Final report

February 2017

Innovating for Improvement

Can electronic prescribing data reduce bottlenecks in the inpatient journey? A proof of concept study in a busy district general hospital

Derby Teaching Hospitals NHS Foundation Trust

The Health Foundation

About the project

Project title: **Can electronic prescribing data reduce bottlenecks in the inpatient journey? A proof of concept study in a busy district general hospital**

Lead organisation: Derby Teaching Hospitals NHS Foundation Trust

Partner organisation: University of Nottingham

Project lead/s: Dr Nigel Sturrock/Dr Andrew Fogarty

Contents

Part 1: Abstract

In completing this section please assume this information will be used to describe your project on our website.

Background and rationale:
At acute hospitals at weekends, severely unwell patients are prioritised and potentially routine tasks often do not occur. This results in less efficient delivery of health care and use of resources compared with weekdays, as important step-downs in treatment are less likely to happen. These delays can increase length of patient stay as the step-downs are implemented on Mondays once regular clinical staff resume ward rounds, and then a period of observation of clinical response is often needed prior to discharge.

For example, data from the Royal Derby Hospital show that the frequency of switching from IV to oral antibiotics is 68% higher on weekdays than at weekends. This project aims to improve patient flow at weekends by identifying and removing bottlenecks in the throughput of patients in secondary care.

A clinical epidemiological/health economics team will be embedded within the busy acute hospital and routinely collected electronic prescribing data will be used to identify and prioritise potential bottlenecks. These analyses will be used to target interventions aimed at removing those bottlenecks with the largest potential financial savings. Advanced clinical practitioners will provide a weekend ward round to facilitate stepping down of clinical care, at the request of the responsible clinician. By introducing interventions that facilitate patient flow, length of stay will be reduced, there will be more efficient use of hospital beds, patients will receive more timely treatment and less exposure to the risk of hospital acquired infection, and cost savings will be made.

Narrative account of project experience:
The first phase of the project went well, with the establishment of a dataset of all patients who received antibiotics at RDH over a one year period. This took a few iterations, as there was a learning process in terms of establishing exactly what data were required, and how we could receive it in a format that was simple to import into statistical software for analysis. The epidemiological analysis was more challenging than anticipated, as we needed to align thousands of rows of data to determine who changed from intravenous (IV) to oral antibiotics, and when this occurred during the week.

The output from the epidemiological analysis demonstrated that as expected, rates of switching from IV to oral antibiotics and stopping nebulisers was lower at the weekends, and that this was associated with a longer length of stay. The health economics analysis suggested that targeting the antibiotic switching at weekends offered the best return on the investment, and so this was the aim of the second phase of the study.

The training of the advanced clinical practitioners (ACP lead) on stepping down from IV to oral antibiotics at the weekend was done by Ms Clare Sutherland (ACP and Dr Andrew Fogarty). This involved one training session of the safest way of implementing this process, the development of a software app that was added to the RDH ward whiteboard to highlight which patients who are suitable or enrolled in the stepdown service and also developing adhesive paper templates for the medical notes to help guide the requesting clinicians, and to maintain a high level of communication and hence good governance standards. The project was publicised by Dr Nigel Sturrock from the Medical Director's office, using face to face meetings at team meetings as well as a variety of personalised emails and items in his weekly communication email to RDH staff.

The project went ‘live’ at the beginning of November, and ACP staff were rostered to provide the service on a rota over the next 10 weeks. Astonishingly, there was no uptake of the service at all. Enquiries as to the reason for this, led to the explanation that no single team thought that their patients were contributing to the bottleneck in stepping down from IV to oral antibiotics at the weekend, despite the epidemiological analysis to the contrary.
After four weeks with no uptake of the ACP antibiotic stepdown service, we reviewed the project as a whole. Rather than continue to invest in a service for which there was no demand, we stopped the intervention.

We then planned a second intervention. Considering that most ward teams did not consider that there was an issue with stepping down from IV to oral antibiotics for their ward, simple transparency of the data was considered a good approach to allow reflection on what each team could do to promote patient flow. This was done creating a simple Excel spreadsheet of the number of patients on IV antibiotics on each ward. This was chosen as it is something that can be easily created by IT departments from electronic drug data, and hence could be adopted by other similar hospitals, and hence is a cheap, scalable intervention.

Final outcome of the intervention:
The data on numbers of patients on IV antibiotics, stratified by ward was sent out to all senior clinicians every week for 12 weeks. Analysis demonstrated that beforehand there no decrease in the proportion of patients on IV antibiotics over the weekend, compared to Mondays. However, the intervention was implemented in December, when clinical activity was increasing as a consequence of seasonal pressures, and the severity of the patients admitted may have been increasing. It is impossible to adjust for these issues in this type of analysis, and hence we cannot be sure that this approach would not have made a difference if implemented over 12 months to adjust for these factors.

Part 2: Progress and outcomes

Our project had two phases. First the data analysis phase to see if there was a problem of stepdown of antibiotics or stopping nebulisers in hospital. Secondly, developing an intervention to help clinicians improve patient flow at weekends by address these issues**.**

The data were obtained from the Information Technology department of the RDH. We used electronic data on drug prescribing and administration, which are only available in certain hospitals at present in the UK. However, over time we anticipate that more hospitals will adopt this technology. The data were relatively easy for us to access, but it is worth bearing in mind that most projects of this type will need 2-3 datasets before the final variables are obtained. The data analysis was done by Professor Sarah Lewis, who is a very careful, cautious statistician, so we have no concerns about our analysis. The outcome measures of rates of switching drugs at the weekend compared to weekdays are unchanged from the beginning of the project.

