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Novelty statement

- People hospitalised with diabetes have poorer outcomes and longer length of stay than those without diabetes.
- We report the impact of a multifaceted, whole systems approach to diabetes care.
- Interrupted time series analysis is used to supplement the commonly used before and after analysis, highlighting the strength of this quasi-experimental methodology.
- Our data show that a nurse-delivered care programme can produce sustained and ongoing reductions in length of stay for patients with diabetes in the NHS today.

ABSTRACT

Objective

To determine whether the Diabetes Inpatient Care and Education (DICE) programme, a whole systems approach to managing inpatient diabetes, reduces length of stay, in-hospital mortality and readmissions.

Research Design and Methods

DICE initiatives included identification of all diabetes admissions, a novel DICE care-pathway, an online system for prioritising referrals, use of web-linked glucose meters, an enhanced diabetes team, and novel diabetes training for doctors.

Patient Administration System data was extracted for patients admitted to Ipswich Hospital from January 2008 to June 2016. Logistic regression was used to compare binary outcomes (mortality, 30-day readmissions) 6 months before and after the intervention; generalized estimating equations were used to compare length of stay. Interrupted time series (ITS) analysis was performed over the full 7.5-year period to account for secular trends.

Results

Before and after analysis revealed a significant reduction in length of stay for patients with and without diabetes, relative ratio 0.89 (95%CI 0.83, 0.97) and 0.93 (0.90, 0.96), respectively. However, in ITS analysis the change in long-term trend for length of stay following the intervention was significant only for diabetes (p=0.017 vs p=0.48). Odds ratios for mortality were 0.63 (0.48, 0.82) and 0.81 (0.70, 0.93) in patients with and without diabetes, respectively; however, the change in trend was not significant in patients with diabetes while there was an apparent increase in patients without diabetes. There was no significant change in 30-day readmissions, but ITS analysis revealed a rising trend in both groups.

Conclusion

The DICE programme was associated with reduced length of stay in inpatients with diabetes beyond that observed in people without diabetes.

INTRODUCTION

Inpatient diabetes care is a growing concern. Almost two thirds of diabetes health care expenses are spent on hospitalisation with a minority of patients contributing to the majority of this cost (1). The ever-increasing prevalence of diabetes in the general population has resulted in a steady rise in beds occupied by those with diabetes from 1 in 8 in 2011 to 1 in 6 in the National Diabetes Inpatient Audit conducted in 2017 (2; 3). At this rate, projecting forward it has been estimated that by 2030 more than one in four inpatients will have diabetes. Indeed, in some UK hospitals the prevalence is as high as 30% (3) a prevalence already exceeded in some American states (4).

In 2011, the NHS in England was estimated to spend £2.3-2.5 billion a year on inpatient care for people with diabetes – around 11% of total inpatient care expenditure and approximately 25% of the total expenditure on diabetes care (5). More sizable estimates have been made for the American (25%), French (38%) and Italian (57%) health care systems, confirming that inpatient care is the largest component of medical expenditure for diabetes (1; 6).

People with diabetes are more frequently admitted to hospital than those without the condition, with diabetes reported in the five most prevalent comorbidities in hospitalised and readmitted patients (7). Despite its documented frequency, most patients with diabetes are hospitalised for another reason, with diabetes-related emergencies primarily implicated in fewer than 10% of admissions (3). The majority of inpatients with diabetes are therefore under the care of non-diabetologists within both medical and surgical specialities (2).

The care that people with diabetes receive is suboptimal. Inpatients with diabetes have poorer clinical outcomes with longer length of stay (8), higher complication rates (9), and increased mortality (10) compared to people without diabetes. The reasons for these differences are not fully understood, however glycaemic control has been implicated, with hyperglycaemia thought to account for increased infection rates (11) and hypoglycaemia associated with increased mortality (12).

Several measures have been used as indicators of the quality of hospital care, including length of stay, readmission rates and mortality (13; 14). In the multi-morbid patient with diabetes in whom managing glycaemic control during illness within the hospital environment is challenging, a reduction in length of stay is thought to indicate improved quality of care, though not at the expense of readmissions.

In the current financial climate, cost effective ways to improve care and outcomes in this growing cohort are of paramount importance. A number of strategies have been adopted by some hospitals; these include protocols for glucose management, staff education programmes and alert systems such as the ‘Think Glucose’ programme to identify those requiring specialist team review (15). Their success in reducing length of stay and hospital acquired diabetes complications such as diabetic ketoacidosis or foot ulceration is not known. Some studies suggest that diabetes specialist nurses reduce length of stay (16; 17), however these

were undertaken some years ago when length of stay for all inpatients was much greater than today. Nevertheless, based on these publications the economic case for inpatient diabetes teams was made in a document by Marion Kerr in 2011; this showed the cost of diabetes inpatient nurses was repaid within 3 years (5). With the increasing emphasis on ambulatory management and early discharge, it is not clear whether similar bed-day savings would be seen today.

While randomised controlled trials (RCTs) are the research gold standard, they can be impractical and in some cases unethical to conduct. Before and after studies analysing observational data are most commonly used to assess the impact of health service interventions. These studies may overestimate effect size as they do not assess the ongoing, effect of an intervention, which may diminish or return to baseline soon after the post-intervention analysis. Conversely, before and after studies may fail to observe a real effect if the time between the intervention, behavioural change and the subsequent follow-up period is insufficient for the impact to become evident.

Recently, the application of quasi-experimental analysis to observational data has allowed researchers to design methodologies to circumvent some of these issues. Interrupted time series (ITS) analysis is one such technique, which carries a number of benefits over RCTs and before and after studies.

