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Using hospital administrative data to support case finding of patients at higher risk of severe healthcare-related harm

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Using hospital administrative data to support case finding of patients at higher risk of severe healthcare-related harm

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Abstract

Objectives: To identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying those patients who have suffered avoidable severe harm

Design: Development and testing of thresholds and criteria for two indirect indicators of healthcare-related harm (long length of stay (LOS) and emergency readmission) and applying these to four patient cohorts to determine the yield and distribution of specified harms coded in Hospital Episode Statistics (HES).

Setting: English Acute Hospital Trusts

Participants: HES for acute myocardial infarction, bowel cancer surgery and hip replacement admissions from 2014/15

Interventions: Linear regression models were used to determine expected LOS for patient cohorts in 2013/14 and parameter estimates applied to 2014/15 population. Different thresholds were examined to determine the association with harm. Screening criteria for readmission included time to readmission, length of readmission and diagnoses in initial admission and readmission. The association with harm was examined for each criterion.

Outcome measures: Harm coded in the HES record

Results: The selection of thresholds for screening had a significant impact on the yield of harm. Longer LOS were associated with a higher proportion of coded harms, however as the number of patients at these higher thresholds was small, the overall proportion of harm identified is relatively small. Selection of the time to readmission had an effect on the yield of harms but this varied with condition. At least 50% of surgical patients had a harm code if readmitted within 7 days compared with 21% AMI patients.

Conclusions: Our approach would select a substantial number of patients for case record review. Many of these cases would contain no evidence of healthcare-related harm. In practice, Trusts may choose how many reviews it is feasible to do in advance and then select random samples of cases that satisfy the screening criteria.

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Article Summary

Strengths and limitations of the study

Routine hospital administrative data is inexpensive and easy to access.

Potential healthcare-related harm can be identified in these data by specific codes used for such harms e.g. complications and adverse reactions or by using indirect indicators known to be linked to such harm such as long length of stay (LOS) or readmission

Comparing the performance of long LOS and readmission across four contrasting cohorts of patients (emergency: acute myocardial infarction (AMI); urgent: non-elective bowel cancer surgery; semi-urgent: elective bowel cancer surgery; and elective: hip replacement) when thresholds for LOS and criteria for readmission are manipulated shows that sensitivity and positive predictive power to identify harm can be increased.

To confirm if any harm identified in the administrative records is healthcare-related, retrospective case record review is required

The approach would identify potential healthcare-related harm in large numbers of cases. A selection process for those going forward to case record review would be required.

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Introduction

There are two main ways that the incidence of avoidable severe harm are monitored in patients in acute hospitals in the NHS in England. However, both methods have shortcomings. Incident reporting systems tend to underestimate as they depend on staff compliance and don't reveal the extent to which the harm was avoidable; retrospective case record reviews (RCRR) provide insight into the clinical circumstances that might have led to harm but the method requires considerable resources which preclude universal application to all hospital admissions.

An alternative approach could be to for hospitals to employ administrative data to screen records for case note review. These include codes for healthcare-related harm ('direct' indicators of harm) such as 'complications and adverse events' or 'pulmonary embolism after a surgical procedure'. In theory, all harm should be recorded though the completeness of recording is doubtful. In addition, the data will not distinguish between levels of severity so instances of severe harm cannot be distinguished from lesser forms. There has been no recent estimation of the completeness of reporting of harm in administrative data, but a historical (1999-2003) comparison with Australia suggested under-reporting: 2.2% of all NHS admissions compared with 4.75% in Australia.[1, 2]

Administrative data also offers the possibility of using two 'indirect' indicators that reflect the potential consequences of healthcare-related harm: longer than expected length of stay (LOS) and unplanned readmission. Such indicators might be used to identify those patients in whom it is likely harm has occurred even if it had not been recorded. In this way the detection or yield of harm could be enhanced. Support for such an approach comes from RCRR studies that have shown adverse events are associated with longer LOS,[3-5] though the direction of causality is unclear as a longer stay increases the risk of an error in care and subsequent harm.[6, 7] Similarly, a high rate of unplanned readmissions has been shown to be associated with harm having occurred.[8-10]

Our aim was to identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying those patients who suffered avoidable severe harm. In this paper we focus on exploring the potential use of two indirect measures (long lengths of stay and early unplanned readmissions) in

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patients with one of four tracer conditions. These were selected to represent elective, urgent and emergency admissions for medical and surgical reasons. With lengths of stay we have evaluated different thresholds for defining a long stay; whilst with early readmissions we have assessed a range of criteria. .

Method

Data

For this analysis we used hospital administrative data as reported in Hospital Episode Statistics (HES) for the 2014/15 financial year. Diagnosis and procedure codes are based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) and the OPCS Classification of Interventions and Procedures, version 4 (OPCS-4). There are 20 diagnostic fields per episode: a primary diagnosis and up to 19 secondary diagnoses.

Categorising direct indicators of harm

A set of ICD-10 codes were selected as direct indicators of harm. These included complications and adverse reactions [T80-88; Y40-84] plus others identified from the literature,[11-13] or through consultation with clinicians and clinical coders and other sources of guidance. [14, 15] Direct indicators of harm were divided into eight groups: complications and adverse reactions; thromboembolism; pneumonia; pressure sores; urinary tract infections; falls; fractures; post-procedural complications. Further details on these definitions are shown in *Appendix 1*.

Selection of patient cohorts

Given that the approach to using direct or indirect indicators might vary by the type of admission and condition, we selected four examples that represented both medical and surgical conditions and the urgency of the admission (emergency: acute myocardial infarction (AMI); urgent: non-elective bowel cancer surgery; semi-urgent: elective bowel cancer surgery; and elective: hip replacement). (Full list of ICD-10 and OPCS-4 codes for defining these cohorts is suppled in *Appendix 2*). Cohorts were restricted to adults (over 17 years), their first admissions in 2014/15 to an acute NHS hospital in England for the relevant condition or surgery, and discharged alive. Admissions excluded day cases or regular day or night attenders.

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Evaluating thresholds for unexpected long length of stay (LOS)

The expected LOS of each patient was estimated using a linear regression model that controlled for age, sex, comorbidities, deprivation and emergency admissions in the previous 12 months. The expected LOS was estimated for each of the patient cohorts in 2013/14 and the parameter estimates applied to the 2014/15 population.

Thresholds for long lengths of stay were defined as multiples of the expected values, specifically two, three, four and five times. For each threshold we investigated the association with the direct indicators of harm using a linear regression model. We then evaluated the impact of different thresholds on the number of patient records that each trust would have to review in order to find instances of harm (positive predictive value) and the proportion of patients with harms reported in the spell that would be selected (sensitivity).

Unplanned readmission

Patients in each cohort were identified as having an unplanned readmission if their subsequent admission was an emergency and occurred either in 2014/15 or 2015/16. Screening criteria for readmissions were derived from combinations of:

- time to readmission,
- harm reported in the first episode of the readmission spell,
- harm reported in the initial admission (present either in second or subsequent episodes),
- primary diagnosis on readmission, and
- length of the readmission spell.

The relevance of the primary diagnosis on readmission to harm having occurred in the previous admission was determined by expert clinical review. This was done for each cohort to allow for differences types of harm between the four cohorts (e.g. conditions that are relevant for the hip replacement cohort may not be relevant for the AMI cohort).

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As with lengths of stay, different options were evaluated in terms of proportions of case notes to be reviewed, and the sensitivity and positive predicted value associated with the occurrence of direct indicators of harm.

Patient Involvement

Patients sat on the Steering Group for this study and contributed to decisions on the number and type of harm codes that were to be used.

Results

Mean age was similar across the patient cohorts (68-70 years) and each cohort had similar distribution of socio-economic status (*Table 1*). There were differences in sex: men made up 66% of the AMI cohort but only 40% of the elective hip replacements. There were also differences in comorbidity: 45% of emergency bowel cancer patients had Charlson scores of four or more compared to 5% of patients receiving elective hip replacement.

Long lengths of stay: association with direct indicators of harm

The median LOS differed between cohorts (*Table 2*) and the distribution was highly positively skewed. The prevalence of harm increased with LOS (*Figure 1*). For example, 94% of emergency bowel surgery patients staying longer than 50 days had experienced harm compared to 16% in those who stayed 5-9 days. Linear regression analysis found that nearly all categories of harm were significantly positively associated with LOS: some exceptions being fractures in emergency bowel cancer patients and hospital-acquired infections in all bowel cancer patients (*Appendix 3, Table 3.1*).

Long lengths of stay: screening criteria and resource implications

The impacts of different length of stay thresholds on the numbers of patient notes that would be selected and on the sensitivity of detecting harm are shown in *Table 3*.

Of all the patients with a direct indicator of harm, the proportion included in these subgroups (the sensitivity) decreases as the threshold rises, from 56% to 15%. At the same time, the positive predictive value (PPV - the number of cases identified in each threshold that would actually have a harm code) increases. For example, for

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hip replacement the value rises from 10% among all patients to 51% for those staying 3 times longer than expected.

Emergency readmissions: association with direct indicators of harm in the readmission spell

Rates of readmission within seven days for AMI and bowel surgery (6-7%) are notably higher than for hip replacement (2.6%) (*Table 2*). Approximately half of readmissions within 28 days occur within the first seven days. More than half the surgical patients readmitted within seven days had a direct indicator of harm compared to 21% in the AMI cohort (*Figure 2*). With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This pattern among the surgical cohorts is specifically due to declines in 'complications and adverse reactions' which constitutes approximately 65% of harm across these groups in contrast to the AMI cohort where only 25% are 'complications and adverse reactions'.

Emergency readmissions: association with direct indicator of harm in the initial spell

For individuals who have a direct indicator of harm reported in the initial spell, the seven-day readmission rates are higher than the overall seven-day rates for each cohort except those undergoing urgent bowel cancer surgery (*Table 4*). After adjusting for age and likelihood of readmission (using Patients at Risk of Re-admission within 30 days Score[16]), the time to readmission was only related to the record of a direct indicator of harm in the initial spell for the AMI cohort (excluding cases where there was a direct indicator of harm reported in both the initial spell and the readmission).

Emergency readmissions: Length of stay after readmission

The proportion being readmitted for more than three days varied by cohort: bowel surgery over 50%, AMI 44%, hip replacement 32%. The latter group have more patients who stay for less than a day (32% compared to 13% to 17% for the other cohorts). 44% of these readmissions are for conditions reported as 'other soft tissue disorders' and they also include all patients with a primary diagnosis of 'phlebitis and thrombophlebitis' (including deep vein thrombosis). The latter represent cases where

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patients are discharged quickly after the readmission to manage the condition in the community. Direct indicators of harm are significantly more prevalent when the readmission LOS is longer than three days (*Table 5*) (p-value < 0.001 for each cohort).

Emergency readmissions: Primary diagnosis on readmission

Just over half of readmissions within seven days for the AMI cohort were admitted with a primary diagnosis that was judged by expert review to be potentially related to harm (*Table 6*). This compares with much higher proportions among the other cohorts, with nearly 99% of the hip surgery cohort having a diagnosis that could be potentially related to harm among that group (more details in *Appendix 3: Table 3.2*). There were no significant differences in the proportions within 7 days from 8-28 days among the surgical cohorts. However, there are significant reductions in proportions among elective bowel surgery readmissions that occur after 28 days (p < 0.001). Among the AMI cohort, the proportion among the earlier readmissions (50.9%) is significantly higher than among the later readmissions (p < 0.001).

Emergency readmissions; screening criteria and resource implications

Choices of criteria against which to select case records for review will depend on a trade-off between numbers of cases selected and proportion of harm that is found. Table 7 shows the outcomes of different criteria using 28-day readmissions as a baseline against which to compare proportions of notes selected and sensitivities. With the hip surgery and elective bowel replacement cohorts, given the majority of the primary diagnoses on readmission are associated with harm having occurred (*Table 7*), restricting selection to these primary diagnoses (scenario C) makes little difference. Further limiting selection to cases where readmission lengths of stay exceed three days will reduce the number of case records for review by 50% or more but will correspond to larger reductions in sensitivity (comparing scenario E with scenario C). Including any cases where direct indicators of harm are present, regardless of length of stay and primary diagnosis will increase the positive predictive value at the expense of having a larger proportion of notes to review.

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Discussion

Main findings

It is possible to derive criteria from hospital administrative data to select case records in order to find cases of severe hospital-related harm. Our findings suggest that adopting screening rules based on two indirect indicators (long lengths of stay and early readmission) has the potential to improve the targeting of case record reviews. The precise scale of any improvements is unclear until selection criteria have been tested against the outcomes of such reviews.

The selection of length of stay thresholds for screening could have a significant impact on the yield of cases of harm. For example, over half those who stayed at least three times longer than expected had a direct indicator of harm. The positive predictive value of the screen increases across the thresholds, such that the number of cases identified as having a direct indicator of harm as a proportion of all cases examined increases. By manipulating LOS threshold, choices can be made in relation to the trade-off between the number of cases that will actually have a harm code present at that threshold and the proportion of all the harm that will be found if only those cases are investigated.

Selection of the time to readmission has an effect on the yield of potential cases of harm but it varies by condition. At least 50% or more of the surgical patients had a direct indicator of harm if readmitted within 7 days, compared with 21% in the AMI cohort. With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This suggests that the sampling window for the latter two conditions could be extended to 28 days without significant impact, with the added benefit of increasing the number of patients in the hip replacement cohort where there are relatively few readmissions. The lack of any relationship between a harm code found in the initial admission with time to readmission suggests that the occurrence of harms in the initial episode may not be useful as a criterion for selecting case records, except, perhaps, for AMI patients.

For primary diagnoses on readmission deemed to be potentially associated with harm, there were higher frequencies among the surgical cohorts with between 80%

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and 100% of readmission primary diagnoses identified by clinical reviewers being potentially associated with harm. For the AMI cohort, the corresponding proportion was around 50%. This suggests that the nature of the primary readmission diagnosis can be useful as a further criterion for selecting case records and this approach would have the greatest impact on the AMI cohort.

Other literature

Previous RCRR studies estimated that the proportion of inpatients with an adverse event ranged from 3.8% to 16.6%.[17] Across the four cohorts, we found higher proportions of harm codes. However, the conditions we studied were chosen to highlight different admission types and were not representative of all conditions. Similar rates of harm in bowel cancer patients (between 20% and 40%) have been found in previous studies.[18] A recent Dutch study found a higher proportion of harm in patients admitted with AMI, between 13.3 and 29.9%.[19] The harm in this study was found using an audit tool to screen electronic patient records which could account for a greater proportion of harm being uncovered. National clinical audits suggest that the rate of complications after percutaneous coronary interventions is around 9% in England,[20] and after total hip replacement are about 1% for infection and venous thromboembolism and 3-4% for dislocation.[21] This is consistent with the lower incidence of harm that we found in this group.

Limitations

There are a number of limitations to be considered when interpreting our findings. First, our estimates of harm, based on our inclusive approach, are inflated by an element of double counting when the same harms are coded under more than one of the harm categories. This inflation is compounded by the fact that we inevitably include a number of conditions that were present on admission. Harm codes such as pneumonia or urinary tract infection, which occur more commonly in emergency medical patients, are also more difficult to attribute to healthcare-related processes. It is also known that hospitals vary in the way they use complication and adverse reaction codes which has the potential to introduce further bias in measurement.[1]

Second, one of the main limitations of developing screening approaches is the accuracy and completeness of the routine data.[1, 22] This limitation is particularly

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important to consider in this study which used harm codes for the internal validation of indirect indicators of harm derived from the same routine hospital administrative data source. As our approach to harm code definitions was inclusive in an attempt to increase sensitivity, it is likely that our estimates are inflated which may have biased assessment of the performance of indirect indicators as screening tools.

Third, to assess the feasibility of using indirect indicators to detect cases of harm, we have relied on direct indicators. However, we cannot know the relationship with other types of harm that are not so easily identifiable within routine data, and whether approaches that would work for the detection of harm codes we identified would work more generally. Our analytic approach can indicate that a patient may have experienced harm and the patterns of harm amongst groups of patients with differing conditions and across an organisation but it cannot confirm if that harm was healthcare-related, its severity or its avoidability without recourse to case record review.

Implications

Our approach to screening using long lengths of stay or early readmissions would identify a substantial number of patients for case record review if extended across all patients. In 2014/15, there were approximately 16 million admissions to all NHS acute trusts in England,[23] yet the cohorts we included in this analysis comprised less than 1%. If a threshold of twice the expected length of stay was used for screening, we estimate this would have resulted in 9,974 case record reviews in 2014/15 across the four cohorts, which equates to about 70 per trust. If we assume a similar length of stay distribution across all hospital admissions, this scales up to around 7,000 reviews per year in an average sized trust. Furthermore, having increased the sensitivity of the screening process at the expense of specificity, many of these cases would contain no evidence of healthcare-related harm.

In practice, therefore, this suggests that one approach might be for Trusts to decide how many reviews they are going to do in advance and then select random samples of cases that satisfy the screening criteria. Consideration of how to adapt or create algorithms applicable to wider patient populations would also be required.

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Contributorship

HH, NB, CSJ and JVM designed the study. CSJ, NCO and KC carried out the analyses. NB,CSJ and HH wrote the first draft of the manuscript. All authors provided input and approved the final version for submission.

Conflicts of interest

None

Data Sharing Statement

Further details on statistical models and definitions are available from the Nuffield Trust at research@nuffieldtrust.org.uk.