Results

Phase 1. Identification of potential bottlenecks

The rate of switching from IV to oral antibiotics was lower on Saturdays and Sundays compared to week days, and the rate of stopping nebulized bronchodilators was similarly lower at weekends ($p < 0.001$). Median length of stay was lower at 4 days in those whose antibiotic treatment was stepped down at weekends than in those stepped down on week days (median 5 days). A similar, though non-significant, pattern was observed for nebulized salbutamol. We estimate that, at this hospital, approximately £61 000 annually could be saved if the rate of stepping down of treatments at weekends was comparable to that during the rest of the week.

This work has been submitted for publication. We anticipate that it will be of interest to NHS Trusts, and will stimulate other interventions and evaluations of weekend bottlenecks in clinical care. Please refer to Appendix 3 for the manuscript.

Figure A a) Day of the week of switching IV to oral antibiotics

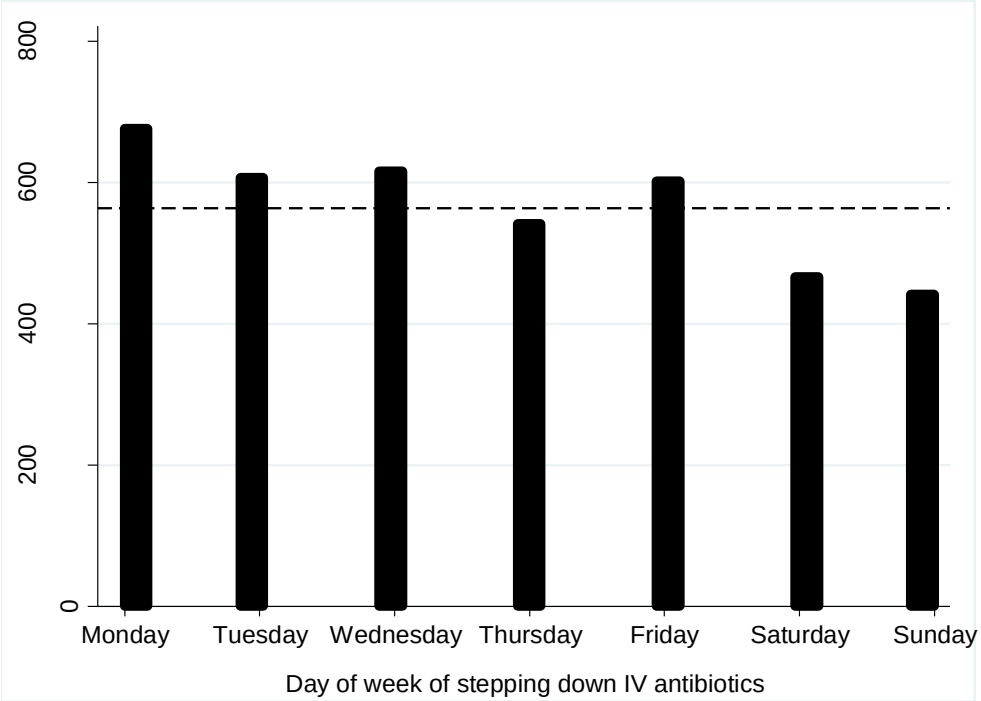


Figure A b) Day of the week of stepping down nebulized salbutamol

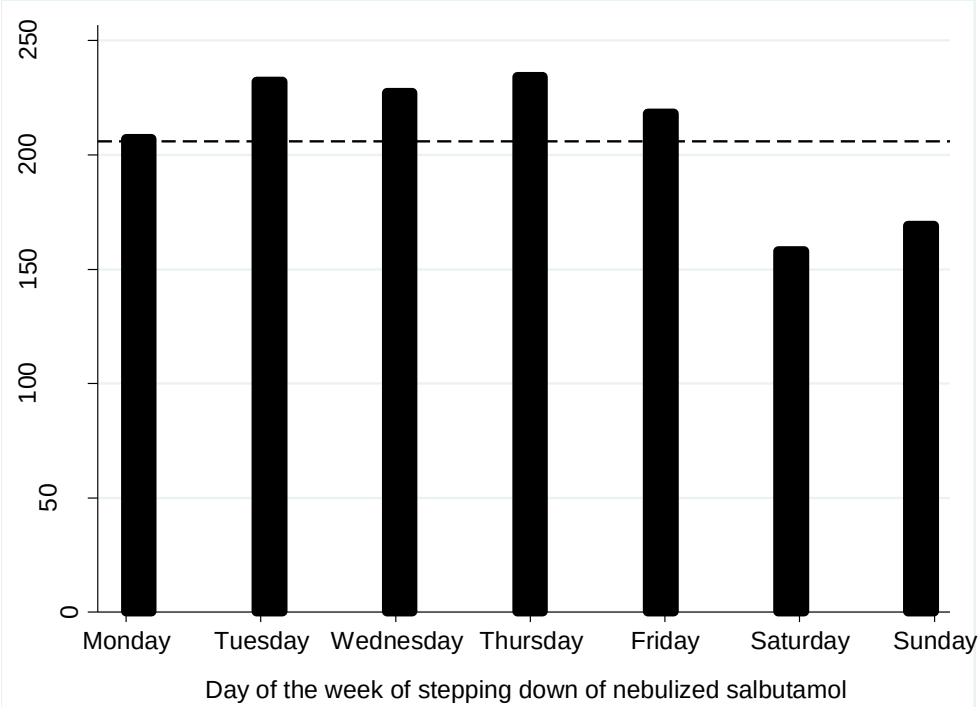
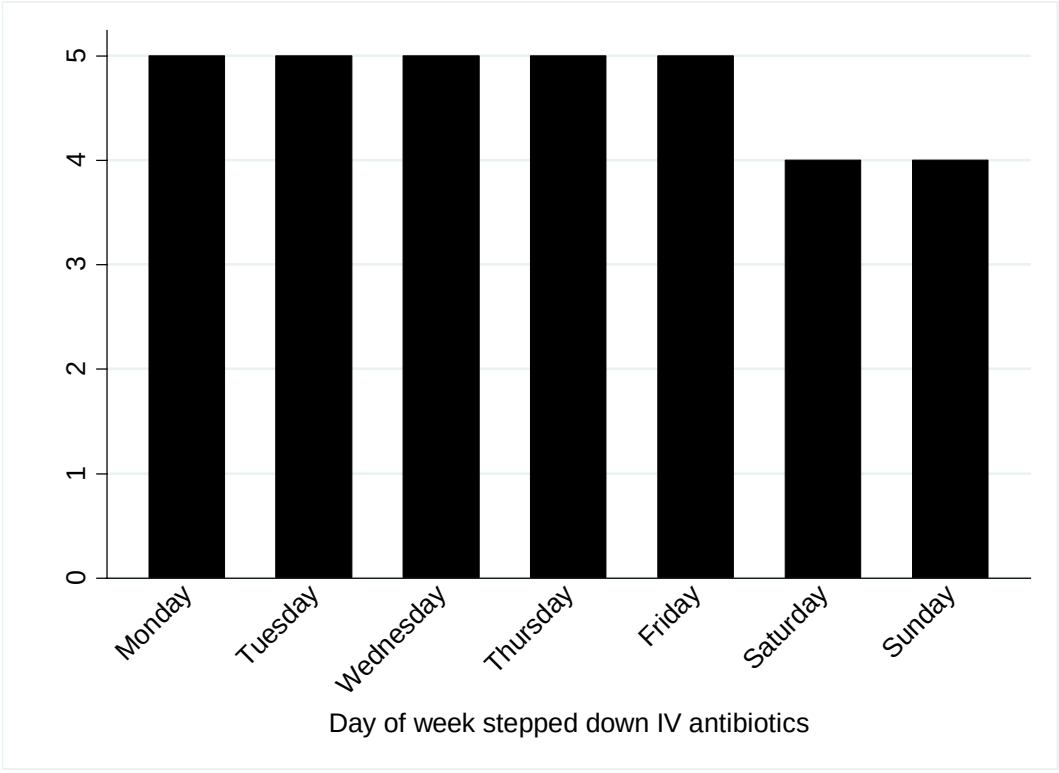
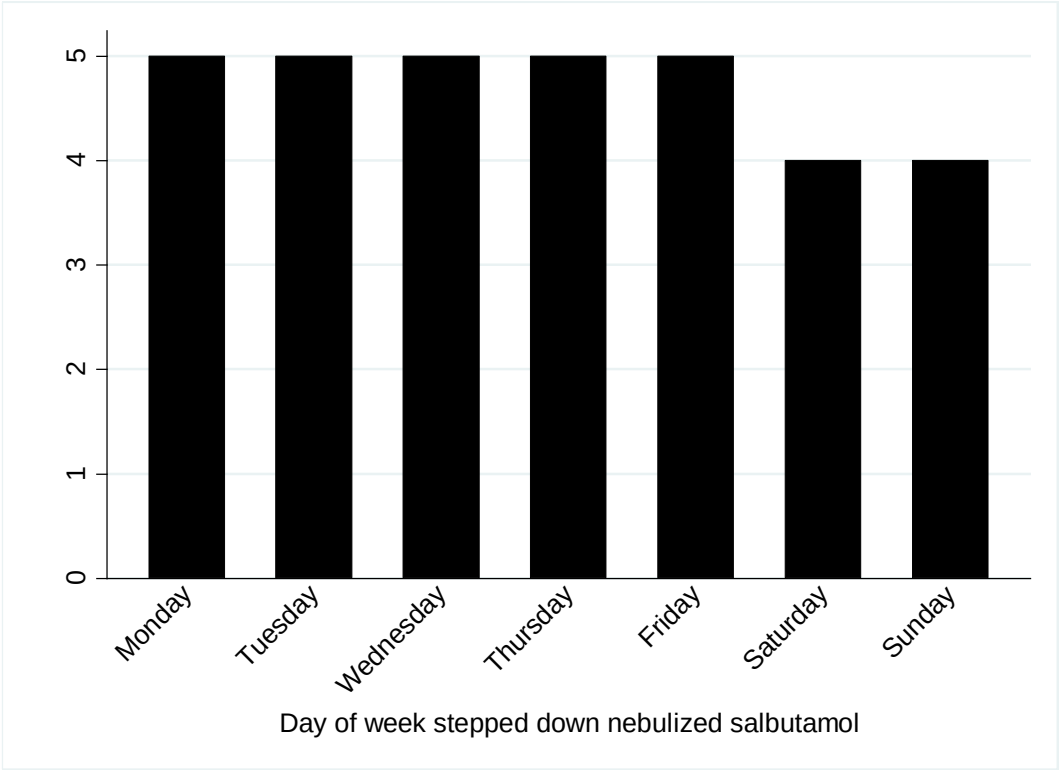


Figure B) Median length of stay according to the day of week of a) stepping down IV antibiotics and b) stopping nebulized salbutamol.

