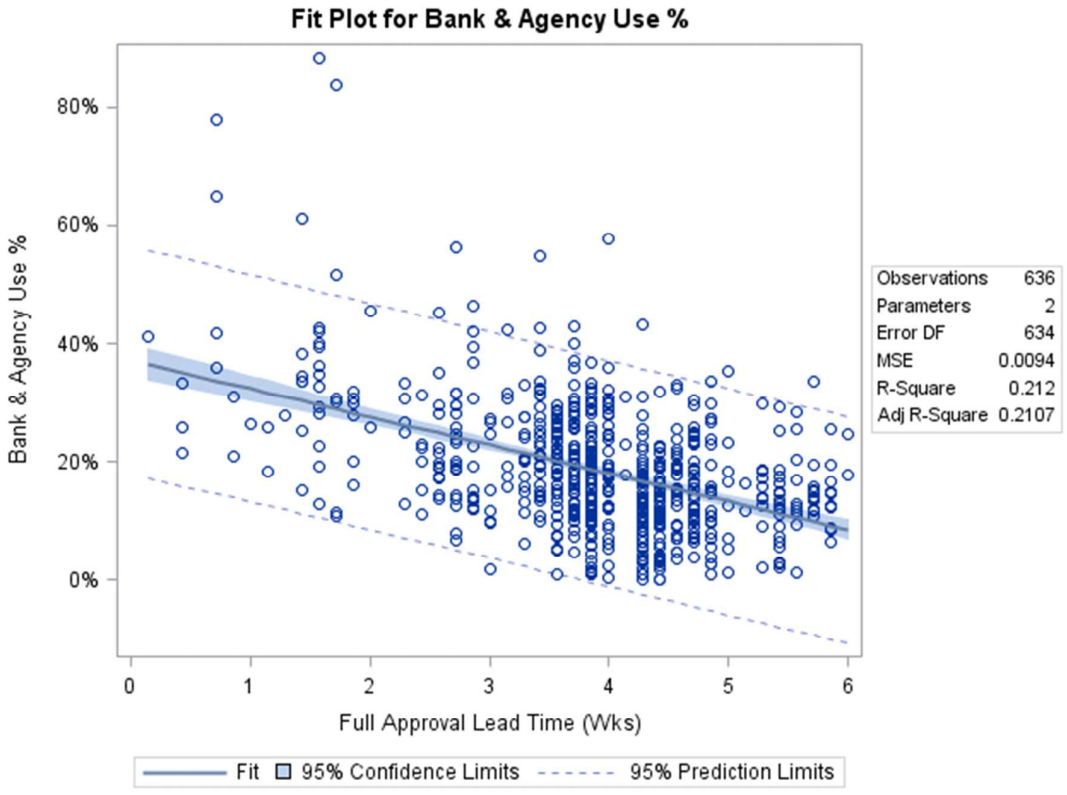

Figure 2: Approval lead-time vs. temporary staff usage