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References

1. Aylin P, Tanna S, Bottle A, Jarman B. How often are adverse events reported in English hospital statistics? BMJ. 2004 Aug 14;329(7462):369
2. Australian Institute for Health and Welfare. Reporting of adverse event in routinely collected data sets in Australia. Australian Institute for Health and Welfare,, 2001.
3. Sari AB ST, Cracknell A, Turnbull A, Dobson Y, Grant C, Gray W, Richardson A. Extent, nature and consequences of adverse events: results of a retrospective casenote review in a large NHS hospital. Qual Saf Health Care. 2007;16(6):434-9
4. Baker GR, Norton PG, Flintoft V, Blais R, Brown A, Cox J, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. CMAJ. 2004;170(11):1678-86
5. Davis P, Lay-Yee R, Briant R, Ali W, Scott A, Schug S. Adverse events in New Zealand public hospitals I: occurrence and impact. N Z Med J. 2002;115(1167):U271
6. Asher RA. The dangers of going to bed. Crit Care Update. 1983;10(5):40-1, 51
7. Kandula PV, Wenzel RP. Postoperative wound infection after total abdominal hysterectomy: a controlled study of the increased duration of hospital stay and trends in postoperative wound infection. Am J Infect Control. 1993;21(4):201-4
8. Care Quality Commission Intelligent monitoring: NHS acute hospitals- indicators and methodology guidance. Care Quality Commission 2015.
9. Nolte E, McKee M, Wait S. Chapter 2. Describing and evaluating health systems. Maidenhead: Open University Press, 2005.
10. Leng GC, Walsh D, Fowkes FG, Swainson CP. Is the emergency readmission rate a valid outcome indicator? Qual Health Care. 1999;8(4):234-8
11. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
12. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51
13. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
14. Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. Health and Social Care Information Centre, 2017.
15. NHS Digital. HES Data Dictionary : Admitted Patient Care (May 2016). NHS Digital, 2016.
16. Billings J, Blunt I, Steventon A, Georghiou T, Lewis G, Bardsley M. Development of a predictive model to identify inpatients at risk of re-admission within 30 days of discharge (PARR-30). BMJ Open. 2012;2(4)
17. de Vries EN, Ramrattan MA, Smorenburg SM, Gouma DJ, Boermeester MA. The incidence and nature of in-hospital adverse events: a systematic review. Qual Saf Health Care. 2008;17(3):216-23
18. Alves A, Panis Y, Mathieu P, Mantion G, Kwiatkowski F, Slim K, et al. Postoperative mortality and morbidity in French patients undergoing colorectal surgery: results of a prospective multicenter study. Arch Surg. 2005 Mar;140(3):278-83, discussion 84
19. Eindhoven DC, Borleffs CJ, Dietz MF, Schalij MJ, Brouwers C, de Bruijne MC. Design and reliability of a specific instrument to evaluate patient safety for patients with acute myocardial infarction treated in a predefined care track: a retrospective patient record review study in a single tertiary hospital in the Netherlands. BMJ Open. 2017 Mar 20;7(3):e014360
20. Banning AP, Baumbach A, Blackman D, Curzen N, Devadathan S, Fraser D, et al. Percutaneous coronary intervention in the UK: recommendations for good practice 2015. Heart. 2015 May;101 Suppl 3:1-13

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21. National Joint Registry Editorial Board. National Joint Registry for England, Wales, Northern Ireland and Isle of Man 13th Annual Report. National Joint Registry, 2016.
22. Raftery J, Roderick P, Stevens A. Potential use of routine databases in health technology assessment. Health technology assessment. 2005 May;9(20):1-92, iii-iv
23. Hospital Episode Statistics: Admitted Patient Care, England 2014-15. Health and Social Care Information Centre , 2015, https://files.digital.nhs.uk/publicationimport/pub19xxx/pub19124/hosp-epis-stat-admi-summ-rep-2014-15-rep.pdf.

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Table 1: Patient cohort characteristics

	Acute Myocardial Infarction		Urgent bowel surgery		Elective bowel surgery		Hip replacement	
	N	%	N	%	N	%	N	%
Sex								
Male	39,887	66	1,637	52	9,856	58	21,206	40
Female	20,299	34	1,490	48	7,245	42	31,532	60
Age group (years)								
< 54	11,017	18	471	15	1,849	11	6,651	13
55 - 64	12,504	21	533	17	3,567	21	10,622	20
65-74	13,935	23	801	26	5,757	34	18,345	35
75 - 84	14,029	23	951	30	4,839	28	14,437	27
> 85	8,701	14	371	12	1,089	6	2,683	5
Charlson score								
0	24,299	40	1,037	33	8,286	48	34,203	65
1	9,448	16	203	6	1,739	10	4,776	9
2	10,597	18	307	10	2,174	13	8,135	15
3	6,483	11	166	5	951	6	3,238	6
4 +	9,359	16	1,414	45	3,951	23	2,386	5
IMD quintiles								
1 - least deprived	13,148	22	551	18	2,489	15	7,203	14
2	12,273	21	591	19	2,975	18	9,222	18
3	12,129	20	678	22	3,699	22	11,380	22
4	11,621	20	684	22	3,959	23	12,326	24
5 - most deprived	10,258	17	588	19	3,815	23	11,811	23
Admission in previous year	13,470	22	980	31	4,020	24	5,221	10
Direct indicator of harm present during the hospital spell	8,348	14	1,080	35	4,479	26	5,317	10
Total	60,186		3,127		17,101		52,738	

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Table 2: Median and average lengths of stay and readmissions by condition

	Total number of patients in cohort	Lengths of stay				Readmissions within 7 days		Readmissions within 28 days	
		Median (days)	Mean (days)	Min (days)	Max (days)	Number of readmissions	Rate	Number of readmissions	Rate
Acute Myocardial infarction	60,186	4	6.5	0	412	4,072	6.8%	8,149	13.5%
Emergency bowel cancer surgery	3,127	13	17.4	0	207	202	6.5%	445	14.2%
Elective bowel cancer surgery	17,101	7	9.7	0	235	1,086	6.4%	2,057	12.0%
Elective hip replacement surgery	52,738	4	4.8	0	174	1,344	2.6%	2,776	5.3%

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Table 3: Impact of different 'longer than expected LOS' thresholds on (i) the proportion of patients selected and (ii) the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm

Threshold	All cases	Longer than expected	2 x longer than expected	3 x longer than expected
Acute myocardial infarction				
% selected (n)	100% (60,186)	28% (17,072)	9% (5,664)	4% (2,618)
Sensitivity	100%	56%	27%	15%
PPV	14%	27%	40%	47%
Urgent bowel surgery				
% selected (n)	100% (3,127)	58% (1,806)	20% (631)	9% (270)
Sensitivity	100%	81%	39%	19%
PPV	35%	48%	66%	74%
Elective bowel surgery				
% selected (n)	100% (17,101)	26% (4,420)	7% (1,163)	3% (468)
Sensitivity	100%	59%	21%	9%
PPV	26%	60%	82%	88%
Hip replacement				
% selected (n)	100% (52,738)	31% (16,528)	5% (2,516)	2% (835)
Sensitivity	100%	60%	20%	8%
PPV	10%	19%	41%	51%

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Table 4: Seven-day readmission proportions for patients with a direct indicator of harm in the second or subsequent episode of the initial spell

	A direct indicator of harm in the second or subsequent episode of the initial spell			Overall 7-day readmission rate	p-value associated with the presence of direct harm
	Present				
	Number of patients	Number readmitted	Proportion readmitted within 7 days		
Acute myocardial infarction	2,569	218	8.5%	6.8%	< 0.001
Urgent bowel surgery	393	24	6.1%	6.5%	0.76
Elective bowel surgery	528	42	8.0%	6.4%	0.12
Hip replacement	150	8	5.3%	2.6%	0.06

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Table 5: Proportion of direct indicators of harm by length of readmission spell for readmissions within seven days

Length of stay (days)	AMI		Bowel surgery		Hip replacement	
	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)
0	560	14.1% (11.2 - 17.0)	211	62.6% (56.1 - 69.1)	427	34.7% (30.2 - 39.2)
1	852	12.4% (10.2 - 14.6)	158	50.0% (42.2 - 57.8)	248	49.2% (43.0 - 55.4)
2	492	13.8% (10.8 - 16.9)	123	61.0% (52.4 - 69.6)	127	48.8% (40.1 - 57.5)
3	376	19.9% (15.9 - 23.9)	127	53.5% (44.8 - 62.2)	112	50.0% (40.7 -59.3)
>3	1792	29.6% (27.5 - 31.7)	669	68.6% (65.1 - 72.1)	430	64.2% (60.0 - 68.8)

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Table 6: Proportions of patients readmitted with a primary diagnosis that is potentially related to harm

Cohort	Numbers with potential harm-related primary diagnosis					
	Readmissions within 7 days		Readmissions between 8 and 28 days		Readmissions after 28 days	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
AMI	2071	50.9 (49.4-52.4)	1802	44.2 (42.7-45.7)	5024	43.6 (42.7-44.5)
Urgent bowel surgery	169	83.7 (78.6-88.8)	204	84.0 (79.3-88.6)	432	82.1 (78.9-85.4)
Elective bowel surgery	1019	93.8 (92.4-95.3)	915	94.2 (92.8-95.7)	1807	90.2 (88.9-91.5)
Hip replacement	1325	98.6 (98.0-99.2)	1417	99.0 (98.5-99.5)	5195	98.0 (97.6-98.4)

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Table 7: Implications of different scenarios for selecting case notes for readmitted patients in terms of the proportion of 28-day readmissions selected and the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm occurring within 28 days

.Scenario	A	B	C	D	E	F
	All patients readmitted within 28 days	**All patients readmitted within 7 days**	**7-day readmissions: only primary diagnoses associated with potential harm**	**7-day readmissions: primary diagnoses associated with potential harm or other reported direct indicators of harm**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days, or other reported direct indicators of harm regardless of length of stay**
Acute Myocardial Infarction						
% selected (n)[1]	100% (8,149)	50% (4,072)	25% (2,071)	28% (2,313)	13% (1,084)	19% (1,544)
Sensitivity[2]	100%	51%	36%	51%	24%	51%
PPV[3]	21%	21%	30%	37%	37%	56%
Urgent bowel surgery						
% selected (n)[1]	100% (445)	45% (202)	38% (169)	41% (181)	18% (81)	32% (141)
Sensitivity	100%	50%	44%	50%	22%	50%
PPV	49%	53%	57%	60%	59%	77%
Elective bowel surgery						
% selected (n)[1]	100% (2,057)	53% (1,086)	50% (1,019)	50% (1,038)	26% (533)	41% (849)
Sensitivity	100%	58%	57%	58%	32%	58%
PPV	59%	65%	67%	68%	73%	83%
Hip replacement						
% selected (n)[1]	100% (2,776)	48% (1,344)	48% (1,325)	48% (1,330)	15% (420)	29% (812)
Sensitivity	100%	48%	48%	48%	20%	48%
PPV	50%	49%	50%	50%	65%	82%

1. Proportions are of all readmissions within 28 days
2. Proportion of direct indicators of harm occurring in readmissions within 28 days
3. Proportion of selected cases that have a direct indicator of harm

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Figure 1: Prevalence of harm by length of stay

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

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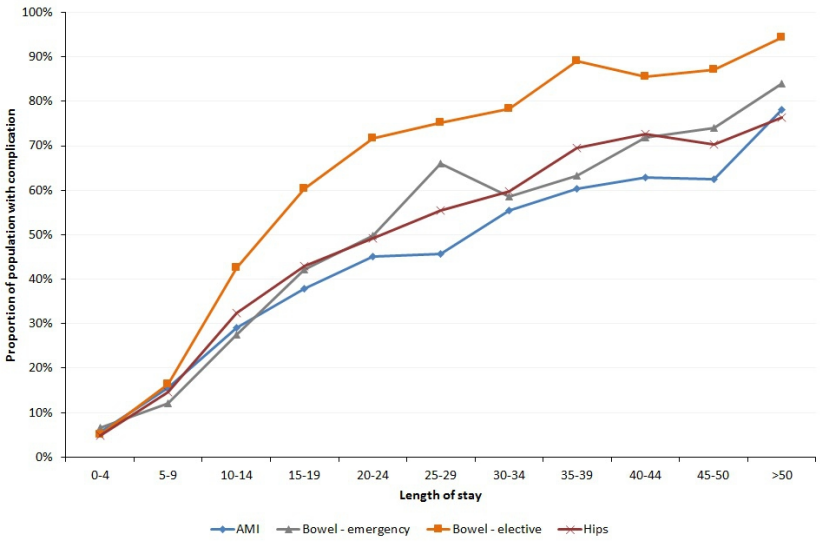

Figure 1: Prevalence of harm by length of stay

304x171mm (96 x 96 DPI)

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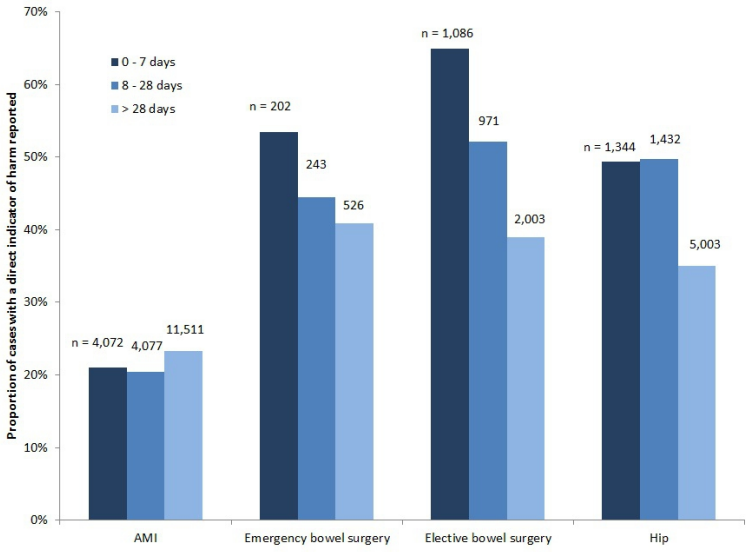

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

304x171mm (96 x 96 DPI)

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Appendix 1. Codes defining patient cohorts

Only a patient's first admission to hospital for the given condition in the financial year 2014/15 was included, where the patient was discharged alive (Dismeth=1,2,3). Patient selection is further restricted to those aged 18-149, who had an "ordinary admission" (Classpat =1) rather than a day case or maternity admission, or were classed as regular day or night attenders.

1. Acute Myocardial Infarction

a. Admission type: Emergency only (admimeth=2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
I210	Acute transmural myocardial infarction of anterior wall
I211	Acute transmural myocardial infarction of inferior wall
I212	Acute transmural myocardial infarction of other sites
I213	Acute transmural myocardial infarction of unspecified site
I214	Acute subendocardialmyocardial infarction
I219	Acute myocardial infarction, unspecified
I220	Subsequent myocardial infarction of anterior wall
I221	Subsequent myocardial infarction of inferior wall
I228	Subsequent myocardial infarction of other sites
I229	Subsequent myocardial infarction of unspecified site

c. Procedure type: None specified

2. Bowel cancer surgery

a. Admission type: Emergency and elective (admimeth = 1 or 2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
C180	Malignant neoplasm: Caecum
C181	Malignant neoplasm: Appendix
C182	Malignant neoplasm: Ascending colon
C183	Malignant neoplasm: Hepatic flexure
C184	Malignant neoplasm: Transverse colon
C185	Malignant neoplasm: Splenic flexure
C186	Malignant neoplasm: Descending colon
C187	Malignant neoplasm: Sigmoid colon
C19	Malignant neoplasm of rectosigmoid junction
C20	Malignant neoplasm of rectum

c. Procedure type: primary procedure in any episode – list of procedures as advised by bowel cancer registry.[1]

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3. Elective hip surgery

a. Admission type: Elective only (admimeth = 1)
b. Diagnosis type: None specified
c. Procedure type:
    i. Primary procedure in first episode with following codes:

Code	Procedure description
W371	Primary total prosthetic replacement of hip joint using cement
W378	Other specified total prosthetic replacement of hip joint using cement
W379	Unspecified total prosthetic replacement of hip joint using cement
W381	Primary total prosthetic replacement of hip joint not using cement
W388	Other specified total prosthetic replacement of hip joint not using cement
W389	Unspecified total prosthetic replacement of hip joint not using cement
W391	Primary total prosthetic replacement of hip joint NEC
W398	Other specified other total prosthetic replacement of hip joint
W399	Unspecified other total prosthetic replacement of hip joint
W931	Primary hybrid prosthetic replacement of hip joint using cemented acetabular component
W938	Other specified hybrid prosthetic replacement of hip joint using cemented acetabular component
W939	Unspecified hybrid prosthetic replacement of hip joint using cemented acetabular component
W941	Primary hybrid prosthetic replacement of hip joint using cemented femoral component
W948	Other specified hybrid prosthetic replacement of hip joint using cemented femoral component
W949	Unspecified hybrid prosthetic replacement of hip joint using cemented femoral component
W951	Primary hybrid prosthetic replacement of hip joint using cement NEC
W958	Other specified hybrid prosthetic replacement of hip joint using cement
W959	Unspecified hybrid prosthetic replacement of hip joint using cement

OR

ii. In first episode:

Primary procedure	Any subsequent procedure	Procedure description
W521	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone using cement NEC
W531	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone not using cement NEC
W541	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone NEC
W581	And (Z843 Or Z761 Or Z756)	Primary resurfacing arthroplasty of joint

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Appendix 2. Definitions of direct indicators of harm

Condition	ICD-10 codes	Source
1. Complications and adverse reactions		Ghali et al[2]
• Complications of surgical and medical care: *T80-T88 codes are post-procedural complications/disorders that are not specifically classified to a post-procedural disorder code within a body system chapter.*	T80-88	
• Drugs, medicaments and biological substances causing adverse effects in therapeutic use: *These are adverse effects that result from the proper use of a substance and a reaction to that drug or medicine occurs. This type of reaction can be described as: adverse effect of drug, allergic reaction, cumulative toxicity, hypersensitivity, idiosyncratic reaction, interaction of drugs, 'side effects'. The adverse effect should be recorded first, followed by the Y40-59 code naming the medication/drug that caused it*	Y40-Y59	
• Misadventures to patients during surgical and medical care: *When misadventure to a patient occurs during a procedure, a code from categories Y60-Y69 must be assigned in a secondary position to the code describing the misadventure caused.*	Y60-Y69	
• Medical devices associated with adverse incidents in diagnostic and therapeutic use: *If an adverse incident that is out of the surgeon's control occurs during a procedure, a code from categories Y70-Y82 must be assigned in a secondary position to the code describing the adverse incident caused.*	Y70-82	
• Surgical and other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure: *Where an abnormal reaction of the patient occurs after the procedure, a code from categories Y83-Y84 must be assigned.*	Y83-84	
2. Sequelae of injuries of poisoning & other consequences: *A sequelae or "late effect" is a current condition in a patient that is caused by a previous condition which is no longer present. The code describing the current condition must be sequenced before a code from categories T90-T98.*	T90-T98	Blunt et al[3]
3. Thrombo-embolism		
• Pulmonary embolism	I26.0, I26.9	
• Cerebral infarction	I63.1, I63.4	
• Arterial embolism and thrombosis	I74,	
• Phlebitis and thrombophlebitis, Portal vein thrombosis, Other venous embolism/thrombosis	I80-82	
• Air embolism, Fat embolism	T79.0, T79.1	
4. Pneumonia		Blunt et al[3] and extended following clinical
• Viral pneumonia, not elsewhere classified	J12	
• Pneumonia due to Streptococcus pneumoniae	J13	
• Pneumonia due to Haemophilus influenza	J14	
• Bacterial pneumonia, not elsewhere classified	J15	
• Pneumonia due to other infectious organisms, not elsewhere	J16	