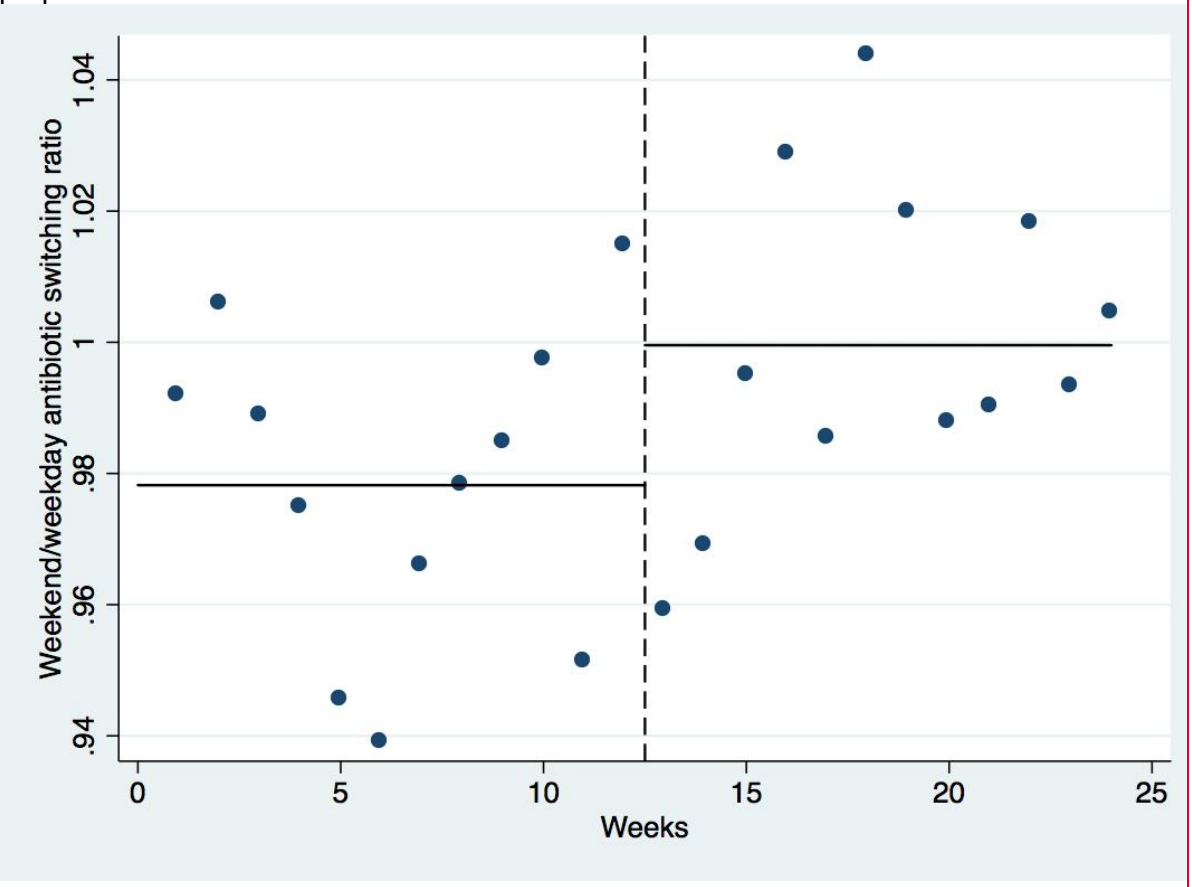




Phase 2. 'Data transparency' intervention
After the Advanced Clinical Practitioner intervention was not adopted, we chose to implement a second 'data transparency' intervention.

To assess the impact of the 'data transparency' email intervention we compared 12 weeks of baseline data before the intervention, with 12 weeks after the intervention. The data were for antibiotic from the hospital as a whole, and looked at the number of patients on IV antibiotics on Saturday, Sunday and Monday. This was well received by clinicians, and judging by email correspondence, led to evaluation of clinical practice.

To facilitate comparison, the main outcome was a ratio for each week consisting of the (number of patients on IV antibiotics on Saturday + Sunday)/(number of patients on IV antibiotics on Monday x2). Thus, if the daily number of patients on IV antibiotics over the weekend is greater than on Monday, the ratio should be above one. As can be seen below, the ratio before the intervention was 0.98, increasing to 1.00 after the intervention. This suggests that there were equal numbers of patients on IV antibiotics on Saturday, Sunday and Monday after the intervention, which is contrary to our hypothesis. One possible explanation is that as the intervention was implemented in December 2016 to February 2017, more patients with more severe disease were admitted, increasing the proportion of those who need intravenous antibiotics.



Reflections
It is striking that we should have had no adoption of our initial ACP 'antibiotic stepdown' service from the clinicians, as this was free and would help them in their weekend ward care. However, ironically this has probably forced us to develop a second intervention, the 'data transparency' nudge intervention that is much more suited to a resource limited NHS, as it is simple, cheap and scalable. However, in our pilot study, there was no substantial impact to reduce the relative number of patients on IV antibiotics at weekends.

Part 3: Cost impact

Deriving reliable costs measures for assessing the intervention proved more difficult than expected. We finally obtained a figure of £200 for each additional bed-night at the RDH.

The initial health economic analysis estimated that reducing IV antibiotic and nebuliser stepdown rates at the weekend to the same rates as weekdays, has the potential to save the NHS £60k annually.

The initial intervention of using the ACPs to deliver a weekend 'stepdown service' was on reflection relatively costly. The second 'Plan B' intervention of data transparency is much cheaper, although we have not costed it formally. Once the search algorithms are automated, then it should take 5 minutes for the IT person to generate and send to the Medical Director's Office. This is then sent out from the Medical Director's Office with a friendly, non-judgemental email in a process that probably takes 10 minutes of the Medical Director's time.

The sustainability of this project is now to be determined by the Medical Director and his team. It is important to appreciate that NHS staff receive many emails with information and guidance from management teams. Hence, they may only respond to a certain amount of information, and there may be an opportunity cost of sending out too many emails as this leads to lack of clinician responsiveness.