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classified • Pneumonia in diseases classified elsewhere • Pneumonia, organism unspecified	 J17 J18	advice
5. Pressure sores: Decubitus ulcer and pressure area was considered indicative of suboptimal care.	L89	Blunt et al[3]
***6.* Poisoning by drugs medicaments & biological substances:** *Reactions to drugs and medicines that occur from their improper use must be coded with (T36-T50). Poisoning can also be described as: intoxication, overdose, therapeutic misadventure, toxic effect/toxicity, wrong dosage given or taken, wrong substance given or taken.*	T36-T50	Blunt et al[3]
7. Urinary Tract Infections	N39	Recommended by clinicians
8. Falls • Falls: All falls, excluding falls involving ice-skates, skis, roller-skates or skateboards; playground equipment; ladder; scaffolding, tree or cliff • In-hospital falls: The codes are as above, with a fifth character of 2 which is generically "School, other institution and public administrative area" but includes a hospital. Brand et al suggest this as a way to captures in-hospital falls	 W01, W03-08, W10, W13, W17-19 With additional .2	Brand & Sundararajan[4]
9. Fracture • Fracture of: neck, rib(s), sternum and thoracic spine, lumbar spine and pelvis, shoulder and upper arm, forearm, wrist and hand level, femur, lower leg, foot • Fractures involving multiple body regions, Fracture of: spine, upper or lower limb	 S12, S22, S32, S32, S42, S52, S62, S72, S82, S92, T02, T08, T10, T12	Brand & Sundararajan[4]
10. Post procedural complications: Body system specific post-procedural complication • Post-procedural endocrine and metabolic disorders, not elsewhere classified • Post-procedural disorders of nervous system, not elsewhere classified • Post-procedural disorders of eye and adnexa, not elsewhere classified • Post-procedural disorders of ear and mastoid process, not elsewhere classified • Post-procedural disorders of circulatory system, not elsewhere classified • Post-procedural respiratory disorders, not elsewhere classified • Post-procedural disorders of digestive system, not elsewhere classified	 E89 G97 H59 H95 I97 J95 K91	Recommended by clinical coders

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• Post-procedural musculoskeletal disorders, not elsewhere classified • Post-procedural disorders of genitourinary system, not elsewhere classified	M96 N99	
11. Hospital acquired infections: *When the responsible consultant has documented in the medical record that a condition is 'hospital acquired' code Y95.X Nosocomial condition must be assigned directly after the code for the condition that has been documented as being 'hospital acquired'*	Y95X	Recommended by clinical coders

Source: Many of the definitions listed were taken from the National Clinical Coding Standards guidance (Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. 2017)

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Appendix 3: Further supplementary tables

Table 3.1: Regression parameters modelling length of stay

Variable	AMI			Elective bowel surgery			Emergency bowel surgery			Hip replacement		
	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value
Charlson score (reference value = 0)												
1	0.61	0.09	< 0.001	1.15	0.23	< 0.001	1.91	0.96	0.05	0.58	0.06	< 0.001
2	0.92	0.09	< 0.001	0.48	0.21	0.02	2.02	0.82	0.01	0.56	0.05	< 0.001
3	1.66	0.11	< 0.001	1.56	0.30	< 0.001	0.64	1.05	0.54	1.07	0.07	< 0.001
≥ 4	2.66	0.10	< 0.001	1.39	0.17	< 0.001	0.91	0.51	0.08	1.86	0.09	< 0.001
IMD quintile (reference value = 1, category 5 is most deprived)												
2	-0.14	0.09	0.13	-0.04	0.23	0.85	-1.55	0.73	0.03	-0.15	0.06	0.01
3	-0.17	0.09	0.07	-1.03	0.22	< 0.001	-1.49	0.70	0.03	-0.28	0.06	< 0.001
4	-0.35	0.10	< 0.001	-1.04	0.22	< 0.001	-1.91	0.70	0.007	-0.37	0.06	< 0.001
5	-0.37	0.10	< 0.001	-1.18	0.22	< 0.001	-2.33	0.73	0.001	-0.40	0.06	< 0.001
Age (reference category = 18 – 49)												
50 – 54	0.29	0.14	0.05	0.36	0.41	0.38	-0.97	1.15	0.4	-0.07	0.10	0.44
55 – 59	0.49	0.14	< 0.001	0.95	0.37	0.01	0.60	1.12	0.59	-0.04	0.09	0.68
60 – 64	0.81	0.14	< 0.001	0.78	0.34	0.02	1.25	1.05	0.23	0.08	0.08	0.32
65 – 69	1.07	0.13	< 0.001	0.89	0.33	0.008	1.58	1.00	0.11	0.23	0.08	0.004
70 – 74	1.43	0.14	< 0.001	1.30	0.33	< 0.001	2.35	0.99	0.02	0.59	0.08	< 0.001
75 – 79	2.05	0.14	< 0.001	1.65	0.33	< 0.001	3.01	0.95	0.002	1.15	0.08	< 0.001
80 – 84	2.12	0.14	< 0.001	2.28	0.35	< 0.001	5.16	0.98	< 0.001	2.24	0.09	< 0.001
85 – 89	2.45	0.15	< 0.001	2.57	0.41	< 0.001	3.34	1.11	0.003	3.89	0.11	< 0.001
90+	2.67	0.17	< 0.001	2.92	0.73	< 0.001	6.16	1.41	< 0.001	5.16	0.20	< 0.001

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Female gender	0.20	0.07	0.003	-0.47	0.14	< 0.001	1.58	0.45	< 0.001	0.45	0.04	< 0.001
Number of emergency admissions in previous year	0.08	0.02	< 0.001	0.45	0.08	< 0.001	0.38	0.22	0.08	0.77	0.03	< 0.001
Reported harm												
Complications and adverse reactions	3.84	0.15	< 0.001	7.29	0.19	< 0.001	8.26	0.59	< 0.001	3.04	0.07	< 0.001
Sequelae	-1.82	1.14	0.11	5.75	2.79	0.04	*	*	*	0.90	0.28	0.001
Thromboembolism	4.08	0.39	< 0.001	8.88	0.75	< 0.001	10.11	1.41	< 0.001	5.31	0.30	< 0.001
Pneumonia	6.50	0.18	< 0.001	9.37	0.49	< 0.001	9.76	1.10	< 0.001	5.90	0.27	< 0.001
Pressure sores	7.61	0.34	< 0.001	12.47	0.91	< 0.001	9.21	1.56	< 0.001	6.08	0.28	< 0.001
Poisoning	1.70	1.34	0.2	3.50	5.08	0.49	-9.18	12.50	0.46	1.70	0.87	0.05
Urinary tract infections	7.41	0.17	< 0.001	9.11	0.36	< 0.001	9.05	0.87	< 0.001	3.99	0.14	< 0.001
In-hospital falls	8.90	0.50	< 0.001	15.13	1.59	< 0.001	17.92	2.43	< 0.001	4.16	0.34	< 0.001
Fractures	12.17	0.51	< 0.001	5.66	2.59	0.03	3.25	4.76	0.49	3.99	0.26	< 0.001
Post-procedural complications (body system specific)	5.71	0.56	< 0.001	8.54	0.26	< 0.001	9.17	0.90	< 0.001	1.77	0.22	< 0.001
Hospital acquired infections	11.25	0.32	< 0.001	0.43	0.62	0.48	0.90	1.42	0.52	3.85	0.34	< 0.001

* The number of reported cases of sequelae in emergency bowel surgery patients was too low

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Table 3.2: List of most common primary diagnoses within each cohort including frequency and whether associated with potential harm

Primary diagnosis	AMI		Bowel surgery		Hip surgery	
	N	%	N	%	N	%
Abdominal and pelvic pain			75	5.8%		
Acute myocardial infarction	721	17.7%				
Acute renal failure			26	2.0%		
Angina pectoris	211	5.2%				
Atrial fibrillation and flutter	66	1.6%				
Cellulitis					28	2.1%
Chronic ischaemic heart disease	254	6.2%				
Complications of internal orthopaedic prosthetic devices, implants and grafts					181	13.5%
Complications of procedures, not elsewhere classified			338	26.2%	120	8.9%
Diarrhoea and gastroenteritis of presumed infectious origin			28	2.2%		
Heart failure	273	6.7%				
Malignant neoplasm of colon			31	2.4%		
Other acute ischaemic heart diseases	149	3.7%				
Other diseases of digestive system			33	2.6%		
Other disorders of urinary system			36	2.8%		
Other functional intestinal disorders			41	3.2%	32	2.4%
Other joint disorders, not elsewhere classified					71	5.3%
Other soft tissue disorders, not elsewhere classified					248	18.5%
Pain in throat and chest	594	14.6%				
Paralytic ileus and intestinal obstruction without hernia			85	6.6%		
Phlebitis and thrombophlebitis					33	2.5%
Pneumonia, organism unspecified	168	4.1%			31	2.3%
Postprocedural disorders of digestive system, not elsewhere classified			153	11.9%		
Pulmonary embolism					26	1.9%
Retention of urine					32	2.4%
Subsequent myocardial infarction	119	2.9%				
Unspecified acute lower respiratory infection	65	1.6%				
All other diagnoses	1452	35.7%	442	34.30%	542	40.30%

Not related to harm | Potentially related to harm

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References

1. National Bowel Cancer Audit. Clinical Audit and Registries Management Service. https://www.nboca.org.uk/resources/nboca-dataset/ (Accessed 9th June 2018).
2. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
3. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
4. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51

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An observational study to determine the utility of hospital administrative data to support case finding of English patients at higher risk of severe healthcare-related harm

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Abstract

Objectives: To identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying avoidable severe harm

Design: Development and testing of thresholds and criteria for two indirect indicators of healthcare-related harm (long length of stay [LOS] and emergency readmission) to determine the yield of specified harms coded in Hospital Episode Statistics (HES).

Setting: Acute NHS hospitals in England

Participants: HES for acute myocardial infarction (AMI), bowel cancer surgery and hip replacement admissions from 2014/15

Interventions: Case-mix-adjusted linear regression models were used to determine expected LOS. Different thresholds were examined to determine the association with harm. Screening criteria for readmission included time to readmission, length of readmission and diagnoses in initial admission and readmission. The association with harm was examined for each criterion.

Results: The proportions of AMI cases with a harm code increased from 14% among all cases to 47% if a threshold of three times the expected LOS was used. For hip replacement the respective increase was from 10% to 51%. However as the number of patients at these higher thresholds was small, the overall proportion of harm identified is relatively small (15%, 19%, 9% and 8% among AMI, urgent bowel surgery, elective bowel surgery and hip replacement cohorts respectively). Selection of the time to readmission had an effect on the yield of harms but this varied with condition. At least 50% of surgical patients had a harm code if readmitted within 7 days compared with 21% of AMI patients.

Conclusions: Our approach would select a substantial number of patients for case record review. Many of these cases would contain no evidence of healthcare-related harm. In practice, Trusts may choose how many reviews it is feasible to do in advance and then select random samples of cases that satisfy the screening criteria.

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Article Summary

Strengths and limitations of the study

- Routine hospital administrative data is inexpensive and easy to access.
- Potential healthcare-related harm can be identified in these data by specific codes used for such harms e.g. complications and adverse reactions or by using indirect indicators known to be linked to such harm such as long length of stay (LOS) or readmission
- Comparing the performance of long LOS and readmission across four contrasting cohorts of patients (emergency: acute myocardial infarction [AMI]; urgent: non-elective bowel cancer surgery; semi-urgent: elective bowel cancer surgery; and elective: hip replacement) when thresholds for LOS and criteria for readmission are manipulated shows that sensitivity and positive predictive power to identify harm can be increased.
- To confirm if any harm identified in the administrative records is healthcare-related, retrospective case record review is required
- The approach would identify potential healthcare-related harm in large numbers of cases. A selection process for those going forward to case record review would be required.

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Introduction

There are two main ways avoidable severe harm is identified in patients in acute hospitals in the NHS in England. However, both approaches have shortcomings. Incident reporting systems depend on staff compliance whilst retrospective case record reviews (RCRR) requires considerable resources which preclude universal application to all hospital admissions.

An alternative approach could be for hospitals to employ administrative data to screen records for case note review. These include codes for healthcare-related harm ('direct' indicators of harm) such as 'complications and adverse events' or 'pulmonary embolism after a surgical procedure'. In theory, all harm should be recorded though the completeness of recording is doubtful. In addition, the data will not distinguish between levels of severity so instances of severe harm cannot be distinguished from lesser forms. There has been no recent estimation of the completeness of reporting of harm in administrative data, but a historical (1999-2003) comparison with Australia suggested under-reporting: 2.2% of all NHS admissions compared with 4.75% in Australia.[1, 2]

Administrative data also offers the possibility of using two 'indirect' indicators that reflect the potential consequences of healthcare-related harm: longer than expected length of stay (LOS) and unplanned readmission. Such indicators might be used to identify those patients in whom it is likely harm has occurred even if it had not been recorded. In this way the detection or yield of harm could be enhanced. Support for such an approach comes from RCRR studies that have shown adverse events are associated with longer LOS,[3-5] though the direction of causality is unclear as a longer stay increases the risk of an error in care and subsequent harm.[6, 7] Similarly, a high rate of unplanned readmissions has been shown to be associated with harm having occurred.[8-10]

Our aim was to identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying those patients who suffered avoidable severe harm. In this paper we focus on exploring the potential use of two indirect measures (long lengths of stay and early unplanned readmissions) in patients with one of four tracer conditions (acute myocardial infarction, bowel cancer surgery (elective and emergency) and hip replacement). These were selected to

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represent elective, urgent and emergency admissions for medical and surgical reasons.

With lengths of stay we have evaluated different thresholds for defining a long stay; whilst with early readmissions we have assessed a range of criteria. To evaluate different thresholds we assessed how they are associated with the presence of direct indicators of harm coded within the electronic care records. We then used this to understand the resource implications for choosing different screening criteria. Our specific analyses, therefore, focussed on:

- The relationships between direct indicators of harm and::
  - Long lengths of stay;
  - The time between a patient is discharged from hospital and readmitted as an emergency;
  - The length of a readmission spell;
- How the presence of a direct indicator of harm affects the chances of a subsequent readmission, and
- Primary diagnoses on readmission that reflect potential harm.

Method

Data

For this analysis we used hospital administrative data as reported in Hospital Episode Statistics (HES) for the 2014/15 financial year. Diagnosis and procedure codes are based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) and the OPCS Classification of Interventions and Procedures, version 4 (OPCS-4). There are 20 diagnostic fields per episode: a primary diagnosis and up to 19 secondary diagnoses.

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Categorising direct indicators of harm

A set of ICD-10 codes were selected as direct indicators of harm. These included complications and adverse reactions [T80-88; Y40-84] plus others identified from the literature,[11-13] or through consultation with clinicians and clinical coders and other sources of guidance. [14, 15] Direct indicators of harm were divided into eight groups: complications and adverse reactions; thromboembolism; pneumonia; pressure sores; urinary tract infections; falls; fractures; post-procedural complications. Further details on these definitions are shown in *Appendix 1*.

Selection of patient cohorts

Given that the approach to using direct or indirect indicators might vary by the type of admission and condition, we selected four examples that represented both medical and surgical conditions and the urgency of the admission: (1) emergency: acute myocardial infarction (AMI); (2) urgent: non-elective bowel cancer surgery; (3) semi-urgent: elective bowel cancer surgery; and (4) elective: hip replacement. A full list of ICD-10 and OPCS-4 codes for defining these cohorts is suppled in *Appendix 2*. Cohorts were restricted to adults (over 17 years), their first admissions in 2014/15 to an acute NHS hospital in England for the relevant condition or surgery, and discharged alive. Admissions excluded day cases or regular day or night attenders.

Evaluating thresholds for unexpected long length of stay (LOS)

Length of stay was measured as the time between admission and discharge, ignoring transfers to other hospitals. The expected LOS of each patient was estimated using a linear regression model that controlled for age, sex, comorbidities, deprivation and emergency admissions in the previous 12 months. Comorbidities were measured using the Charlson Score and deprivation by quintiles of the Index of Multiple Deprivation (IMD). The expected LOS was estimated for each of the patient cohorts in 2013/14 and the parameter estimates applied to the 2014/15 population.

Thresholds for long lengths of stay were defined as multiples of the expected values, specifically two, three, four and five times. For each threshold we investigated the association with the direct indicators of harm using a linear regression model adjusting for age, sex, Charlson Score, IMD and number of emergency admissions in the previous year. We then evaluated the impact of different thresholds on the

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number of patient records that each trust would have to review in order to find instances of harm (positive predictive value) and the proportion of patients with harms reported in the spell that would be selected (sensitivity).

Unplanned readmission

Patients in each cohort were identified as having an unplanned readmission if their subsequent admission was an emergency and occurred either in 2014/15 or 2015/16. Screening criteria for readmissions were derived from combinations of:

- time to readmission,
- harm reported in the first episode of the readmission spell,
- harm reported in the initial admission (present either in second or subsequent episodes),
- primary diagnosis on readmission, and
- length of the readmission spell.

The relevance of the primary diagnosis on readmission to harm having occurred in the previous admission was determined by expert clinical review. The reviewers judged whether the primary diagnosis codes used in the dataset could represent healthcare-related harm. This was done for each cohort to allow for differences types of harm between the four cohorts (e.g. conditions that are relevant for the hip replacement cohort may not be relevant for the AMI cohort).

As with lengths of stay, different options were evaluated in terms of proportions of case notes to be reviewed, and the sensitivity and positive predicted value associated with the occurrence of direct indicators of harm.

Patient Involvement

Two patients sat on the Steering Group for this study and contributed to decisions on the number and type of harm codes that were to be used.

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Results

Mean age was similar across the patient cohorts (68-70 years) and each cohort had similar distribution of socio-economic status (*Table 1*). There were differences in sex: men made up 66% of the AMI cohort but only 40% of the elective hip replacements. There were also differences in comorbidity: 45% of emergency bowel cancer patients had Charlson scores of four or more compared to 5% of patients receiving elective hip replacement.

What is the relationship between long lengths of stay and direct indicators of harm?

The median LOS differed between cohorts (*Table 2*) and the distribution was highly positively skewed. The prevalence of harm increased with LOS (*Figure 1*). For example, 94% of emergency bowel surgery patients staying longer than 50 days had experienced harm compared to 16% in those who stayed 5-9 days. Linear regression analysis found that nearly all categories of harm were significantly positively associated with LOS: some exceptions being fractures in emergency bowel cancer patients and hospital-acquired infections in all bowel cancer patients (*Appendix 3, Table 3.1*).

What are the resource implications for choosing different screening criteria derived from length of stay?

The impacts of different length of stay thresholds on the numbers of patient notes that would be selected and on the sensitivity of detecting harm are shown in *Table 3*.

Of all the patients with a direct indicator of harm, the proportion included in these subgroups (the sensitivity) decreases as the threshold rises, from 56% to 15%. At the same time, the positive predictive value (PPV - the number of cases identified in each threshold that would actually have a harm code) increases. For example, for hip replacement the value rises from 10% among all patients to 51% for those staying 3 times longer than expected.

What is the relationship between the presence of a direct indicator of harm and time to emergency readmission?

Rates of readmission within seven days for AMI and bowel surgery (6-7%) are notably higher than for hip replacement (2.6%) (*Table 2*). Approximately half of

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readmissions within 28 days occur within the first seven days. More than half the surgical patients readmitted within seven days had a direct indicator of harm compared to 21% in the AMI cohort (*Figure 2*). With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This pattern among the surgical cohorts is specifically due to declines in 'complications and adverse reactions' which constitutes approximately 65% of harm across these groups in contrast to the AMI cohort where only 25% are 'complications and adverse reactions'.

How does the presence of a direct indicator of harm affect the chances of a subsequent emergency readmission?

For individuals who have a direct indicator of harm reported in the initial spell, the seven-day readmission rates are higher than the overall seven-day rates for each cohort except those undergoing urgent bowel cancer surgery (*Table 4*). After adjusting for age and likelihood of readmission (using Patients at Risk of Re-admission within 30 days Score[16]), the time to readmission was only related to the record of a direct indicator of harm in the initial spell for the AMI cohort (excluding cases where there was a direct indicator of harm reported in both the initial spell and the readmission).

How is the presence of a direct indicator of harm related to the length of a readmission spell?

The proportion being readmitted for more than three days varied by cohort: bowel surgery over 50%, AMI 44%, hip replacement 32%. The latter group have more patients who stay for less than a day (32% compared to 13% to 17% for the other cohorts). 44% of these readmissions are for conditions reported as 'other soft tissue disorders' and they also include all patients with a primary diagnosis of 'phlebitis and thrombophlebitis' (including deep vein thrombosis). The latter represent cases where patients are discharged quickly after the readmission to manage the condition in the community. Direct indicators of harm are significantly more prevalent when the readmission LOS is longer than three days (*Table 5*) (p-value < 0.001 for each cohort).

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In how many readmissions is a potential harm suggested by the primary diagnosis?

Just over half of readmissions within seven days for the AMI cohort were admitted with a primary diagnosis that was judged by expert review to be potentially related to harm (*Table 6*). This compares with much higher proportions among the other cohorts, with nearly 99% of the hip surgery cohort having a diagnosis that could be potentially related to harm among that group (more details in *Appendix 3: Table 3.2*). There were no significant differences in the proportions within 7 days from 8-28 days among the surgical cohorts. However, there are significant reductions in proportions among elective bowel surgery readmissions that occur after 28 days ($p < 0.001$). Among the AMI cohort, the proportion among the earlier readmissions (50.9%) is significantly higher than among the later readmissions ($p < 0.001$).

What are the resource implications for choosing different screening criteria derived from emergency readmissions?

Choices of criteria against which to select case records for review will depend on a trade-off between numbers of cases selected and proportion of harm that is found. Table 7 shows the outcomes of different criteria using 28-day readmissions as a baseline against which to compare proportions of notes selected and sensitivities. With the hip surgery and elective bowel replacement cohorts, given the majority of the primary diagnoses on readmission are associated with harm having occurred (*Table 7*), restricting selection to these primary diagnoses (scenario C) makes little difference. Further limiting selection to cases where readmission lengths of stay exceed three days will reduce the number of case records for review by 50% or more but will correspond to larger reductions in sensitivity (comparing scenario E with scenario C). Including any cases where direct indicators of harm are present, regardless of length of stay and primary diagnosis will increase the positive predictive value at the expense of having a larger proportion of notes to review.

Discussion

Main findings

It is possible to derive criteria from hospital administrative data to select case records in order to find cases of severe hospital-related harm. Our findings suggest that

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adopting screening rules based on two indirect indicators (long lengths of stay and early readmission) has the potential to improve the targeting of case record reviews. The precise scale of any improvements is unclear until selection criteria have been tested against the outcomes of such reviews.

The selection of length of stay thresholds for screening could have a significant impact on the yield of cases of harm. For example, over half those who stayed at least three times longer than expected had a direct indicator of harm. The positive predictive value of the screen increases across the thresholds, such that the number of cases identified as having a direct indicator of harm as a proportion of all cases examined increases. By manipulating LOS threshold, choices can be made in relation to the trade-off between the number of cases that will actually have a harm code present at that threshold and the proportion of all the harm that will be found if only those cases are investigated.

Selection of the time to readmission has an effect on the yield of potential cases of harm but it varies by condition. At least 50% or more of the surgical patients had a direct indicator of harm if readmitted within 7 days, compared with 21% in the AMI cohort. With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This suggests that the sampling window for the latter two conditions could be extended to 28 days without significant impact, with the added benefit of increasing the number of patients in the hip replacement cohort where there are relatively few readmissions. The lack of relationships between a harm code found in the initial admission with time to readmission suggests that the occurrence of harms in the initial episode may not be useful as a criterion for selecting case records, except, perhaps, for AMI patients. However, because we were not able to identify individuals who had died outside hospital soon after the initial spell this analysis may underestimate subsequent outcomes after discharge following a harm.

For primary diagnoses on readmission deemed to be potentially associated with harm, there were higher frequencies among the surgical cohorts with between 80% and 100% of readmission primary diagnoses identified by clinical reviewers being potentially associated with harm. For the AMI cohort, the corresponding proportion

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was around 50%. This suggests that the nature of the primary readmission diagnosis can be useful as a further criterion for selecting case records and this approach would have the greatest impact on the AMI cohort.

Our assessments of thresholds used positive predictive values and sensitivity as we were interested in the value of case note review in revealing a harm and an indication of how effective they are at detecting all harms that may have occurred. We could also have used specificity and negative predictive values, but considered them less useful in this context.

Other literature

Previous RCRR studies estimated that the proportion of inpatients with an adverse event ranged from 3.8% to 16.6%.[17] Across the four cohorts, we found higher proportions of harm codes. However, the conditions we studied were chosen to highlight different admission types and were not representative of all conditions. Similar rates of harm in bowel cancer patients (between 20% and 40%) have been found in previous studies.[18] A recent Dutch study found a higher proportion of harm in patients admitted with AMI, between 13.3 and 29.9%.[19] The harm in this study was found using an audit tool to screen electronic patient records which could account for a greater proportion of harm being uncovered. National clinical audits suggest that the rate of complications after percutaneous coronary interventions is around 9% in England,[20] and after total hip replacement are about 1% for infection and venous thromboembolism and 3-4% for dislocation.[21] This is consistent with the lower incidence of harm that we found in this group.

Our study is the first to look at the relationships between different LOS thresholds and a variety readmission characteristics and coded harm in hospital administrative records in the UK. The Dutch have used a threshold based indicator, unexpectedly long LOS (UL-LOS), defined as the percentage of clinically admitted patients with an actual hospital stay that is more than 50% longer than expected, as a generic indicator of hospital safety for a number of years.[22] Cihangir et al found a significant positive correlation between UL-LOS and another indicator of potentially poor quality care, the hospital standardised mortality ratio ($r=0.44$ ($p<0.001$)) in hospital administrative data from two-thirds of Dutch hospitals.[23] In a small, single site validation study the authors found that in 85 out of 191 colorectal cancer patients

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with UL-LOS, 43 (51%) had one or more adverse events, compared with 9% (4 out of 44) in the non-unexpected long LOS group.[24]

Limitations

There are a number of limitations to be considered when interpreting our findings. First, our estimates of harm, based on our inclusive approach, are inflated by an element of double counting when the same harms are coded under more than one of the harm categories. This inflation is compounded by the fact that we inevitably include a number of conditions that were present on admission without the routine application of" present on admission" codes. Harm codes such as pneumonia or urinary tract infection, which occur more commonly in emergency medical patients, are also more difficult to attribute to healthcare-related processes. It is also known that hospitals vary in the way they use complication and adverse reaction codes which has the potential to introduce further bias in measurement.[1]

Second, one of the main limitations of developing screening approaches is the accuracy and completeness of the routine data.[1, 25] This limitation is particularly important to consider in this study which used harm codes for the internal validation of indirect indicators of harm derived from the same routine hospital administrative data source. As our approach to harm code definitions was inclusive in an attempt to increase sensitivity, it is likely that our estimates are inflated which may have biased assessment of the performance of indirect indicators as screening tools.

Third, to assess the feasibility of using indirect indicators to detect cases of harm, we have relied on direct indicators. However, we cannot know the relationship with other types of harm that are not so easily identifiable within routine data, and whether approaches that would work for the detection of harm codes we identified would work more generally. Our analytic approach can indicate that a patient may have experienced harm and the patterns of harm amongst groups of patients with differing conditions and across an organisation but it cannot confirm if that harm was healthcare-related, its severity or its avoidability without recourse to case record review.

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Finally, not all long lengths of stay reflect a patient's acute care needs as there may be several days when a patient is awaiting discharge. However, it has not been possible to distinguish these from the data.

Implications

Screening for harm using routine data allows large numbers of records to be rapidly processed with minimal resources required. The Global Trigger Tool has also been developed as a harm screening tool.[26] However using this tool to identify triggers linked to harm, case records need to be individually screened, which is usually done manually creating a more resource intense process. Our approach to screening using long lengths of stay or early readmissions would identify a substantial number of patients for case record review if extended across all patients. In 2014/15, there were approximately 16 million admissions to all NHS acute trusts in England,[27] yet the cohorts we included in this analysis comprised less than 1%. If a threshold of twice the expected length of stay was used for screening, we estimate this would have resulted in 9,974 case record reviews in 2014/15 across the four cohorts, which equates to about 70 per trust. If we assume a similar length of stay distribution across all hospital admissions, this scales up to around 7,000 reviews per year in an average sized trust. Furthermore, having increased the sensitivity of the screening process at the expense of specificity, many of these cases would contain no evidence of healthcare-related harm.

In practice, therefore, this suggests that one approach might be for Trusts to decide how many reviews they are going to do in advance and then select random samples of cases that satisfy the screening criteria. Consideration of how to adapt or create algorithms applicable to wider patient populations would also be required.

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Ethics

This study was approved by North West- Lancaster Research Ethics Committee (15/NW/0941).

Contributorship

HH, NB, CSJ and JVM designed the study. CSJ, NCO and KC carried out the analyses. NB,CSJ and HH wrote the first draft of the manuscript. All authors provided input and approved the final version for submission.

Conflicts of interest

None

Data Sharing Statement

Further details on statistical models and definitions are available from the Nuffield Trust at research@nuffieldtrust.org.uk.

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References

1. Aylin P, Tanna S, Bottle A, Jarman B. How often are adverse events reported in English hospital statistics? BMJ. 2004 Aug 14;329(7462):369
2. Australian Institute for Health and Welfare. Reporting of adverse event in routinely collected data sets in Australia. Australian Institute for Health and Welfare,, 2001.
3. Sari AB ST, Cracknell A, Turnbull A, Dobson Y, Grant C, Gray W, Richardson A. Extent, nature and consequences of adverse events: results of a retrospective casenote review in a large NHS hospital. Qual Saf Health Care. 2007;16(6):434-9
4. Baker GR, Norton PG, Flintoft V, Blais R, Brown A, Cox J, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. CMAJ. 2004;170(11):1678-86
5. Davis P, Lay-Yee R, Briant R, Ali W, Scott A, Schug S. Adverse events in New Zealand public hospitals I: occurrence and impact. N Z Med J. 2002;115(1167):U271
6. Asher RA. The dangers of going to bed. Crit Care Update. 1983;10(5):40-1, 51
7. Kandula PV, Wenzel RP. Postoperative wound infection after total abdominal hysterectomy: a controlled study of the increased duration of hospital stay and trends in postoperative wound infection. Am J Infect Control. 1993;21(4):201-4
8. Care Quality Commission Intelligent monitoring: NHS acute hospitals- indicators and methodology guidance. Care Quality Commission 2015.
9. Nolte E, McKee M, Wait S. Chapter 2. Describing and evaluating health systems. Maidenhead: Open University Press, 2005.
10. Leng GC, Walsh D, Fowkes FG, Swainson CP. Is the emergency readmission rate a valid outcome indicator? Qual Health Care. 1999;8(4):234-8
11. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
12. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51
13. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
14. Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. Health and Social Care Information Centre, 2017.
15. NHS Digital. HES Data Dictionary : Admitted Patient Care (May 2016). NHS Digital, 2016.
16. Billings J, Blunt I, Steventon A, Georghiou T, Lewis G, Bardsley M. Development of a predictive model to identify inpatients at risk of re-admission within 30 days of discharge (PARR-30). BMJ Open. 2012;2(4)
17. de Vries EN, Ramrattan MA, Smorenburg SM, Gouma DJ, Boermeester MA. The incidence and nature of in-hospital adverse events: a systematic review. Qual Saf Health Care. 2008;17(3):216-23
18. Alves A, Panis Y, Mathieu P, Mantion G, Kwiatkowski F, Slim K, et al. Postoperative mortality and morbidity in French patients undergoing colorectal surgery: results of a prospective multicenter study. Arch Surg. 2005 Mar;140(3):278-83, discussion 84
19. Eindhoven DC, Borleffs CJ, Dietz MF, Schalij MJ, Brouwers C, de Bruijne MC. Design and reliability of a specific instrument to evaluate patient safety for patients with acute myocardial infarction treated in a predefined care track: a retrospective patient record review study in a single tertiary hospital in the Netherlands. BMJ Open. 2017 Mar 20;7(3):e014360
20. Banning AP, Baumbach A, Blackman D, Curzen N, Devadathan S, Fraser D, et al. Percutaneous coronary intervention in the UK: recommendations for good practice 2015. Heart. 2015 May;101 Suppl 3:1-13

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21. National Joint Registry Editorial Board. National Joint Registry for England, Wales, Northern Ireland and Isle of Man 13th Annual Report. National Joint Registry, 2016.
22. Ghielen J, Cihangir S, Hekkert K, Borghans I, Kool RB. Can differences in length of stay between Dutch university hospitals and other hospitals be explained by patient characteristics? A cross-sectional study. BMJ Open. 2019 Feb 15;9(2):e021851
23. Borghans I, Hekkert KD, den Ouden L, Cihangir S, Vesseur J, Kool RB, et al. Unexpectedly long hospital stays as an indicator of risk of unsafe care: an exploratory study. BMJ Open. 2014;4(6):e004773
24. Cihangir S, Borghans I, Hekkert K, Muller H, Westert G, Kool RB. A pilot study on record reviewing with a priori patient selection. BMJ Open. 2013;3(7):e003034
25. Raftery J, Roderick P, Stevens A. Potential use of routine databases in health technology assessment. Health technology assessment. 2005 May;9(20):1-92, iii-iv
26. Griffin F, Resar R. IHI Global Trigger Tool for measuring adverse events. 2nd Edition. Cambridge, Massachusetts: Institute for Healthcare Improvement, 2009.
27. Hospital Episode Statistics: Admitted Patient Care, England 2014-15. Health and Social Care Information Centre , 2015, https://files.digital.nhs.uk/publicationimport/pub19xxx/pub19124/hosp-epis-stat-admi-summ-rep-2014-15-rep.pdf.

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Table 1: Patient cohort characteristics

	Acute Myocardial Infarction		Urgent bowel surgery		Elective bowel surgery		Hip replacement	
	N	%	N	%	N	%	N	%
Sex								
Male	39,887	66	1,637	52	9,856	58	21,206	40
Female	20,299	34	1,490	48	7,245	42	31,532	60
Age group (years)								
< 54	11,017	18	471	15	1,849	11	6,651	13
55 - 64	12,504	21	533	17	3,567	21	10,622	20
65-74	13,935	23	801	26	5,757	34	18,345	35
75 - 84	14,029	23	951	30	4,839	28	14,437	27
> 85	8,701	14	371	12	1,089	6	2,683	5
Charlson score								
0	24,299	40	1,037	33	8,286	48	34,203	65
1	9,448	16	203	6	1,739	10	4,776	9
2	10,597	18	307	10	2,174	13	8,135	15
3	6,483	11	166	5	951	6	3,238	6
4 +	9,359	16	1,414	45	3,951	23	2,386	5
IMD quintiles								
1 - least deprived	13,148	22	551	18	2,489	15	7,203	14
2	12,273	21	591	19	2,975	18	9,222	18
3	12,129	20	678	22	3,699	22	11,380	22
4	11,621	20	684	22	3,959	23	12,326	24
5 - most deprived	10,258	17	588	19	3,815	23	11,811	23
Admission in previous year	13,470	22	980	31	4,020	24	5,221	10
Direct indicator of harm present during the hospital spell	8,348	14	1,080	35	4,479	26	5,317	10
Total	60,186		3,127		17,101		52,738	

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Table 2: Median and average lengths of stay and readmissions by condition

	Total number of patients in cohort	Lengths of stay				Readmissions within 7 days		Readmissions within 28 days	
		Median (days)	Mean (days)	Min (days)	Max (days)	Number of readmissions	Rate	Number of readmissions	Rate
Acute Myocardial infarction	60,186	4	6.5	0	412	4,072	6.8%	8,149	13.5%
Emergency bowel cancer surgery	3,127	13	17.4	0	207	202	6.5%	445	14.2%
Elective bowel cancer surgery	17,101	7	9.7	0	235	1,086	6.4%	2,057	12.0%
Elective hip replacement surgery	52,738	4	4.8	0	174	1,344	2.6%	2,776	5.3%

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Table 3: Impact of different 'longer than expected LOS' thresholds on (i) the proportion of patients selected and (ii) the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm

Threshold	All cases	Longer than expected	2 x longer than expected	3 x longer than expected
Acute myocardial infarction				
% selected (n)	100% (60,186)	28% (17,072)	9% (5,664)	4% (2,618)
Sensitivity	100%	56%	27%	15%
PPV	14%	27%	40%	47%
Urgent bowel surgery				
% selected (n)	100% (3,127)	58% (1,806)	20% (631)	9% (270)
Sensitivity	100%	81%	39%	19%
PPV	35%	48%	66%	74%
Elective bowel surgery				
% selected (n)	100% (17,101)	26% (4,420)	7% (1,163)	3% (468)
Sensitivity	100%	59%	21%	9%
PPV	26%	60%	82%	88%
Hip replacement				
% selected (n)	100% (52,738)	31% (16,528)	5% (2,516)	2% (835)
Sensitivity	100%	60%	20%	8%
PPV	10%	19%	41%	51%

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Table 4: Seven-day readmission proportions for patients with a direct indicator of harm in the second or subsequent episode of the initial spell

	A direct indicator of harm in the second or subsequent episode of the initial spell			Overall 7-day readmission rate	p-value associated with the presence of direct harm
	Present				
	Number of patients	Number readmitted	Proportion readmitted within 7 days		
Acute myocardial infarction	2,569	218	8.5%	6.3%	< 0.001
Urgent bowel surgery	393	24	6.1%	6.5%	0.76
Elective bowel surgery	528	42	8.0%	6.4%	0.12
Hip replacement	150	8	5.3%	2.6%	0.06

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Table 5: Proportion of direct indicators of harm by length of readmission spell for readmissions within seven days

Length of stay (days)	AMI		Bowel surgery		Hip replacement	
	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)
0	560	14.1% (11.2 - 17.0)	211	62.6% (56.1 - 69.1)	427	34.7% (30.2 - 39.2)
1	852	12.4% (10.2 - 14.6)	158	50.0% (42.2 - 57.8)	248	49.2% (43.0 - 55.4)
2	492	13.8% (10.8 - 16.9)	123	61.0% (52.4 - 69.6)	127	48.8% (40.1 - 57.5)
3	376	19.9% (15.9 - 23.9)	127	53.5% (44.8 - 62.2)	112	50.0% (40.7 -59.3)
>3	1792	29.6% (27.5 - 31.7)	669	68.6% (65.1 - 72.1)	430	64.2% (60.0 - 68.8)

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Table 6: Proportions of patients readmitted with a primary diagnosis that is potentially related to harm