Part 4: Learning from your project

Positives
Collectively, we have learnt a lot from this project as it has bought together a diverse group of health professionals who all look at the issues involved from different perspectives. We achieved the epidemiological analysis of the electronic medication data, although this was more complicated than anticipated and took longer than expected. The involvement and patience of the RDH data extraction staff was vital, as we needed 3-4 datasets before we had exactly what was required. If this work had not been prioritised by the Trust, we would not have hit the deadlines. Having Mark Norwood (Associate Director of IT at the Trust) opened doors for us, and also by having discussions about what was available, helped generate realistic goals for the study. High level IT managerial support for this type of project is vital to its success.

Although it was not taken up by the clinicians, the development of the weekend IV antibiotic step-down service by Ms Clare Sutherland (ACP lead) was very important. Knowing the hospital and the ACP service well, she helped convince the ACPs to support an extension of their role, and also developed an App for the RDH ward whiteboard system that looked fantastic.

The familiarity of the management team with the clinical reality of the NHS and also 'nudge' behavioural theory was an asset when the first intervention was not adopted, and a 'Plan B' was required. This led to the 'data transparency' approach of sharing the raw data of numbers of patients on IV antibiotics over the weekend, so that each ward team could view their ward in relation to the rest. It was important that these data are shared in a non-judgemental way, as there are many reasons for differences between wards, and many NHS staff feel the intense pressure of work and the general lack of appreciation for the work that is being done.

Reflections on what did not work out
The lack of adoption of the clinical staff of the weekend ACP antibiotic stepdown service was a surprise. We tried to arrange focus groups to explore the reasons for the further, but had no respondents. Our personal interpretation is that everyone in the NHS is working flat out, and it is likely that appreciating the problem at the ward level may be difficult for individual clinical teams to see. This may also explain why the 'data transparency' approach was unsuccessful.

Introducing innovations in the NHS
Our project is probably mainly relevant to hospitals with electronic prescribing systems. The approach of sharing numbers of patients on IV antibiotics with clinicians on each ward is easily deliverable in this context. There also may be other clinical scenarios where this approach would also be useful.

Advice to others attempting a similar project?

- Look at the raw numbers of patients on IV antibiotics on Saturday, Sunday and Monday on each ward.
- Share these data with clinicians in a neutral, non-judgemental manner.
- Assess the impact of the intervention after a fixed period compared to baseline to determine if it is worth persevering with. The analyses are not very complicated, but do involve a learning curve before being regularly deliverable. Hence, it may be best if one person in the IT department does them or that a linkage with a statistician is established. In the long run, it is more sustainable if these effectiveness assessments are done 'in house'.

Part 5: Sustainability and spread

This section is intended for you to communicate your plans for sustainability and spread.

We are still considering the implications of this project. The first outcome is that the initial ACP intervention did not work, so putting further resources into this is futile. The ‘data transparency’ intervention also was unsuccessful, and hence while attractive there is no point in continuing this.

The biggest gain is the extensive collaboration between the hospital IT department and the University of Nottingham epidemiology team, that has resulted in a number of further projects being initiated. The observation that health services interventions can be relatively easily evaluated using electronic prescribing data is one that we will be exploring further.

This project has already led to a further Health Foundation Behavioural Insights grant to try and rationalise blood test use and reduce unnecessary radiation exposure.

Appendix 1: Resources and appendices

1.

Appendix 2: Project finance

Please provide a financial summary showing spending against your Innovating for Improvement award budget.

This section should be completed and signed off by your finance department. You should report against the exact budget that was signed off in your award agreement using the template below.

We understand that there may be variations to the original budget agreed. Please let us know where this is the case and please show where money has been moved from one budget type to another or across a number of budget types and the impact that this has had on the project.

Please highlight any underspends and how you plan to use this money. Please note, we will only authorise your underspend if we told about this in advance and where the reallocation will benefit your original project aims.

Budget template
 Financial summary template
Commentary on variations to the budget
Royal Derby Hospital Budget The original plan was to pay ACPs for the work at weekends to review patients and switch from IV to oral antibiotics but that intervention was not successful due to the lack of patients recruited. It was therefore agreed to use the remainder of the funding allocated to ACPs for IT support in order to provide real time data on IV usage and cessation. **University of Nottingham Budget** The University of Nottingham budget consisted of two main components, salaries and equipment/travel. The salaries have been spent as planned. We have spent £492 on travel, which is approximately on budget. We have a team policy of only replacing equipment when it is spent, rather than buying new kit when there is a viable working option already in place. Hence, we have a £1882 underspend for consumables that we would be happy to use for disseminating the findings from this project, other health services research projects, or return to the HF as directed.

Authorisation from finance department	
Signed	
Name	Joanne Lancaster
Role	Head of Financial Management

APPENDIX 3. Frequency of stepping down common medications is lower at weekends compared to weekdays: an observational study

Sarah Lewis
Tessa Langley
Julia Lacey*
Rob Skelly*
Mark Norwood*
Nigel Sturrock*
Andrew W Fogarty

*Royal Derby Hospital, Uttoxeter Rd, Derby, DE22 3NE

Division of Epidemiology and Public Health, University of Nottingham, Clinical Sciences Building, City Hospital, Nottingham NG5 1PB, UK

Correspondence and requests for reprints to Andrew Fogarty
Email: andrew.fogarty@nottingham.ac.uk

Key words: healthcare delivery, efficiency, antibiotics, nebulisers
Funding: Health Foundation
Running title: delivering efficient healthcare
Conflicts of interest for the authors: None

Word count: 1686 words

Abstract

Background

The introduction of electronic prescribing systems allows patient care pathways to be observed, and possibly improved. We hypothesized that delays in providing non-urgent stepdowns to medical management may negatively impact on patient care and also be associated with increased length of stay.