Cohort	Numbers with potential harm-related primary diagnosis					
	Readmissions within 7 days		Readmissions between 8 and 28 days		Readmissions after 28 days	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
AMI	2071	50.9 (49.4-52.4)	1802	44.2 (42.7-45.7)	5024	43.6 (42.7-44.5)
Urgent bowel surgery	169	83.7 (78.6-88.8)	204	84.0 (79.3-88.6)	432	82.1 (78.9-85.4)
Elective bowel surgery	1019	93.8 (92.4-95.3)	915	94.2 (92.8-95.7)	1807	90.2 (88.9-91.5)
Hip replacement	1325	98.6 (98.0-99.2)	1417	99.0 (98.5-99.5)	5195	98.0 (97.6-98.4)

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Table 7: Implications of different scenarios for selecting case notes for readmitted patients in terms of the proportion of 28-day readmissions selected and the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm occurring within 28 days

.Scenario	A	B	C	D	E	F
	All patients readmitted within 28 days	**All patients readmitted within 7 days**	**7-day readmissions: only primary diagnoses associated with potential harm**	**7-day readmissions: primary diagnoses associated with potential harm or other reported direct indicators of harm**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days, or other reported direct indicators of harm regardless of length of stay**
Acute Myocardial Infarction						
% selected (n)[1]	100% (8,149)	50% (4,072)	25% (2,071)	28% (2,313)	13% (1,084)	19% (1,544)
Sensitivity[2]	100%	51%	36%	51%	24%	51%
PPV[3]	21%	21%	30%	37%	37%	56%
Urgent bowel surgery						
% selected (n)[1]	100% (445)	45% (202)	38% (169)	41% (181)	18% (81)	32% (141)
Sensitivity	100%	50%	44%	50%	22%	50%
PPV	49%	53%	57%	60%	59%	77%
Elective bowel surgery						
% selected (n)[1]	100% (2,057)	53% (1,086)	50% (1,019)	50% (1,038)	26% (533)	41% (849)
Sensitivity	100%	58%	57%	58%	32%	58%
PPV	59%	65%	67%	68%	73%	83%
Hip replacement						
% selected (n)[1]	100% (2,776)	48% (1,344)	48% (1,325)	48% (1,330)	15% (420)	29% (812)
Sensitivity	100%	48%	48%	48%	20%	48%
PPV	50%	49%	50%	50%	65%	82%

1. Proportions are of all readmissions within 28 days
2. Proportion of direct indicators of harm occurring in readmissions within 28 days
3. Proportion of selected cases that have a direct indicator of harm

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Figure 1: Prevalence of harm by length of stay

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

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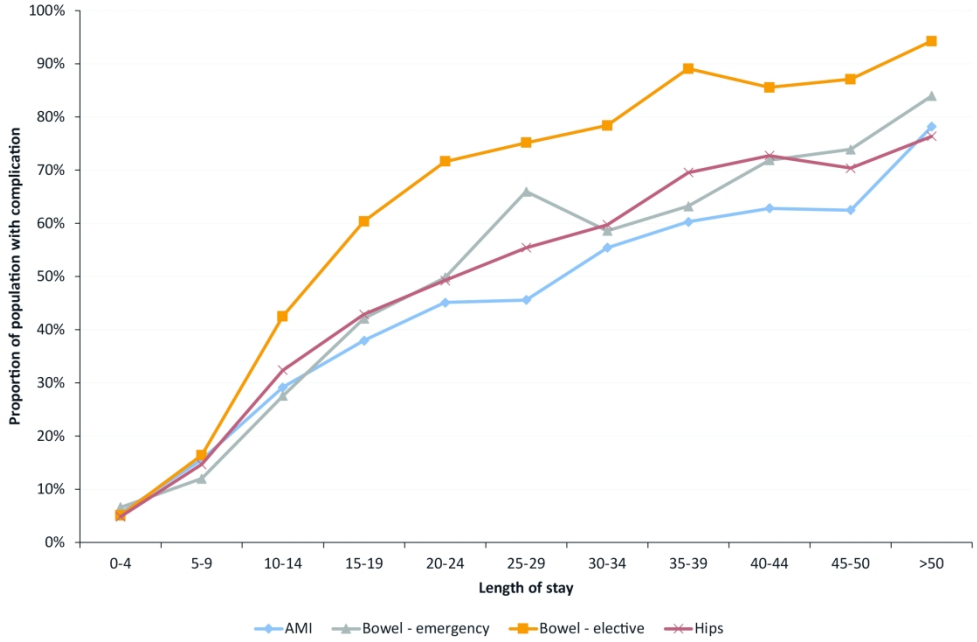

Figure 1: Prevalence of harm by length of stay

257x169mm (300 x 300 DPI)

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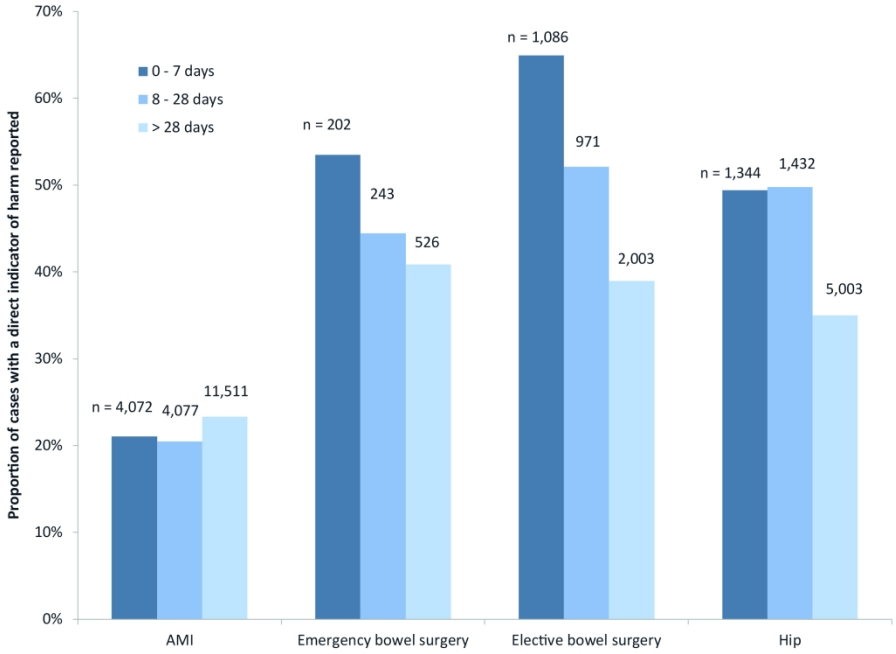

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

257x169mm (300 x 300 DPI)

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Appendix 1. Codes defining patient cohorts

Only a patient's first admission to hospital for the given condition in the financial year 2014/15 was included, where the patient was discharged alive (Dismeth=1,2,3). Patient selection is further restricted to those aged 18-149, who had an "ordinary admission" (Classpat =1) rather than a day case or maternity admission, or were classed as regular day or night attenders.

1. Acute Myocardial Infarction

a. Admission type: Emergency only (admimeth=2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
I210	Acute transmural myocardial infarction of anterior wall
I211	Acute transmural myocardial infarction of inferior wall
I212	Acute transmural myocardial infarction of other sites
I213	Acute transmural myocardial infarction of unspecified site
I214	Acute subendocardialmyocardial infarction
I219	Acute myocardial infarction, unspecified
I220	Subsequent myocardial infarction of anterior wall
I221	Subsequent myocardial infarction of inferior wall
I228	Subsequent myocardial infarction of other sites
I229	Subsequent myocardial infarction of unspecified site

c. Procedure type: None specified

2. Bowel cancer surgery

a. Admission type: Emergency and elective (admimeth = 1 or 2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
C180	Malignant neoplasm: Caecum
C181	Malignant neoplasm: Appendix
C182	Malignant neoplasm: Ascending colon
C183	Malignant neoplasm: Hepatic flexure
C184	Malignant neoplasm: Transverse colon
C185	Malignant neoplasm: Splenic flexure
C186	Malignant neoplasm: Descending colon
C187	Malignant neoplasm: Sigmoid colon
C19	Malignant neoplasm of rectosigmoid junction
C20	Malignant neoplasm of rectum

c. Procedure type: primary procedure in any episode – list of procedures as advised by bowel cancer registry.[1]

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3. Elective hip surgery

a. Admission type: Elective only (admimeth = 1)
b. Diagnosis type: None specified
c. Procedure type:
    i. Primary procedure in first episode with following codes:

Code	Procedure description
W371	Primary total prosthetic replacement of hip joint using cement
W378	Other specified total prosthetic replacement of hip joint using cement
W379	Unspecified total prosthetic replacement of hip joint using cement
W381	Primary total prosthetic replacement of hip joint not using cement
W388	Other specified total prosthetic replacement of hip joint not using cement
W389	Unspecified total prosthetic replacement of hip joint not using cement
W391	Primary total prosthetic replacement of hip joint NEC
W398	Other specified other total prosthetic replacement of hip joint
W399	Unspecified other total prosthetic replacement of hip joint
W931	Primary hybrid prosthetic replacement of hip joint using cemented acetabular component
W938	Other specified hybrid prosthetic replacement of hip joint using cemented acetabular component
W939	Unspecified hybrid prosthetic replacement of hip joint using cemented acetabular component
W941	Primary hybrid prosthetic replacement of hip joint using cemented femoral component
W948	Other specified hybrid prosthetic replacement of hip joint using cemented femoral component
W949	Unspecified hybrid prosthetic replacement of hip joint using cemented femoral component
W951	Primary hybrid prosthetic replacement of hip joint using cement NEC
W958	Other specified hybrid prosthetic replacement of hip joint using cement
W959	Unspecified hybrid prosthetic replacement of hip joint using cement

OR

ii. In first episode:

Primary procedure	Any subsequent procedure	Procedure description
W521	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone using cement NEC
W531	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone not using cement NEC
W541	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone NEC
W581	And (Z843 Or Z761 Or Z756)	Primary resurfacing arthroplasty of joint

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Appendix 2. Definitions of direct indicators of harm

Condition	ICD-10 codes	Source
1. Complications and adverse reactions		Ghali et al[2]
• Complications of surgical and medical care: *T80-T88 codes are post-procedural complications/disorders that are not specifically classified to a post-procedural disorder code within a body system chapter.*	T80-88	
• Drugs, medicaments and biological substances causing adverse effects in therapeutic use: *These are adverse effects that result from the proper use of a substance and a reaction to that drug or medicine occurs. This type of reaction can be described as: adverse effect of drug, allergic reaction, cumulative toxicity, hypersensitivity, idiosyncratic reaction, interaction of drugs, 'side effects'. The adverse effect should be recorded first, followed by the Y40-59 code naming the medication/drug that caused it*	Y40-Y59	
• Misadventures to patients during surgical and medical care: *When misadventure to a patient occurs during a procedure, a code from categories Y60-Y69 must be assigned in a secondary position to the code describing the misadventure caused.*	Y60-Y69	
• Medical devices associated with adverse incidents in diagnostic and therapeutic use: *If an adverse incident that is out of the surgeon's control occurs during a procedure, a code from categories Y70-Y82 must be assigned in a secondary position to the code describing the adverse incident caused.*	Y70-82	
• Surgical and other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure: *Where an abnormal reaction of the patient occurs after the procedure, a code from categories Y83-Y84 must be assigned.*	Y83-84	
2. Sequelae of injuries of poisoning & other consequences: *A sequelae or "late effect" is a current condition in a patient that is caused by a previous condition which is no longer present. The code describing the current condition must be sequenced before a code from categories T90-T98.*	T90-T98	Blunt et al[3]
3. Thrombo-embolism		
• Pulmonary embolism	I26.0, I26.9	
• Cerebral infarction	I63.1, I63.4	
• Arterial embolism and thrombosis	I74,	
• Phlebitis and thrombophlebitis, Portal vein thrombosis, Other venous embolism/thrombosis	I80-82	
• Air embolism, Fat embolism	T79.0, T79.1	
4. Pneumonia		Blunt et al[3] and extended following clinical
• Viral pneumonia, not elsewhere classified	J12	
• Pneumonia due to Streptococcus pneumoniae	J13	
• Pneumonia due to Haemophilus influenza	J14	
• Bacterial pneumonia, not elsewhere classified	J15	
• Pneumonia due to other infectious organisms, not elsewhere	J16	

classified		advice
• Pneumonia in diseases classified elsewhere	J17	
• Pneumonia, organism unspecified	J18	
5. Pressure sores: Decubitus ulcer and pressure area was considered indicative of suboptimal care.	L89	Blunt et al[3]
6. **Poisoning by drugs medicaments & biological substances:** *Reactions to drugs and medicines that occur from their improper use must be coded with (T36-T50). Poisoning can also be described as: intoxication, overdose, therapeutic misadventure, toxic effect/toxicity, wrong dosage given or taken, wrong substance given or taken.*	T36-T50	Blunt et al[3]
7. Urinary Tract Infections	N39	Recommended by clinicians
8. Falls		
• Falls: All falls, excluding falls involving ice-skates, skis, roller-skates or skateboards; playground equipment; ladder; scaffolding, tree or cliff	W01, W03-08, W10, W13, W17-19 With additional .2	Brand & Sundararajan[4]
• In-hospital falls: The codes are as above, with a fifth character of 2 which is generically "School, other institution and public administrative area" but includes a hospital. Brand et al suggest this as a way to captures in-hospital falls		
9. Fracture		
• Fracture of: neck, rib(s), sternum and thoracic spine, lumbar spine and pelvis, shoulder and upper arm, forearm, wrist and hand level, femur, lower leg, foot	S12, S22, S32, S32, S42, S52, S62, S72, S82, S92, T02, T08, T10, T12	Brand & Sundararajan[4]
• Fractures involving multiple body regions, Fracture of: spine, upper or lower limb		
10. Post procedural complications: Body system specific post-procedural complication		
• Post-procedural endocrine and metabolic disorders, not elsewhere classified	E89	Recommended by clinical coders
• Post-procedural disorders of nervous system, not elsewhere classified	G97	
• Post-procedural disorders of eye and adnexa, not elsewhere classified	H59	
• Post-procedural disorders of ear and mastoid process, not elsewhere classified	H95	
• Post-procedural disorders of circulatory system, not elsewhere classified	I97	
• Post-procedural respiratory disorders, not elsewhere classified	J95	
• Post-procedural disorders of digestive system, not elsewhere classified	K91	

• Post-procedural musculoskeletal disorders, not elsewhere classified • Post-procedural disorders of genitourinary system, not elsewhere classified	M96 N99	
11. Hospital acquired infections: *When the responsible consultant has documented in the medical record that a condition is 'hospital acquired' code Y95.X Nosocomial condition must be assigned directly after the code for the condition that has been documented as being 'hospital acquired'*	Y95X	Recommended by clinical coders

Source: Many of the definitions listed were taken from the National Clinical Coding Standards guidance (Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. 2017)

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Appendix 3: Further supplementary tables

Table 3.1: Regression parameters modelling length of stay

Variable	AMI			Elective bowel surgery			Emergency bowel surgery			Hip replacement		
	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value
Charlson score (reference value = 0)												
1	0.61	0.09	< 0.001	1.15	0.23	< 0.001	1.91	0.96	0.05	0.58	0.06	< 0.001
2	0.92	0.09	< 0.001	0.48	0.21	0.02	2.02	0.82	0.01	0.56	0.05	< 0.001
3	1.66	0.11	< 0.001	1.56	0.30	< 0.001	0.64	1.05	0.54	1.07	0.07	< 0.001
≥ 4	2.66	0.10	< 0.001	1.39	0.17	< 0.001	0.91	0.71	0.08	1.86	0.09	< 0.001
IMD quintile (reference value = 1, category 5 is most deprived)												
2	-0.14	0.09	0.13	-0.04	0.23	0.85	-1.55	0.73	0.03	-0.15	0.06	0.01
3	-0.17	0.09	0.07	-1.03	0.22	< 0.001	-1.49	0.70	0.03	-0.28	0.06	< 0.001
4	-0.35	0.10	< 0.001	-1.04	0.22	< 0.001	-1.91	0.70	0.007	-0.37	0.06	< 0.001
5	-0.37	0.10	< 0.001	-1.18	0.22	< 0.001	-2.33	0.73	0.001	-0.40	0.06	< 0.001
Age (reference category = 18 – 49)												
50 – 54	0.29	0.14	0.05	0.36	0.41	0.38	-0.97	1.15	0.4	-0.07	0.10	0.44
55 – 59	0.49	0.14	< 0.001	0.95	0.37	0.01	0.60	1.02	0.59	-0.04	0.09	0.68
60 – 64	0.81	0.14	< 0.001	0.78	0.34	0.02	1.25	1.05	0.23	0.08	0.08	0.32
65 – 69	1.07	0.13	< 0.001	0.89	0.33	0.008	1.58	1.00	0.11	0.23	0.08	0.004
70 – 74	1.43	0.14	< 0.001	1.30	0.33	< 0.001	2.35	0.99	0.02	0.59	0.08	< 0.001
75 – 79	2.05	0.14	< 0.001	1.65	0.33	< 0.001	3.01	0.95	0.002	1.15	0.08	< 0.001
80 – 84	2.12	0.14	< 0.001	2.28	0.35	< 0.001	5.16	0.98	< 0.001	2.24	0.09	< 0.001
85 – 89	2.45	0.15	< 0.001	2.57	0.41	< 0.001	3.34	1.11	0.003	3.89	0.11	< 0.001
90+	2.67	0.17	< 0.001	2.92	0.73	< 0.001	6.16	1.41	< 0.001	5.16	0.20	< 0.001

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Female gender	0.20	0.07	0.003	-0.47	0.14	< 0.001	1.58	0.15	< 0.001	0.45	0.04	< 0.001
Number of emergency admissions in previous year	0.08	0.02	< 0.001	0.45	0.08	< 0.001	0.38	0.22	0.08	0.77	0.03	< 0.001
Reported harm												
Complications and adverse reactions	3.84	0.15	< 0.001	7.29	0.19	< 0.001	8.26	0.29	< 0.001	3.04	0.07	< 0.001
Sequelae	-1.82	1.14	0.11	5.75	2.79	0.04	*	*	*	0.90	0.28	0.001
Thromboembolism	4.08	0.39	< 0.001	8.88	0.75	< 0.001	10.11	1.01	< 0.001	5.31	0.30	< 0.001
Pneumonia	6.50	0.18	< 0.001	9.37	0.49	< 0.001	9.76	1.50	< 0.001	5.90	0.27	< 0.001
Pressure sores	7.61	0.34	< 0.001	12.47	0.91	< 0.001	9.21	1.26	< 0.001	6.08	0.28	< 0.001
Poisoning	1.70	1.34	0.2	3.50	5.08	0.49	-9.18	12.50	0.46	1.70	0.87	0.05
Urinary tract infections	7.41	0.17	< 0.001	9.11	0.36	< 0.001	9.05	0.37	< 0.001	3.99	0.14	< 0.001
In-hospital falls	8.90	0.50	< 0.001	15.13	1.59	< 0.001	17.92	2.13	< 0.001	4.16	0.34	< 0.001
Fractures	12.17	0.51	< 0.001	5.66	2.59	0.03	3.25	4.26	0.49	3.99	0.26	< 0.001
Post-procedural complications (body system specific)	5.71	0.56	< 0.001	8.54	0.26	< 0.001	9.17	0.30	< 0.001	1.77	0.22	< 0.001
Hospital acquired infections	11.25	0.32	< 0.001	0.43	0.62	0.48	0.90	1.42	0.52	3.85	0.34	< 0.001

* The number of reported cases of sequelae in emergency bowel surgery patients was too low

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Table 3.2: List of most common primary diagnoses within each cohort including frequency and whether associated with potential harm

Primary diagnosis	AMI		Bowel surgery		Hip surgery	
	N	%	N	%	N	%
Abdominal and pelvic pain			75	5.8%		
Acute myocardial infarction	721	17.7%				
Acute renal failure			26	2.0%		
Angina pectoris	211	5.2%				
Atrial fibrillation and flutter	66	1.6%				
Cellulitis					28	2.1%
Chronic ischaemic heart disease	254	6.2%				
Complications of internal orthopaedic prosthetic devices, implants and grafts					181	13.5%
Complications of procedures, not elsewhere classified			338	26.2%	120	8.9%
Diarrhoea and gastroenteritis of presumed infectious origin			28	2.2%		
Heart failure	273	6.7%				
Malignant neoplasm of colon			31	2.4%		
Other acute ischaemic heart diseases	149	3.7%				
Other diseases of digestive system			33	2.6%		
Other disorders of urinary system			36	2.8%		
Other functional intestinal disorders			41	3.2%	32	2.4%
Other joint disorders, not elsewhere classified					71	5.3%
Other soft tissue disorders, not elsewhere classified					248	18.5%
Pain in throat and chest	594	14.6%				
Paralytic ileus and intestinal obstruction without hernia			85	6.6%		
Phlebitis and thrombophlebitis					33	2.5%
Pneumonia, organism unspecified	168	4.1%			31	2.3%
Postprocedural disorders of digestive system, not elsewhere classified			153	11.9%		
Pulmonary embolism					26	1.9%
Retention of urine					32	2.4%
Subsequent myocardial infarction	119	2.9%				
Unspecified acute lower respiratory infection	65	1.6%				
All other diagnoses	1452	35.7%	442	34.30%	542	40.30%

Not related to harm | Potentially related to harm

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References

1. National Bowel Cancer Audit. Clinical Audit and Registries Management Service. https://www.nboca.org.uk/resources/nboca-dataset/ (Accessed 9th June 2018).
2. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
3. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
4. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
P1Title and abstract	1	Indicate the study's design with a commonly used term in the title or the abstract P1
		(a)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found P2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported P4
Objectives	3	State specific objectives, including any prespecified hypotheses P5
Methods		
Study design	4	Present key elements of study design early in the paper p5-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection p5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up p5-6 *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable p6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P5-7
Bias	9	Describe any efforts to address potential sources of bias P6-7
Study size	10	Explain how the study size was arrived at P6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P6
		(*b*) Describe any methods used to examine subgroups and interactions P6-7
		(*c*) Explain how missing data were addressed P13
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders P8
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time P8-P10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included P8-10
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives P10-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results P14
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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An observational study to determine the utility of hospital administrative data to support case finding of English patients at higher risk of severe healthcare-related harm

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An observational study to determine the utility of hospital administrative data to support case finding of English patients at higher risk of severe healthcare-related harm

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Figures 2

Supplementary files 1

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Abstract

Objectives: To identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying avoidable severe harm

Design: Development and testing of thresholds and criteria for two indirect indicators of healthcare-related harm (long length of stay [LOS] and emergency readmission) to determine the yield of specified harms coded in Hospital Episode Statistics (HES).

Setting: Acute NHS hospitals in England

Participants: HES for acute myocardial infarction (AMI), bowel cancer surgery and hip replacement admissions from 2014-15

Interventions: Case-mix-adjusted linear regression models were used to determine expected LOS. Different thresholds were examined to determine the association with harm. Screening criteria for readmission included time to readmission, length of readmission and diagnoses in initial admission and readmission. The association with harm was examined for each criterion.

Results: The proportions of AMI cases with a harm code increased from 14% among all cases to 47% if a threshold of three times the expected LOS was used. For hip replacement the respective increase was from 10% to 51%. However as the number of patients at these higher thresholds was small, the overall proportion of harm identified is relatively small (15%, 19%, 9% and 8% among AMI, urgent bowel surgery, elective bowel surgery and hip replacement cohorts respectively). Selection of the time to readmission had an effect on the yield of harms but this varied with condition. At least 50% of surgical patients had a harm code if readmitted within 7 days compared with 21% of AMI patients.

Conclusions: Our approach would select a substantial number of patients for case record review. Many of these cases would contain no evidence of healthcare-related harm. In practice, Trusts may choose how many reviews it is feasible to do in advance and then select random samples of cases that satisfy the screening criteria.

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Article Summary

Strengths and limitations of the study

- Routine hospital administrative data is inexpensive and easy to access.
- Potential healthcare-related harm can be identified in these data by specific codes used for such harms e.g. complications and adverse reactions or by using indirect indicators known to be linked to such harm such as long length of stay (LOS) or readmission
- Comparing the performance of long LOS and readmission across four contrasting cohorts of patients (emergency: acute myocardial infarction [AMI]; urgent: non-elective bowel cancer surgery; semi-urgent: elective bowel cancer surgery; and elective: hip replacement) when thresholds for LOS and criteria for readmission are manipulated shows that sensitivity and positive predictive power to identify harm can be increased.
- To confirm if any harm identified in the administrative records is healthcare-related, retrospective case record review is required
- The approach would identify potential healthcare-related harm in large numbers of cases. A selection process for those going forward to case record review would be required.

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Introduction

There are two main ways avoidable severe harm is identified in patients in acute hospitals in the NHS in England. However, both approaches have shortcomings. Incident reporting systems depend on staff compliance whilst retrospective case record reviews (RCRR) requires considerable resources which preclude universal application to all hospital admissions.

An alternative approach could be for hospitals to employ administrative data to screen records for case note review. These include codes for healthcare-related harm ('direct' indicators of harm) such as 'complications and adverse events' or 'pulmonary embolism after a surgical procedure'. In theory, all harm should be recorded though the completeness of recording is doubtful. In addition, the data will not distinguish between levels of severity so instances of severe harm cannot be distinguished from lesser forms. There has been no recent estimation of the completeness of reporting of harm in administrative data, but a historical (1999-2003) comparison with Australia suggested under-reporting: 2.2% of all NHS admissions compared with 4.75% in Australia.[1, 2]

Administrative data also offers the possibility of using two 'indirect' indicators that reflect the potential consequences of healthcare-related harm: longer than expected length of stay (LOS) and unplanned readmission. Such indicators might be used to identify those patients in whom it is likely harm has occurred even if it had not been recorded. In this way the detection or yield of harm could be enhanced. Support for such an approach comes from RCRR studies that have shown adverse events are associated with longer LOS,[3-5] though the direction of causality is unclear as a longer stay increases the risk of an error in care and subsequent harm.[6, 7] Similarly, a high rate of unplanned readmissions has been shown to be associated with harm having occurred.[8-10]

Our aim was to identify ways of using routine hospital data to improve the efficiency of retrospective reviews of case records for identifying those patients who suffered avoidable severe harm. In this paper we focus on exploring the potential use of two indirect measures (long lengths of stay and early unplanned readmissions) in patients with one of four tracer conditions (acute myocardial infarction, bowel cancer surgery [elective and emergency] and hip replacement). These were selected to

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represent elective, urgent and emergency admissions for medical and surgical reasons.

With lengths of stay we have evaluated different thresholds for defining a long stay; whilst with early readmissions we have assessed a range of criteria. To evaluate different thresholds we assessed how they are associated with the presence of direct indicators of harm coded within the electronic care records. We then used this to understand the resource implications for choosing different screening criteria. Our specific analyses, therefore, focussed on:

- The relationships between direct indicators of harm and::
  - Long lengths of stay;
  - The time between a patient is discharged from hospital and readmitted as an emergency;
  - The length of a readmission spell;
- How the presence of a direct indicator of harm affects the chances of a subsequent readmission, and
- Primary diagnoses on readmission that reflect potential harm.

Method

Data

For this analysis we used hospital administrative data as reported in Hospital Episode Statistics (HES) for the 2014- 2015 financial year. Diagnosis and procedure codes are based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) and the OPCS Classification of Interventions and Procedures, version 4 (OPCS-4). There are 20 diagnostic fields per episode: a primary diagnosis and up to 19 secondary diagnoses.

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Categorising direct indicators of harm

A set of ICD-10 codes were selected as direct indicators of harm. These included complications and adverse reactions [T80-88; Y40-84] plus others identified from the literature,[11-13] or through consultation with clinicians and clinical coders and other sources of guidance. [14, 15] Direct indicators of harm were divided into eight groups: complications and adverse reactions; thromboembolism; pneumonia; pressure sores; urinary tract infections; falls; fractures; post-procedural complications. Further details on these definitions are shown in *Appendix 1*.

Selection of patient cohorts

Given that the approach to using direct or indirect indicators might vary by the type of admission and condition, we selected four examples that represented both medical and surgical conditions and the urgency of the admission: (1) emergency: acute myocardial infarction (AMI); (2) urgent: non-elective bowel cancer surgery; (3) semi-urgent: elective bowel cancer surgery; and (4) elective: hip replacement. A full list of ICD-10 and OPCS-4 codes for defining these cohorts is suppled in *Appendix 2*. Cohorts were restricted to adults (over 17 years), their first admissions in 2014- 2015 to an acute NHS hospital in England for the relevant condition or surgery, and discharged alive. Admissions excluded day cases or regular day or night attenders.

Evaluating thresholds for unexpected long length of stay (LOS)

Length of stay was measured as the time between admission and discharge, ignoring transfers to other hospitals. The expected LOS of each patient was estimated using a linear regression model that controlled for age, sex, comorbidities, deprivation and emergency admissions in the previous 12 months. Comorbidities were measured using the Charlson Score and deprivation by quintiles of the Index of Multiple Deprivation (IMD). The expected LOS was estimated for each of the patient cohorts in 2013-2014 and the parameter estimates applied to the 2014- 2015 population.

Thresholds for long lengths of stay were defined as multiples of the expected values, specifically two, three, four and five times. For each threshold we investigated the association with the direct indicators of harm using a linear regression model adjusting for age, sex, Charlson Score, IMD and number of emergency admissions

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in the previous year. We then evaluated the impact of different thresholds on the number of patient records that each trust would have to review in order to find instances of harm (positive predictive value) and the proportion of patients with harms reported in the spell that would be selected (sensitivity).

Unplanned readmission

Patients in each cohort were identified as having an unplanned readmission if their subsequent admission was an emergency and occurred either in 2014- 2015 or 2015- 2016. Screening criteria for readmissions were derived from combinations of:

- time to readmission,
- harm reported in the first episode of the readmission spell,
- harm reported in the initial admission (present either in second or subsequent episodes),
- primary diagnosis on readmission, and
- length of the readmission spell.

The relevance of the primary diagnosis on readmission to harm having occurred in the previous admission was determined by expert clinical review. The reviewers judged whether the primary diagnosis codes used in the dataset could represent healthcare-related harm. This was done for each cohort to allow for differences types of harm between the four cohorts (e.g. conditions that are relevant for the hip replacement cohort may not be relevant for the AMI cohort).

As with lengths of stay, different options were evaluated in terms of proportions of case notes to be reviewed, and the sensitivity and positive predicted value associated with the occurrence of direct indicators of harm.

Patient Involvement

There were two patients on the Steering Group for this study. One was recruited through a local hospital Patient Reference Group and the other was a Patient Advisor for a charity auditing the care of acutely ill patients, who was recruited through contact with the charity. Both had experience of family illness and in the

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case of one representative, a family member who had experienced a healthcare-related harm. The two patient representatives contributed, through discussion at meetings, to the design of the study and suggested a range of possible harms that the study could look at. They also provided helpful input as to how study results might be effectively communicated to wider audiences.

Results

Mean age was similar across the patient cohorts (68-70 years) and each cohort had similar distribution of socio-economic status (*Table 1*). There were differences in sex: men made up 66% of the AMI cohort but only 40% of the elective hip replacements. There were also differences in comorbidity: 45% of emergency bowel cancer patients had Charlson scores of four or more compared to 5% of patients receiving elective hip replacement.

What is the relationship between long lengths of stay and direct indicators of harm?

The median LOS differed between cohorts (*Table 2*) and the distribution was highly positively skewed. The prevalence of harm increased with LOS (*Figure 1*). For example, 94% of emergency bowel surgery patients staying longer than 50 days had experienced harm compared to 16% in those who stayed 5-9 days. Linear regression analysis found that nearly all categories of harm were significantly positively associated with LOS: some exceptions being fractures in emergency bowel cancer patients and hospital-acquired infections in all bowel cancer patients (*Appendix 3, Table 3.1*).

What are the resource implications for choosing different screening criteria derived from length of stay?

The impacts of different length of stay thresholds on the numbers of patient notes that would be selected and on the sensitivity of detecting harm are shown in *Table 3*.

Of all the patients with a direct indicator of harm, the proportion included in these subgroups (the sensitivity) decreases as the threshold rises, from 56% to 15%. At the same time, the positive predictive value (PPV - the number of cases identified in

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each threshold that would actually have a harm code) increases. For example, for hip replacement the value rises from 10% among all patients to 51% for those staying 3 times longer than expected.

What is the relationship between the presence of a direct indicator of harm and time to emergency readmission?

Rates of readmission within seven days for AMI and bowel surgery (6-7%) are notably higher than for hip replacement (2.6%) (*Table 2*). Approximately half of readmissions within 28 days occur within the first seven days. More than half the surgical patients readmitted within seven days had a direct indicator of harm compared to 21% in the AMI cohort (*Figure 2*). With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This pattern among the surgical cohorts is specifically due to declines in 'complications and adverse reactions' which constitutes approximately 65% of harm across these groups in contrast to the AMI cohort where only 25% are 'complications and adverse reactions'.

How does the presence of a direct indicator of harm affect the chances of a subsequent emergency readmission?

For individuals who have a direct indicator of harm reported in the initial spell, the seven-day readmission rates are higher than the overall seven-day rates for each cohort except those undergoing urgent bowel cancer surgery (*Table 4*). After adjusting for age and likelihood of readmission (using Patients at Risk of Re-admission within 30 days Score[16]), the time to readmission was only related to the record of a direct indicator of harm in the initial spell for the AMI cohort (excluding cases where there was a direct indicator of harm reported in both the initial spell and the readmission).

How is the presence of a direct indicator of harm related to the length of a readmission spell?

The proportion being readmitted for more than three days varied by cohort: bowel surgery over 50%, AMI 44%, hip replacement 32%. The latter group have more patients who stay for less than a day (32% compared to 13% to 17% for the other

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cohorts). 44% of these readmissions are for conditions reported as 'other soft tissue disorders' and they also include all patients with a primary diagnosis of 'phlebitis and thrombophlebitis' (including deep vein thrombosis). The latter represent cases where patients are discharged quickly after the readmission to manage the condition in the community. Direct indicators of harm are significantly more prevalent when the readmission LOS is longer than three days (*Table 5*) (p-value < 0.001 for each cohort).

In how many readmissions is a potential harm suggested by the primary diagnosis?

Just over half of readmissions within seven days for the AMI cohort were admitted with a primary diagnosis that was judged by expert review to be potentially related to harm (*Table 6*). This compares with much higher proportions among the other cohorts, with nearly 99% of the hip surgery cohort having a diagnosis that could be potentially related to harm among that group (more details in *Appendix 3: Table 3.2*). There were no significant differences in the proportions within 7 days from 8-28 days among the surgical cohorts. However, there are significant reductions in proportions among elective bowel surgery readmissions that occur after 28 days (p < 0.001). Among the AMI cohort, the proportion among the earlier readmissions (50.9%) is significantly higher than among the later readmissions (p < 0.001).

What are the resource implications for choosing different screening criteria derived from emergency readmissions?

Choices of criteria against which to select case records for review will depend on a trade-off between numbers of cases selected and proportion of harm that is found. Table 7 shows the outcomes of different criteria using 28-day readmissions as a baseline against which to compare proportions of notes selected and sensitivities. With the hip surgery and elective bowel replacement cohorts, given the majority of the primary diagnoses on readmission are associated with harm having occurred (*Table 7*), restricting selection to these primary diagnoses (scenario C) makes little difference. Further limiting selection to cases where readmission lengths of stay exceed three days will reduce the number of case records for review by 50% or more but will correspond to larger reductions in sensitivity (comparing scenario E with scenario C). Including any cases where direct indicators of harm are present,

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regardless of length of stay and primary diagnosis will increase the positive predictive value at the expense of having a larger proportion of notes to review.

Discussion

Main findings

It is possible to derive criteria from hospital administrative data to select case records in order to find cases of severe hospital-related harm. Our findings suggest that adopting screening rules based on two indirect indicators (long lengths of stay and early readmission) has the potential to improve the targeting of case record reviews. The precise scale of any improvements is unclear until selection criteria have been tested against the outcomes of such reviews.

The selection of length of stay thresholds for screening could have a significant impact on the yield of cases of harm. For example, over half those who stayed at least three times longer than expected had a direct indicator of harm. The positive predictive value of the screen increases across the thresholds, such that the number of cases identified as having a direct indicator of harm as a proportion of all cases examined increases. By manipulating LOS threshold, choices can be made in relation to the trade-off between the number of cases that will actually have a harm code present at that threshold and the proportion of all the harm that will be found if only those cases are investigated.

Selection of the time to readmission has an effect on the yield of potential cases of harm but it varies by condition. At least 50% or more of the surgical patients had a direct indicator of harm if readmitted within 7 days, compared with 21% in the AMI cohort. With bowel surgery cases, these proportions decline as time to readmission increases but for hip replacement patients, the decline is only after 28 days and for AMI patients there is no association with time to readmission. This suggests that the sampling window for the latter two conditions could be extended to 28 days without significant impact, with the added benefit of increasing the number of patients in the hip replacement cohort where there are relatively few readmissions. The lack of relationships between a harm code found in the initial admission with time to readmission suggests that the occurrence of harms in the initial episode may not be

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useful as a criterion for selecting case records, except, perhaps, for AMI patients. However, because we were not able to identify individuals who had died outside hospital soon after the initial spell this analysis may underestimate subsequent outcomes after discharge following a harm.

For primary diagnoses on readmission deemed to be potentially associated with harm, there were higher frequencies among the surgical cohorts with between 80% and 100% of readmission primary diagnoses identified by clinical reviewers being potentially associated with harm. For the AMI cohort, the corresponding proportion was around 50%. This suggests that the nature of the primary readmission diagnosis can be useful as a further criterion for selecting case records and this approach would have the greatest impact on the AMI cohort.