Methods

Electronic prescribing data were obtained from a busy acute medical hospital over a period of 52 weeks from November 2014 to October 2015. The main outcomes of interest were switching from intravenous antibiotics to oral antibiotics and stopping nebulized bronchodilators. The frequency of these events on weekend and weekdays were compared, along with the associated length of stay. A simple health economic analysis was performed to estimate the possible savings if the rates of switching these drugs were the same at weekends as weekdays.

Results

The rate of switching from IV to oral antibiotics was lower on Saturdays and Sundays compared to week days, and the rate of stopping nebulized bronchodilators was similarly lower at weekends ($p < 0.001$). Median length of stay was lower at 4 days in those whose antibiotic treatment was stepped down at weekends than in those stepped down on week days (median 5 days). A similar, though non-significant, pattern was observed for nebulized salbutamol. We estimate that, at this hospital, approximately £61 000 annually could be saved if the rate of stepping down of treatments at weekends was comparable to that during the rest of the week.

Conclusions

These data demonstrate that electronic prescribing data can be used to identify possible bottlenecks in patient flow through acute hospitals, and quantify the possible benefits of intervening to reduce them.

Introduction

Increasing demand for acute health care is putting the infrastructure of hospitals and primary care in the United Kingdom under increasing strain, and has resulted in the need for increased efficiency in the context of a limited health budget [1]. One possible bottleneck in the care of patients who are clinically improving is the necessity to change treatment from a more intensive level to one that is more appropriate to home-based care. Two common examples of this are the stepping down from intravenous antibiotics to oral antibiotics and stopping nebulized bronchodilators.

Emergency medical care patients become unwell in a random manner that is generally independent of the weekday in question. However, stepping down medical treatment in hospitals in the United Kingdom is likely to vary at weekends compared to weekdays, as the lower levels of weekend staffing understandably prioritises emergency care. As a consequence,, more routine medical management such as stepping down intravenous antibiotic and stopping unnecessary nebulizer treatments in convalescing patients may get overlooked, hence delaying discharge from hospital. We used electronic prescribing data to analyse the patterns of stepping down intravenous antibiotic and nebuliser bronchodilators at weekends compared to weekdays over 52 weeks in a busy acute general hospital and the associated relationship with length of stay. We also calculated the possible cost saving if rates of switching these two categories of medications were the same at weekends as the rate seen on weekdays.

Methods

Study population

The potential study population consisted of all individuals who were admitted to the Royal Derby Teaching Hospital over the study period. The Royal Derby Teaching Hospital is a busy acute medical hospital that in 2014 admitted 140,960 individuals in 2014. The study was an evaluation of health service delivery and no ethical approval was required.

Data collection

The Royal Derby Teaching Hospital uses iSoft Electronic Prescribing and Administration software to permit electronic prescribing of drugs. Data on all patients who were admitted as an emergency and received either intravenous systemic antibiotics followed by oral antibiotics, or nebulized salbutamol during their hospital admission were collected from November 2014 to October 2015. Antibiotics that are used to treat Clostridium difficile were excluded from the analysis as the treatment period was determined by local guidelines. Data where the place of drug administration was coded as intensive care, maternity, palliative care, rehabilitation and private health wards were excluded from the analysis, as other factors are clinically important in the management of these patients. Data were available on the date and time of administering these drugs.

Statistical analysis

The data were cleaned prior to statistical analysis using the following strategies. Repeat prescriptions for the same drug within an hour were assumed to be coding errors and removed from the dataset. Some patients received alternating intravenous and oral antibiotics, and as we anticipated that these would be complex patients with fluctuating clinical conditions who do not represent simple clinical cases, these were also removed from the dataset that was analysed. Other exclusion criteria were in patients who had an interval of more than two days between the last dose of IV antibiotics and the first dose of oral medications, and as required or single administrations of nebulized salbutamol. The date of administering the first oral antibiotic, and the last nebulized salbutamol, were used to identify the day of switching medications.

Statistical analysis initially involved graphical representation of the day of the week of either switching from intravenous antibiotics to oral antibiotics or stopping nebulizer salbutamol treatment. Similarly, the length of stay for the total admission was presented graphically by day of the week of switching for both the antibiotic and nebulized salbutamol datasets. The binomial probability and Kruskal-Wallis tests were used to see if these frequencies varied by chance. The health economic impact of delivering the same length of stay for those who switch drugs at weekends as those who switch on weekdays was modelled using a cost of £200 for each day in hospital using estimates from the RDH finance team. As our analysis used all available data, there was no formal power calculation.

Results

After identifying eligible patients (Figure 1), we analysed data on 3,951 patients who received intravenous systemic antibiotics followed by an oral antibiotic, and 1,445 patients who received nebulized salbutamol. The distribution of the day of the week of switching antibiotic regimes and stopping nebulized salbutamol is shown in Figure 2; both were less likely to occur on weekend than week days ($p < 0.001$).

The average length of hospital stay varied with the day of the week of switching from IV to oral antibiotics ($p < 0.001$), such that the length of stay was shorter at a median of 4 days for those where stepping down of medical treatment occurred at the weekends than those for whom it occurred on a weekday (median 5 days). A similar pattern was seen in relation to stepping down of nebulized salbutamol though the difference in length of stay was not statistically significant ($p = 0.38$) (Figure 3).

In cost terms, if stepping down of IV antibiotics was equally distributed across the days of the week, an additional 5.6% of the patient population receiving IV antibiotics would be stepped down at the weekend, and, assuming this reduces the length of stay by 1 day, and that a day in hospital costs £200, then in Derby over 1 year, 3951 x 0.056 x 1 day x £200 = £44 251 per year could be saved.