Our assessments of thresholds used positive predictive values and sensitivity as we were interested in the value of case note review in revealing a harm and an indication of how effective they are at detecting all harms that may have occurred. We could also have used specificity and negative predictive values, but considered them less useful in this context.

Other literature

Previous RCRR studies estimated that the proportion of inpatients with an adverse event ranged from 3.8% to 16.6%.[17] Across the four cohorts, we found higher proportions of harm codes. However, the conditions we studied were chosen to highlight different admission types and were not representative of all conditions. Similar rates of harm in bowel cancer patients (between 20% and 40%) have been found in previous studies.[18] A recent Dutch study found a higher proportion of harm in patients admitted with AMI, between 13.3 and 29.9%.[19] The harm in this study was found using an audit tool to screen electronic patient records which could account for a greater proportion of harm being uncovered. National clinical audits suggest that the rate of complications after percutaneous coronary interventions is around 9% in England,[20] and after total hip replacement are about 1% for infection and venous thromboembolism and 3-4% for dislocation.[21] This is consistent with the lower incidence of harm that we found in this group.

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Our study is the first to look at the relationships between different LOS thresholds and a variety readmission characteristics and coded harm in hospital administrative records in the UK. The Dutch have used a threshold based indicator, unexpectedly long LOS (UL-LOS), defined as the percentage of clinically admitted patients with an actual hospital stay that is more than 50% longer than expected, as a generic indicator of hospital safety for a number of years.[22] Cihangir et al found a significant positive correlation between UL-LOS and another indicator of potentially poor quality care, the hospital standardised mortality ratio ($r=0.44$, $p<0.001$) in hospital administrative data from two-thirds of Dutch hospitals.[23] In a small, single site validation study the authors found that in 85 out of 191 colorectal cancer patients with UL-LOS, 43 (51%) had one or more adverse events, compared with 9% (4 out of 44) in the non-unexpected long LOS group.[24]

Limitations

There are a number of limitations to be considered when interpreting our findings. First, our estimates of harm, based on our inclusive approach, are inflated by an element of double counting when the same harms are coded under more than one of the harm categories. This inflation is compounded by the fact that we inevitably include a number of conditions that were present on admission without the routine application of" present on admission" codes. Harm codes such as pneumonia or urinary tract infection, which occur more commonly in emergency medical patients, are also more difficult to attribute to healthcare-related processes. It is also known that hospitals vary in the way they use complication and adverse reaction codes which has the potential to introduce further bias in measurement.[1]

Second, one of the main limitations of developing screening approaches is the accuracy and completeness of the routine data.[1, 25] This limitation is particularly important to consider in this study which used harm codes for the internal validation of indirect indicators of harm derived from the same routine hospital administrative data source. As our approach to harm code definitions was inclusive in an attempt to increase sensitivity, it is likely that our estimates are inflated which may have biased assessment of the performance of indirect indicators as screening tools.

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Third, to assess the feasibility of using indirect indicators to detect cases of harm, we have relied on direct indicators. However, we cannot know the relationship with other types of harm that are not so easily identifiable within routine data, and whether approaches that would work for the detection of harm codes we identified would work more generally. Our analytic approach can indicate that a patient may have experienced harm and the patterns of harm amongst groups of patients with differing conditions and across an organisation but it cannot confirm if that harm was healthcare-related, its severity or its avoidability without recourse to case record review.

Finally, not all long lengths of stay reflect a patient's acute care needs as there may be several days when a patient is awaiting discharge. However, it has not been possible to distinguish these from the data.

Implications

Screening for harm using routine data allows large numbers of records to be rapidly processed with minimal resources required. The Global Trigger Tool has also been developed as a harm screening tool.[26] However using this tool to identify triggers linked to harm, case records need to be individually screened, which is usually done manually creating a more resource intense process. Our approach to screening using long lengths of stay or early readmissions would identify a substantial number of patients for case record review if extended across all patients. In 2014- 2015, there were approximately 16 million admissions to all NHS acute trusts in England,[27] yet the cohorts we included in this analysis comprised less than 1%. If a threshold of twice the expected length of stay was used for screening, we estimate this would have resulted in 9,974 case record reviews in 2014- 2015 across the four cohorts, which equates to about 70 per trust. If we assume a similar length of stay distribution across all hospital admissions, this scales up to around 7,000 reviews per year in an average sized trust. Furthermore, having increased the sensitivity of the screening process at the expense of specificity, many of these cases would contain no evidence of healthcare-related harm.

In practice, therefore, this suggests that one approach might be for Trusts to decide how many reviews they are going to do in advance and then select random samples

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of cases that satisfy the screening criteria. Consideration of how to adapt or create algorithms applicable to wider patient populations would also be required.

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Ethics

This study was approved by North West- Lancaster Research Ethics Committee (15/NW/0941). As data was pseudoanonymised individual patient consent was not required.

Contributorship

HH, NB, CSJ and JVM designed the study. CSJ, NCO and KC carried out the analyses. NB, CSJ and HH wrote the first draft of the manuscript. All authors provided input and approved the final version for submission.

Conflicts of interest

None

Data Sharing Statement

Further details on statistical models and definitions are available from the Nuffield Trust at research@nuffieldtrust.org.uk.

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References

1. Aylin P, Tanna S, Bottle A, Jarman B. How often are adverse events reported in English hospital statistics? BMJ. 2004 Aug 14;329(7462):369
2. Australian Institute for Health and Welfare. Reporting of adverse event in routinely collected data sets in Australia. Australian Institute for Health and Welfare,, 2001.
3. Sari AB ST, Cracknell A, Turnbull A, Dobson Y, Grant C, Gray W, Richardson A. Extent, nature and consequences of adverse events: results of a retrospective casenote review in a large NHS hospital. Qual Saf Health Care. 2007;16(6):434-9
4. Baker GR, Norton PG, Flintoft V, Blais R, Brown A, Cox J, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. CMAJ. 2004;170(11):1678-86
5. Davis P, Lay-Yee R, Briant R, Ali W, Scott A, Schug S. Adverse events in New Zealand public hospitals I: occurrence and impact. N Z Med J. 2002;115(1167):U271
6. Asher RA. The dangers of going to bed. Crit Care Update. 1983;10(5):40-1, 51
7. Kandula PV, Wenzel RP. Postoperative wound infection after total abdominal hysterectomy: a controlled study of the increased duration of hospital stay and trends in postoperative wound infection. Am J Infect Control. 1993;21(4):201-4
8. Care Quality Commission Intelligent monitoring: NHS acute hospitals- indicators and methodology guidance. Care Quality Commission 2015.
9. Nolte E, McKee M, Wait S. Chapter 2. Describing and evaluating health systems. Maidenhead: Open University Press, 2005.
10. Leng GC, Walsh D, Fowkes FG, Swainson CP. Is the emergency readmission rate a valid outcome indicator? Qual Health Care. 1999;8(4):234-8
11. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
12. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51
13. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
14. Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. Health and Social Care Information Centre, 2017.
15. NHS Digital. HES Data Dictionary : Admitted Patient Care (May 2016). NHS Digital, 2016.
16. Billings J, Blunt I, Steventon A, Georghiou T, Lewis G, Bardsley M. Development of a predictive model to identify inpatients at risk of re-admission within 30 days of discharge (PARR-30). BMJ Open. 2012;2(4)
17. de Vries EN, Ramrattan MA, Smorenburg SM, Gouma DJ, Boermeester MA. The incidence and nature of in-hospital adverse events: a systematic review. Qual Saf Health Care. 2008;17(3):216-23
18. Alves A, Panis Y, Mathieu P, Mantion G, Kwiatkowski F, Slim K, et al. Postoperative mortality and morbidity in French patients undergoing colorectal surgery: results of a prospective multicenter study. Arch Surg. 2005 Mar;140(3):278-83, discussion 84
19. Eindhoven DC, Borleffs CJ, Dietz MF, Schalij MJ, Brouwers C, de Bruijne MC. Design and reliability of a specific instrument to evaluate patient safety for patients with acute myocardial infarction treated in a predefined care track: a retrospective patient record review study in a single tertiary hospital in the Netherlands. BMJ Open. 2017 Mar 20;7(3):e014360
20. Banning AP, Baumbach A, Blackman D, Curzen N, Devadathan S, Fraser D, et al. Percutaneous coronary intervention in the UK: recommendations for good practice 2015. Heart. 2015 May;101 Suppl 3:1-13

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21. National Joint Registry Editorial Board. National Joint Registry for England, Wales, Northern Ireland and Isle of Man 13th Annual Report. National Joint Registry, 2016.
22. Ghielen J, Cihangir S, Hekkert K, Borghans I, Kool RB. Can differences in length of stay between Dutch university hospitals and other hospitals be explained by patient characteristics? A cross-sectional study. BMJ Open. 2019 Feb 15;9(2):e021851
23. Borghans I, Hekkert KD, den Ouden L, Cihangir S, Vesseur J, Kool RB, et al. Unexpectedly long hospital stays as an indicator of risk of unsafe care: an exploratory study. BMJ Open. 2014;4(6):e004773
24. Cihangir S, Borghans I, Hekkert K, Muller H, Westert G, Kool RB. A pilot study on record reviewing with a priori patient selection. BMJ Open. 2013;3(7):e003034
25. Raftery J, Roderick P, Stevens A. Potential use of routine databases in health technology assessment. Health technology assessment. 2005 May;9(20):1-92, iii-iv
26. Griffin F, Resar R. IHI Global Trigger Tool for measuring adverse events. 2nd Edition. Cambridge, Massachusetts: Institute for Healthcare Improvement, 2009.
27. Hospital Episode Statistics: Admitted Patient Care, England 2014-15. Health and Social Care Information Centre , 2015, https://files.digital.nhs.uk/publicationimport/pub19xxx/pub19124/hosp-epis-stat-admi-summ-rep-2014-15-rep.pdf.

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Table 1: Patient cohort characteristics

	Acute Myocardial Infarction		Urgent bowel surgery		Elective bowel surgery		Hip replacement	
	N	%	N	%	N	%	N	%
Sex								
Male	39,887	66	1,637	52	9,856	58	21,206	40
Female	20,299	34	1,490	48	7,245	42	31,532	60
Age group (years)								
< 54	11,017	18	471	15	1,849	11	6,651	13
55 - 64	12,504	21	533	17	3,567	21	10,622	20
65-74	13,935	23	801	26	5,757	34	18,345	35
75 - 84	14,029	23	951	30	4,839	28	14,437	27
> 85	8,701	14	371	12	1,089	6	2,683	5
Charlson score								
0	24,299	40	1,037	33	8,286	48	34,203	65
1	9,448	16	203	6	1,739	10	4,776	9
2	10,597	18	307	10	2,174	13	8,135	15
3	6,483	11	166	5	951	6	3,238	6
4 +	9,359	16	1,414	45	3,951	23	2,386	5
IMD quintiles								
1 - least deprived	13,148	22	551	18	2,489	15	7,203	14
2	12,273	21	591	19	2,975	18	9,222	18
3	12,129	20	678	22	3,699	22	11,380	22
4	11,621	20	684	22	3,959	23	12,326	24
5 - most deprived	10,258	17	588	19	3,815	23	11,811	23
Admission in previous year	13,470	22	980	31	4,020	24	5,221	10
Direct indicator of harm present during the hospital spell	8,348	14	1,080	35	4,479	26	5,317	10
Total	60,186		3,127		17,101		52,738	

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Table 2: Median and average lengths of stay and readmissions by condition

	Total number of patients in cohort	Lengths of stay				Readmissions within 7 days		Readmissions within 28 days	
		Median (days)	Mean (days)	Min (days)	Max (days)	Number of readmissions	Rate	Number of readmissions	Rate
Acute Myocardial infarction	60,186	4	6.5	0	412	4,072	6.8%	8,149	13.5%
Emergency bowel cancer surgery	3,127	13	17.4	0	207	202	6.5%	445	14.2%
Elective bowel cancer surgery	17,101	7	9.7	0	235	1,086	6.4%	2,057	12.0%
Elective hip replacement surgery	52,738	4	4.8	0	174	1,344	2.6%	2,776	5.3%

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Table 3: Impact of different 'longer than expected LOS' thresholds on (i) the proportion of patients selected and (ii) the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm

Threshold	All cases	Longer than expected	2 x longer than expected	3 x longer than expected
Acute myocardial infarction				
% selected (n)	100% (60,186)	28% (17,072)	9% (5,664)	4% (2,618)
Sensitivity	100%	56%	27%	15%
PPV	14%	27%	40%	47%
Urgent bowel surgery				
% selected (n)	100% (3,127)	58% (1,806)	20% (631)	9% (270)
Sensitivity	100%	81%	39%	19%
PPV	35%	48%	66%	74%
Elective bowel surgery				
% selected (n)	100% (17,101)	26% (4,420)	7% (1,163)	3% (468)
Sensitivity	100%	59%	21%	9%
PPV	26%	60%	82%	88%
Hip replacement				
% selected (n)	100% (52,738)	31% (16,528)	5% (2,516)	2% (835)
Sensitivity	100%	60%	20%	8%
PPV	10%	19%	41%	51%

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Table 4: Seven-day readmission proportions for patients with a direct indicator of harm in the second or subsequent episode of the initial spell

	A direct indicator of harm in the second or subsequent episode of the initial spell			Overall 7-day readmission rate	p-value associated with the presence of direct harm
	Present				
	Number of patients	Number readmitted	Proportion readmitted within 7 days		
Acute myocardial infarction	2,569	218	8.5%	6.3%	< 0.001
Urgent bowel surgery	393	24	6.1%	6.5%	0.76
Elective bowel surgery	528	42	8.0%	6.4%	0.12
Hip replacement	150	8	5.3%	2.6%	0.06

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Table 5: Proportion of direct indicators of harm by length of readmission spell for readmissions within seven days

Length of stay (days)	AMI		Bowel surgery		Hip replacement	
	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)	Number of readmissions	Proportion with direct indicator of harm (95% CI)
0	560	14.1% (11.2 - 17.0)	211	62.6% (56.1 - 69.1)	427	34.7% (30.2 - 39.2)
1	852	12.4% (10.2 - 14.6)	158	50.0% (42.2 - 57.8)	248	49.2% (43.0 - 55.4)
2	492	13.8% (10.8 - 16.9)	123	61.0% (52.4 - 69.6)	127	48.8% (40.1 - 57.5)
3	376	19.9% (15.9 - 23.9)	127	53.5% (44.8 - 62.2)	112	50.0% (40.7 -59.3)
>3	1792	29.6% (27.5 - 31.7)	669	68.6% (65.1 - 72.1)	430	64.2% (60.0 - 68.8)

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Table 6: Proportions of patients readmitted with a primary diagnosis that is potentially related to harm

Cohort	Numbers with potential harm-related primary diagnosis					
	Readmissions within 7 days		Readmissions between 8 and 28 days		Readmissions after 28 days	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
AMI	2071	50.9 (49.4-52.4)	1802	44.2 (42.7-45.7)	5024	43.6 (42.7-44.5)
Urgent bowel surgery	169	83.7 (78.6-88.8)	204	84.0 (79.3-88.6)	432	82.1 (78.9-85.4)
Elective bowel surgery	1019	93.8 (92.4-95.3)	915	94.2 (92.8-95.7)	1807	90.2 (88.9-91.5)
Hip replacement	1325	98.6 (98.0-99.2)	1417	99.0 (98.5-99.5)	5195	98.0 (97.6-98.4)

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Table 7: Implications of different scenarios for selecting case notes for readmitted patients in terms of the proportion of 28-day readmissions selected and the sensitivity and positive predictive value (PPV) associated with detecting a direct indicator of harm occurring within 28 days

.Scenario	A	B	C	D	E	F
	All patients readmitted within 28 days	**All patients readmitted within 7 days**	**7-day readmissions: only primary diagnoses associated with potential harm**	**7-day readmissions: primary diagnoses associated with potential harm or other reported direct indicators of harm**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days**	**7-day readmissions: primary diagnoses associated with potential harm if length of readmission spell > three days, or other reported direct indicators of harm regardless of length of stay**
Acute Myocardial Infarction						
% selected (n)[1]	100% (8,149)	50% (4,072)	25% (2,071)	28% (2,313)	13% (1,084)	19% (1,544)
Sensitivity[2]	100%	51%	36%	51%	24%	51%
PPV[3]	21%	21%	30%	37%	37%	56%
Urgent bowel surgery						
% selected (n)[1]	100% (445)	45% (202)	38% (169)	41% (181)	18% (81)	32% (141)
Sensitivity	100%	50%	44%	50%	22%	50%
PPV	49%	53%	57%	60%	59%	77%
Elective bowel surgery						
% selected (n)[1]	100% (2,057)	53% (1,086)	50% (1,019)	50% (1,038)	26% (533)	41% (849)
Sensitivity	100%	58%	57%	58%	32%	58%
PPV	59%	65%	67%	68%	73%	83%
Hip replacement						
% selected (n)[1]	100% (2,776)	48% (1,344)	48% (1,325)	48% (1,330)	15% (420)	29% (812)
Sensitivity	100%	48%	48%	48%	20%	48%
PPV	50%	49%	50%	50%	65%	82%

1. Proportions are of all readmissions within 28 days
2. Proportion of direct indicators of harm occurring in readmissions within 28 days
3. Proportion of selected cases that have a direct indicator of harm

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Figure 1: Prevalence of harm by length of stay

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

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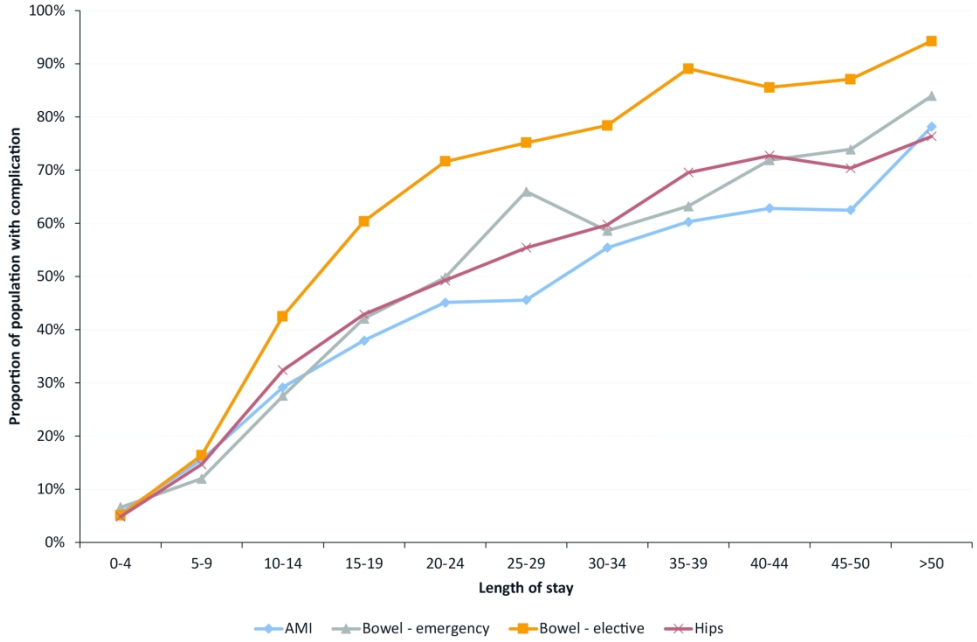

Figure 1: Prevalence of harm by length of stay

257x169mm (300 x 300 DPI)

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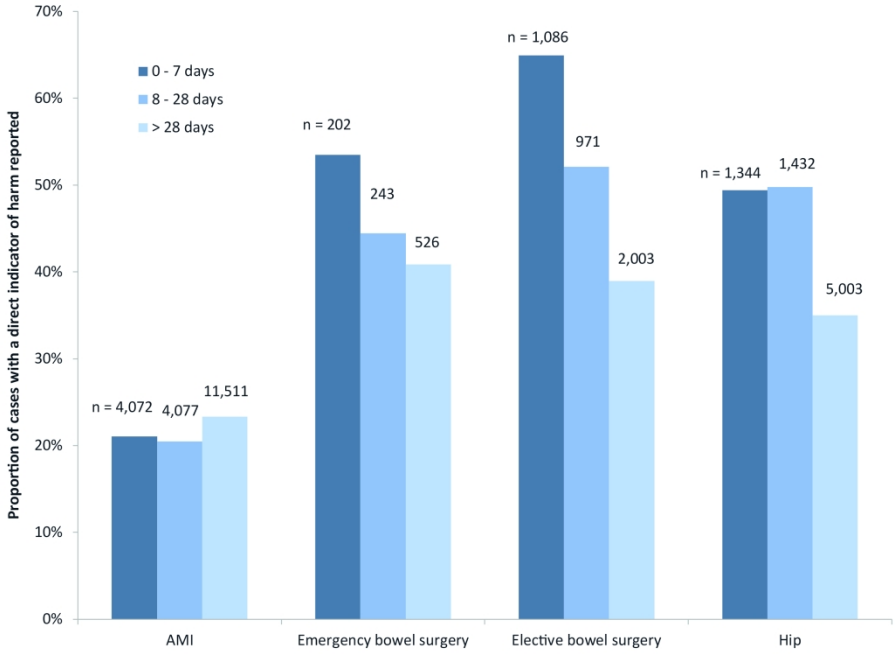

Figure 2: Proportions of cases with direct indicators of harm reported in the first episode of the readmission spell by time to readmission

257x169mm (300 x 300 DPI)

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Appendix 1. Codes defining patient cohorts

Only a patient's first admission to hospital for the given condition in the financial year 2014/15 was included, where the patient was discharged alive (Dismeth=1,2,3). Patient selection is further restricted to those aged 18-149, who had an "ordinary admission" (Classpat =1) rather than a day case or maternity admission, or were classed as regular day or night attenders.