If stepping down of nebulised salbutamol was equally distributed across days of the week, an additional 5.9% of the patient population receiving nebulised salbutamol would be stepped down at the weekend, and, assuming this reduces the length of stay by 1 day, and that a day in hospital costs £200 as before, then in Derby over 1 year, 1445 x 0.059 x 1 day x £200 = £17 051 per year could be saved.

Discussion

These data demonstrate that the frequency of switching from intravenous to oral antibiotics and stopping nebulized bronchodilators is lower at weekends than weekdays, and that stepping down antibiotic treatment at the weekend is associated with a shorter length of stay. This may represent more efficient delivery of timely healthcare to those patients who stepped down their treatment on a weekday as regular clinical review is likely to facilitate patient flow.

The strengths of these data are that they were obtained from the electronic prescribing system that is used in The Royal Derby Teaching Hospital and represent all the medications prescribed during the time period of interest, with accurate dates of administering the drugs of interest and hence permitted identification of the date that treatment was stepped down. Hence, the bias that could be introduced using paper drug charts that may have missing data is avoided. We studied a 52 week period of time to allow our data to reflect a year and hence not be biased by a shorter period of time that may be influenced by the seasonal changes in demand for healthcare [2]. These data

are likely to be generalisable to other hospitals in the United Kingdom as The Royal Derby Teaching Hospital is a medium sized acute medical centre that can be considered broadly representative of a typical hospital in the National Health Service (NHS). One limitation of these data is that we have made the assumption that presentation with acute medical emergencies is independent of the day of the week, yet we are unable to demonstrate that this assumption is true in our data as we have no measures of disease severity. A recent study has demonstrated that fewer patients are admitted at weekends, but also that this group may have more severe disease [3], and hence it is possible that this group may be more likely to be given intravenous antibiotics or nebulized treatment, and hence more likely to step down treatment on a subsequent weekday once they are improving. We also only studied relatively straightforward clinical cases, and excluded those who switched back from oral to IV antibiotics and where there was an interval or more than 2 days between stopping IV antibiotics and starting oral antibiotics. Our cost analysis is very conservative, as we only used data on incremental bed day cost, and were unable to reliably model the extra savings in time avoided by not having to prepare and deliver intravenous medications. Hence, the true cost saving will be greater than our model predicted. There will also be patient oriented benefits in reducing IV antibiotic doses, in terms of decreased discomfort and risk of complications from IV cannulae.

The implications of these data are that switching responsive patients who are clinically improving to less intensive therapies is less likely at weekends compared to weekdays. This in itself is not particularly surprising to busy clinicians, as the priority at weekends is to deal with new emergency admissions and patients who are known to be sick or deteriorating, rather than those who are stable. These data suggest that there may be gains both in quality of patient care and possibly in reduced length of stay if a way can be found to facilitate the provision of review and delivery of treatment to clinically improving patients. However, increasing levels of medical staffing at weekends to those in the week is not possible without extra doctors and non-medical staff [4], while a recent economic analysis suggests that the extra expenditure that this would incur could be more efficiently spent in other areas of healthcare [5].

In conclusion, these data suggest that frequency of switching of both intravenous antibiotics and nebulized bronchodilators to lower intensity treatment is lower at weekends than on weekdays, and that those who do switch down from intravenous antibiotic treatment at weekends have a lower length of stay. This represents a potential bottleneck in the patient pathway for these individuals, that may be amenable to intervention. This analysis represents the first approach of using electronic prescribing data to identify possible inefficiencies in healthcare delivery, and we consider that there may be other such examples that can be highlighted by a multidisciplinary teams of interested clinicians, statisticians, health economists and information technology professionals.

Acknowledgements
The study was funded by the Health Foundation. We would also like to thank Helen Staniforth for patiently providing the data required.

References

1. Roberts A (2015) http://www.health.org.uk/sites/default/files/FundingOverview_NHSFundingProjections.pdf (accessed 7/4/2016). The Health Foundation.
2. Public Health England (2015) The Cold Weather Plan for England. Protecting health and reducing harm from cold weather. https://wwwgovuk/government/uploads/system/uploads/attachment_data/file/468160/CWP_2015pdf (accessed 7/4/2016).
3. Meacock R, Anselmi L, Kristensen S, Doran T, Sutton M (2016) Higher mortality rates amongst emergency patients admitted to hospital at weekends reflect a lower probability of admission. J Health Serv Res Policy doi:10.1177/1355819616649630.
4. Crump H (2015) Seven day working: why the health secretary's proposal is not as simple as it sounds. Brit Med J 351: h4473.
5. Appleby J (2016) A 7/7 NHS: what price equity? Brit Med J 352: i404.

Figure 1. Flow chart of selection of eligible patients from all patients who received antibiotics during study period

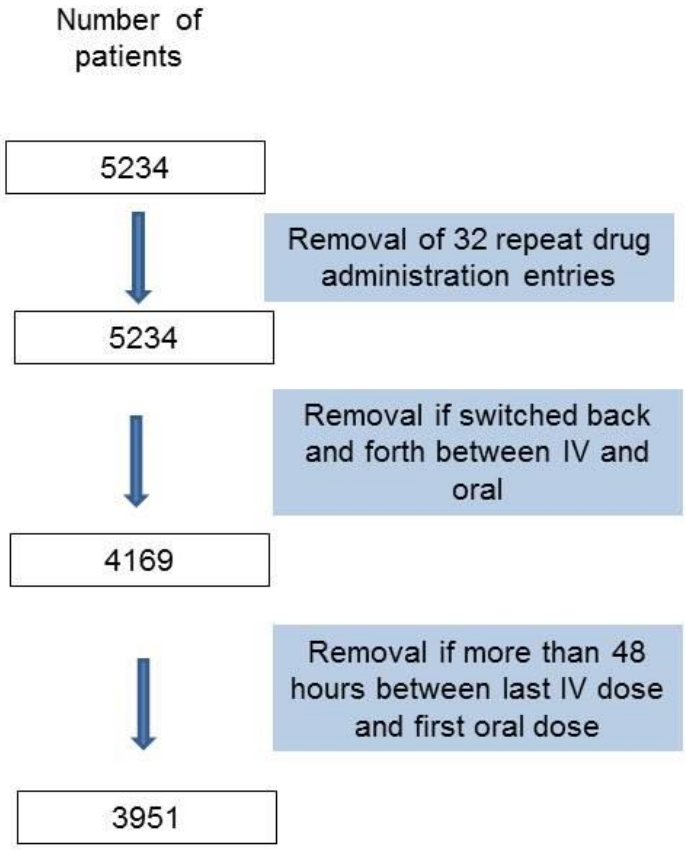


Figure 2 a) Day of the week of switching IV to oral antibiotics
Note: N=3951. The reference line is at 564 individuals, the expected value if switching was equally distributed across the week.

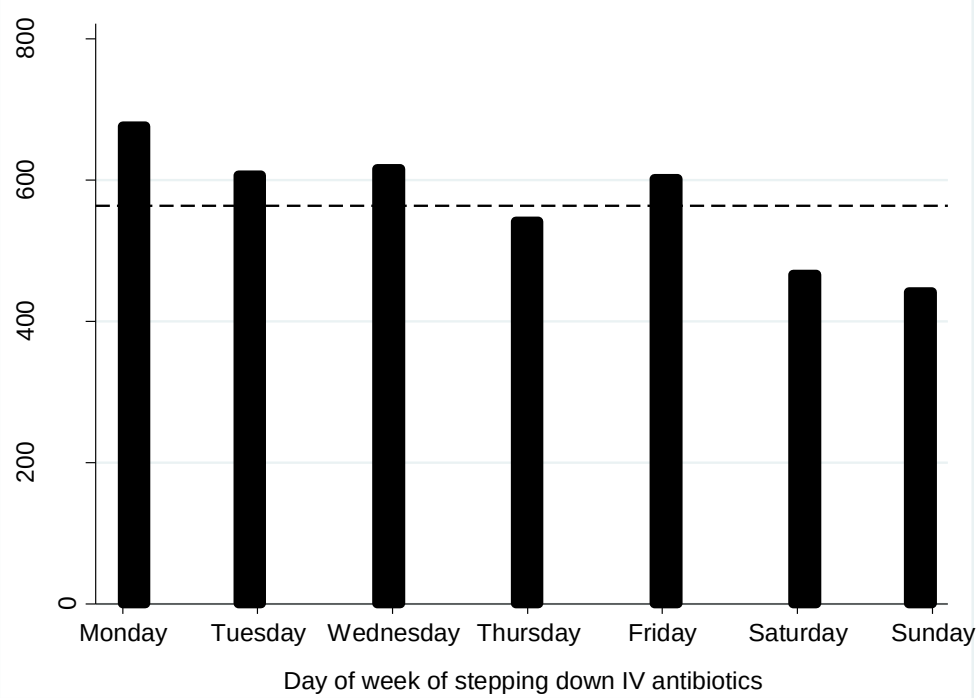


Figure 2 b) Day of the week of stepping down nebulized salbutamol
Note: N=1445. The reference line is at 206 individuals, the expected value if switching was equally distributed across the week.

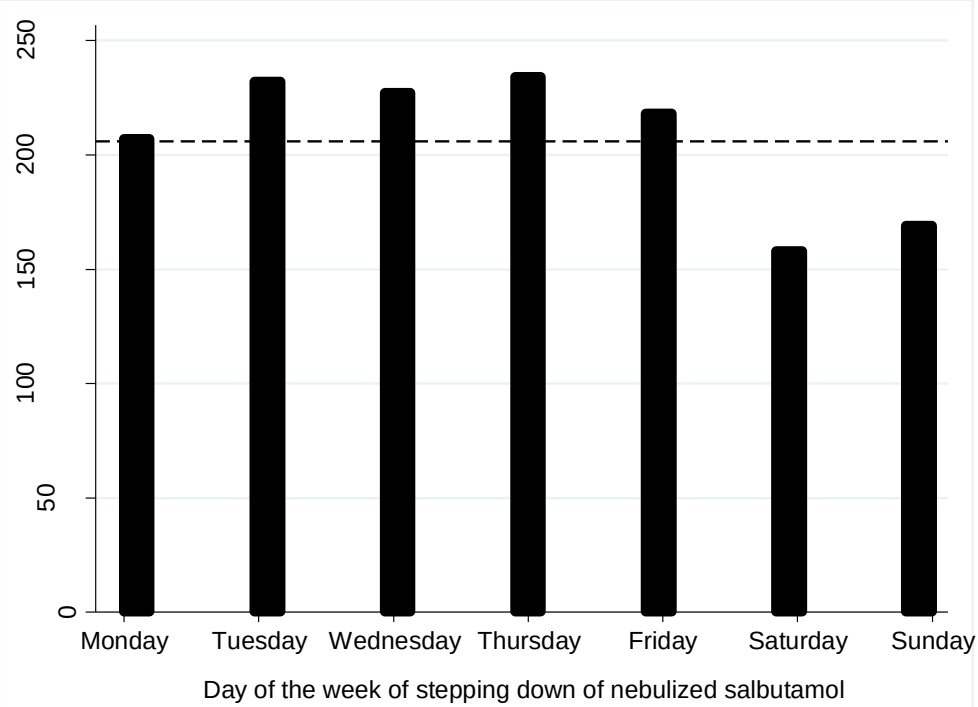


Figure 3) Median length of stay according to the day of week of a) stepping down IV antibiotics and b) stopping nebulized salbutamol.