1. Acute Myocardial Infarction

a. Admission type: Emergency only (admimeth=2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
I210	Acute transmural myocardial infarction of anterior wall
I211	Acute transmural myocardial infarction of inferior wall
I212	Acute transmural myocardial infarction of other sites
I213	Acute transmural myocardial infarction of unspecified site
I214	Acute subendocardialmyocardial infarction
I219	Acute myocardial infarction, unspecified
I220	Subsequent myocardial infarction of anterior wall
I221	Subsequent myocardial infarction of inferior wall
I228	Subsequent myocardial infarction of other sites
I229	Subsequent myocardial infarction of unspecified site

c. Procedure type: None specified

2. Bowel cancer surgery

a. Admission type: Emergency and elective (admimeth = 1 or 2)
b. Diagnosis type: As primary diagnosis in first episode

Code	Diagnosis
C180	Malignant neoplasm: Caecum
C181	Malignant neoplasm: Appendix
C182	Malignant neoplasm: Ascending colon
C183	Malignant neoplasm: Hepatic flexure
C184	Malignant neoplasm: Transverse colon
C185	Malignant neoplasm: Splenic flexure
C186	Malignant neoplasm: Descending colon
C187	Malignant neoplasm: Sigmoid colon
C19	Malignant neoplasm of rectosigmoid junction
C20	Malignant neoplasm of rectum

c. Procedure type: primary procedure in any episode – list of procedures as advised by bowel cancer registry.[1]

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3. Elective hip surgery

a. Admission type: Elective only (admimeth = 1)
b. Diagnosis type: None specified
c. Procedure type:
    i. Primary procedure in first episode with following codes:

Code	Procedure description
W371	Primary total prosthetic replacement of hip joint using cement
W378	Other specified total prosthetic replacement of hip joint using cement
W379	Unspecified total prosthetic replacement of hip joint using cement
W381	Primary total prosthetic replacement of hip joint not using cement
W388	Other specified total prosthetic replacement of hip joint not using cement
W389	Unspecified total prosthetic replacement of hip joint not using cement
W391	Primary total prosthetic replacement of hip joint NEC
W398	Other specified other total prosthetic replacement of hip joint
W399	Unspecified other total prosthetic replacement of hip joint
W931	Primary hybrid prosthetic replacement of hip joint using cemented acetabular component
W938	Other specified hybrid prosthetic replacement of hip joint using cemented acetabular component
W939	Unspecified hybrid prosthetic replacement of hip joint using cemented acetabular component
W941	Primary hybrid prosthetic replacement of hip joint using cemented femoral component
W948	Other specified hybrid prosthetic replacement of hip joint using cemented femoral component
W949	Unspecified hybrid prosthetic replacement of hip joint using cemented femoral component
W951	Primary hybrid prosthetic replacement of hip joint using cement NEC
W958	Other specified hybrid prosthetic replacement of hip joint using cement
W959	Unspecified hybrid prosthetic replacement of hip joint using cement

OR

ii. In first episode:

Primary procedure	Any subsequent procedure	Procedure description
W521	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone using cement NEC
W531	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone not using cement NEC
W541	And (Z843 Or Z761 Or Z756)	Primary prosthetic replacement of articulation of bone NEC
W581	And (Z843 Or Z761 Or Z756)	Primary resurfacing arthroplasty of joint

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Appendix 2. Definitions of direct indicators of harm

Condition	ICD-10 codes	Source
1. Complications and adverse reactions		Ghali et al[2]
• Complications of surgical and medical care: *T80-T88 codes are post-procedural complications/disorders that are not specifically classified to a post-procedural disorder code within a body system chapter.*	T80-88	
• Drugs, medicaments and biological substances causing adverse effects in therapeutic use: *These are adverse effects that result from the proper use of a substance and a reaction to that drug or medicine occurs. This type of reaction can be described as: adverse effect of drug, allergic reaction, cumulative toxicity, hypersensitivity, idiosyncratic reaction, interaction of drugs, 'side effects'. The adverse effect should be recorded first, followed by the Y40-59 code naming the medication/drug that caused it*	Y40-Y59	
• Misadventures to patients during surgical and medical care: *When misadventure to a patient occurs during a procedure, a code from categories Y60-Y69 must be assigned in a secondary position to the code describing the misadventure caused.*	Y60-Y69	
• Medical devices associated with adverse incidents in diagnostic and therapeutic use: *If an adverse incident that is out of the surgeon's control occurs during a procedure, a code from categories Y70-Y82 must be assigned in a secondary position to the code describing the adverse incident caused.*	Y70-82	
• Surgical and other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure: *Where an abnormal reaction of the patient occurs after the procedure, a code from categories Y83-Y84 must be assigned.*	Y83-84	
2. Sequelae of injuries of poisoning & other consequences: *A sequelae or "late effect" is a current condition in a patient that is caused by a previous condition which is no longer present. The code describing the current condition must be sequenced before a code from categories T90-T98.*	T90-T98	Blunt et al[3]
3. Thrombo-embolism		
• Pulmonary embolism	I26.0, I26.9	
• Cerebral infarction	I63.1, I63.4	
• Arterial embolism and thrombosis	I74,	
• Phlebitis and thrombophlebitis, Portal vein thrombosis, Other venous embolism/thrombosis	I80-82	
• Air embolism, Fat embolism	T79.0, T79.1	
4. Pneumonia		Blunt et al[3] and extended following clinical
• Viral pneumonia, not elsewhere classified	J12	
• Pneumonia due to Streptococcus pneumoniae	J13	
• Pneumonia due to Haemophilus influenza	J14	
• Bacterial pneumonia, not elsewhere classified	J15	
• Pneumonia due to other infectious organisms, not elsewhere	J16	

classified		advice
• Pneumonia in diseases classified elsewhere	J17	
• Pneumonia, organism unspecified	J18	
5. Pressure sores: Decubitus ulcer and pressure area was considered indicative of suboptimal care.	L89	Blunt et al[3]
6. **Poisoning by drugs medicaments & biological substances:** *Reactions to drugs and medicines that occur from their improper use must be coded with (T36-T50). Poisoning can also be described as: intoxication, overdose, therapeutic misadventure, toxic effect/toxicity, wrong dosage given or taken, wrong substance given or taken.*	T36-T50	Blunt et al[3]
7. Urinary Tract Infections	N39	Recommended by clinicians
8. Falls		
• Falls: All falls, excluding falls involving ice-skates, skis, roller-skates or skateboards; playground equipment; ladder; scaffolding, tree or cliff • In-hospital falls: The codes are as above, with a fifth character of 2 which is generically "School, other institution and public administrative area" but includes a hospital. Brand et al suggest this as a way to captures in-hospital falls	W01, W03-08, W10, W13, W17-19 With additional .2	Brand & Sundararajan[4]
9. Fracture		
• Fracture of: neck, rib(s), sternum and thoracic spine, lumbar spine and pelvis, shoulder and upper arm, forearm, wrist and hand level, femur, lower leg, foot • Fractures involving multiple body regions, Fracture of: spine, upper or lower limb	S12, S22, S32, S32, S42, S52, S62, S72, S82, S92, T02, T08, T10, T12	Brand & Sundararajan[4]
10. Post procedural complications: Body system specific post-procedural complication		
• Post-procedural endocrine and metabolic disorders, not elsewhere classified	E89	Recommended by clinical coders
• Post-procedural disorders of nervous system, not elsewhere classified	G97	
• Post-procedural disorders of eye and adnexa, not elsewhere classified	H59	
• Post-procedural disorders of ear and mastoid process, not elsewhere classified	H95	
• Post-procedural disorders of circulatory system, not elsewhere classified	I97	
• Post-procedural respiratory disorders, not elsewhere classified	J95	
• Post-procedural disorders of digestive system, not elsewhere classified	K91	

• Post-procedural musculoskeletal disorders, not elsewhere classified • Post-procedural disorders of genitourinary system, not elsewhere classified	M96 N99	
11. Hospital acquired infections: *When the responsible consultant has documented in the medical record that a condition is 'hospital acquired' code Y95.X Nosocomial condition must be assigned directly after the code for the condition that has been documented as being 'hospital acquired'*	Y95X	Recommended by clinical coders

Source: Many of the definitions listed were taken from the National Clinical Coding Standards guidance (Health and Social Care Information Centre. National Clinical Coding Standards ICD-10 4th Edition Addendum: Accurate data for quality information. 2017)

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Appendix 3: Further supplementary tables

Table 3.1: Regression parameters modelling length of stay

Variable	AMI			Elective bowel surgery			Emergency bowel surgery			Hip replacement		
	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value	Coefficient	Standard error	p-value
Charlson score (reference value = 0)												
1	0.61	0.09	< 0.001	1.15	0.23	< 0.001	1.91	0.96	0.05	0.58	0.06	< 0.001
2	0.92	0.09	< 0.001	0.48	0.21	0.02	2.02	0.82	0.01	0.56	0.05	< 0.001
3	1.66	0.11	< 0.001	1.56	0.30	< 0.001	0.64	1.05	0.54	1.07	0.07	< 0.001
≥ 4	2.66	0.10	< 0.001	1.39	0.17	< 0.001	0.91	0.71	0.08	1.86	0.09	< 0.001
IMD quintile (reference value = 1, category 5 is most deprived)												
2	-0.14	0.09	0.13	-0.04	0.23	0.85	-1.55	0.73	0.03	-0.15	0.06	0.01
3	-0.17	0.09	0.07	-1.03	0.22	< 0.001	-1.49	0.70	0.03	-0.28	0.06	< 0.001
4	-0.35	0.10	< 0.001	-1.04	0.22	< 0.001	-1.91	0.70	0.007	-0.37	0.06	< 0.001
5	-0.37	0.10	< 0.001	-1.18	0.22	< 0.001	-2.33	0.73	0.001	-0.40	0.06	< 0.001
Age (reference category = 18 – 49)												
50 – 54	0.29	0.14	0.05	0.36	0.41	0.38	-0.97	1.15	0.4	-0.07	0.10	0.44
55 – 59	0.49	0.14	< 0.001	0.95	0.37	0.01	0.60	1.02	0.59	-0.04	0.09	0.68
60 – 64	0.81	0.14	< 0.001	0.78	0.34	0.02	1.25	1.05	0.23	0.08	0.08	0.32
65 – 69	1.07	0.13	< 0.001	0.89	0.33	0.008	1.58	1.00	0.11	0.23	0.08	0.004
70 – 74	1.43	0.14	< 0.001	1.30	0.33	< 0.001	2.35	0.99	0.02	0.59	0.08	< 0.001
75 – 79	2.05	0.14	< 0.001	1.65	0.33	< 0.001	3.01	0.95	0.002	1.15	0.08	< 0.001
80 – 84	2.12	0.14	< 0.001	2.28	0.35	< 0.001	5.16	0.98	< 0.001	2.24	0.09	< 0.001
85 – 89	2.45	0.15	< 0.001	2.57	0.41	< 0.001	3.34	1.11	0.003	3.89	0.11	< 0.001
90+	2.67	0.17	< 0.001	2.92	0.73	< 0.001	6.16	1.41	< 0.001	5.16	0.20	< 0.001

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Female gender	0.20	0.07	0.003	-0.47	0.14	< 0.001	1.58	0.15	< 0.001	0.45	0.04	< 0.001
Number of emergency admissions in previous year	0.08	0.02	< 0.001	0.45	0.08	< 0.001	0.38	0.22	0.08	0.77	0.03	< 0.001
Reported harm												
Complications and adverse reactions	3.84	0.15	< 0.001	7.29	0.19	< 0.001	8.26	0.29	< 0.001	3.04	0.07	< 0.001
Sequelae	-1.82	1.14	0.11	5.75	2.79	0.04	*	*	*	0.90	0.28	0.001
Thromboembolism	4.08	0.39	< 0.001	8.88	0.75	< 0.001	10.11	1.01	< 0.001	5.31	0.30	< 0.001
Pneumonia	6.50	0.18	< 0.001	9.37	0.49	< 0.001	9.76	1.50	< 0.001	5.90	0.27	< 0.001
Pressure sores	7.61	0.34	< 0.001	12.47	0.91	< 0.001	9.21	1.36	< 0.001	6.08	0.28	< 0.001
Poisoning	1.70	1.34	0.2	3.50	5.08	0.49	-9.18	12.50	0.46	1.70	0.87	0.05
Urinary tract infections	7.41	0.17	< 0.001	9.11	0.36	< 0.001	9.05	0.37	< 0.001	3.99	0.14	< 0.001
In-hospital falls	8.90	0.50	< 0.001	15.13	1.59	< 0.001	17.92	2.13	< 0.001	4.16	0.34	< 0.001
Fractures	12.17	0.51	< 0.001	5.66	2.59	0.03	3.25	4.46	0.49	3.99	0.26	< 0.001
Post-procedural complications (body system specific)	5.71	0.56	< 0.001	8.54	0.26	< 0.001	9.17	0.90	< 0.001	1.77	0.22	< 0.001
Hospital acquired infections	11.25	0.32	< 0.001	0.43	0.62	0.48	0.90	1.42	0.52	3.85	0.34	< 0.001

* The number of reported cases of sequelae in emergency bowel surgery patients was too low

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Table 3.2: List of most common primary diagnoses within each cohort including frequency and whether associated with potential harm

Primary diagnosis	AMI		Bowel surgery		Hip surgery	
	N	%	N	%	N	%
Abdominal and pelvic pain			75	5.8%		
Acute myocardial infarction	721	17.7%				
Acute renal failure			26	2.0%		
Angina pectoris	211	5.2%				
Atrial fibrillation and flutter	66	1.6%				
Cellulitis					28	2.1%
Chronic ischaemic heart disease	254	6.2%				
Complications of internal orthopaedic prosthetic devices, implants and grafts					181	13.5%
Complications of procedures, not elsewhere classified			338	26.2%	120	8.9%
Diarrhoea and gastroenteritis of presumed infectious origin			28	2.2%		
Heart failure	273	6.7%				
Malignant neoplasm of colon			31	2.4%		
Other acute ischaemic heart diseases	149	3.7%				
Other diseases of digestive system			33	2.6%		
Other disorders of urinary system			36	2.8%		
Other functional intestinal disorders			41	3.2%	32	2.4%
Other joint disorders, not elsewhere classified					71	5.3%
Other soft tissue disorders, not elsewhere classified					248	18.5%
Pain in throat and chest	594	14.6%				
Paralytic ileus and intestinal obstruction without hernia			85	6.6%		
Phlebitis and thrombophlebitis					33	2.5%
Pneumonia, organism unspecified	168	4.1%			31	2.3%
Postprocedural disorders of digestive system, not elsewhere classified			153	11.9%		
Pulmonary embolism					26	1.9%
Retention of urine					32	2.4%
Subsequent myocardial infarction	119	2.9%				
Unspecified acute lower respiratory infection	65	1.6%				
All other diagnoses	1452	35.7%	442	34.30%	542	40.30%

Not related to harm Potentially related to harm

Source: Hospital Episode Statistics data © 2017, re-used with the permission of the Health & Social Care Information Centre. All rights reserved.

References

1. National Bowel Cancer Audit. Clinical Audit and Registries Management Service. https://www.nboca.org.uk/resources/nboca-dataset/ (Accessed 9th June 2018).
2. Ghali WA, Pincus HA, Southern DA, Brien SE, Romano PS, Burnand B, et al. ICD-11 for quality and safety: overview of the WHO Quality and Safety Topic Advisory Group. Int J Qual Health Care. 2013 Dec;25(6):621-5
3. Blunt I, Bardsley M, Grove A, Clarke A. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? Emerg Med J. 2015 Jan;32(1):44-50
4. Brand CA, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. Qual Saf Health Care. 2010 Dec;19(6):e51

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
P1Title and abstract	1	Indicate the study's design with a commonly used term in the title or the abstract P1
		(a)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found P2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported P4
Objectives	3	State specific objectives, including any prespecified hypotheses P5
Methods		
Study design	4	Present key elements of study design early in the paper p5-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection p5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up p5-6 *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable p6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P5-7
Bias	9	Describe any efforts to address potential sources of bias P6-7
Study size	10	Explain how the study size was arrived at P6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P6
		(*b*) Describe any methods used to examine subgroups and interactions P6-7
		(*c*) Explain how missing data were addressed P13
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders P8
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time P8-P10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included P8-10
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives P10-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results P14
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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