An ITS design uses data from multiple time-periods to estimate an intervention effect whilst adjusting for any underlying secular trend (18). It allows the comparison of pre- and post-intervention periods without the requirement for a comparison group (19), and enables examination of changes to the outcome post-intervention with an allowance for natural variation in the outcome over time.

We introduced a whole systems approach to improving diabetes inpatient care in Ipswich Hospital using technology, education, protocols, and pathways for identifying patients most in need of specialist diabetes input (outlined below). An ITS analysis was used to supplement a before and after analysis to assess the impact of this whole systems approach.

The DICE programme

The Diabetes Inpatient Care and Education (DICE) programme was designed and developed as a whole systems approach to managing inpatient diabetes. It comprised a number of changes to existing diabetes practices.

The DICE care pathway

Every patient with diabetes is initiated on an 8 page diabetes pathway, the DICE chart/booklet, which remains with them throughout their stay. It is also an education tool for all Health Care Professionals (HCPs) directing care. Within the DICE booklet there are user-friendly glucose and insulin charts designed to improve patient safety, a foot check form to be completed on admission with instructions on how to perform a simple foot examination using the novel Ipswich Touch Test, as well as instructions on who and how to refer to the multidisciplinary foot team (20). The pathway contains the unique Diabetic Patient At Risk

(DPAR) scoring system which empowers ward staff to refer patients to the diabetes specialist nurse and foot team, and enables prioritisation according to clinical urgency. The system has been very well received by medical and nursing staff, and since implementation over 95% of referrals are reviewed within our pre-specified best practice period (21).

The booklet contains a checklist to facilitate insulin self-management and finally a safe-discharge checklist. The DICE booklet is described in greater detail in the online supplement.

The programme also comprised a number of other interventions developed by the DICE team. These include an electronic system to identify all patients admitted with diabetes and hypoglycaemia alert system utilising web-linked point of care blood glucose meters (outlined in Supplementary Appendix 1).

Novel induction programme for junior doctors

We introduced an induction programme for junior doctors based on common case scenarios and adapted this to include training in the use of the DICE pathway. This was positively evaluated by the trainees (22).

Staffing

Key in delivering these changes in practice was the employment of additional diabetes inpatient specialist nurses (DISN), who, in addition to the existing specialist nurse, resulted in 2.5 whole time equivalents. This enabled seven-day working, providing a morning only service at the weekend. Over 90% of inpatients with diabetes were seen by a DISN.

This multifaceted service was implemented across all the medical, surgical, haematology and oncology wards from 1st July 2013. Randomisation was considered unethical as it would remove access to medication adjustments following a hypoglycaemic episode and restrict appropriate specialist review.

The DISN's aims were:

1. To facilitate self-care where appropriate, educate and support patients in their diabetes care.
2. To educate and support non-specialist HCPs in caring for people with diabetes.
3. To avoid hypoglycaemia through proactive adjustment of hypoglycaemic oral medication and insulin on admission, prescription of a bedtime snack, and targeting first events to prevent recurrence.
4. To reduce hospital-acquired foot complications by auditing foot examinations and facilitating foot protection for those at risk and prompt referral of those with foot complications to the multidisciplinary foot team.
5. To optimise glycaemic control, aiming for glucose readings between 6 and 12 mmol/l where appropriate.
6. To facilitate safe and early discharge and to prevent readmission.

AIM

The aim was to investigate the effect of the DICE programme on mortality, length of stay and 30-day readmissions of inpatients with diabetes at Ipswich Hospital NHS Trust, using routinely collected administrative data for patients admitted to the trust between January 2008 and June 2016.

METHODS

Study design

A single centre before and after study supplemented by an ITS analysis to reveal any background trends and changes in care following implementation of the DICE programme.

Source of data

Data was extracted from the patient administration system (PAS) at Ipswich Hospital NHS Trust. For the before and after study, an extract was taken to compare identical 6 month periods, 01/01/2013 to 30/06/2013 and 01/01/2014 to 30/06/2014, i.e. prior to and after the implementation of the DICE programme (01/07/2013 to 31/12/2013). For the ITS analysis, a second extract was taken from 01/01/2008 to 30/06/2016.

Population

Adult patients with a primary or secondary diagnosis of diabetes defined by ICD-10 codes E10 to E14 in the PAS data were the population of interest. Patients without a diagnostic code of diabetes were used as a negative control group to assess the impact of temporal trends and changes in non-diabetes care processes that might impact on the outcomes of patients with diabetes.

Only patients admitted under specialities that were routinely involved in the in the DICE project were included in the analysis; therefore, paediatrics, neonatology and obstetrics were excluded, accounting for 97 beds of this 587-bed hospital. Day case procedures were also excluded.

Covariates for before and after analysis

Demographic information (age and sex), ethnicity, index of multiple deprivation (IMD) category, admission and discharge times (to calculate length of stay), method of discharge, type of admission (emergency or elective), intensive therapy unit (ITU) stay, healthcare resource group (HRG) codes, and comorbidities were obtained from the PAS data. A modified Charlson comorbidity score (excluding diabetes) was calculated using ICD-10 codes for comorbidities. The 2015 HRG categories were applied to the full dataset.

Analysis

A before and after analysis was performed followed by an interrupted time series analysis.

Before and after analysis

Outcomes in the 6-month periods before and after implementation of the DICE project were compared. Pre-DICE analysis was performed in the populations with and without diabetes from 01/01/2013 to 30/06/2013, and post-DICE analysis from 01/01/2014 to 30/06/2014. This allowed assessment of whether the intervention led to a change in each of the outcomes in patients with diabetes above any difference observed in patients without diabetes.

Primary outcomes were length of stay and mortality. Length of stay was derived in hours as the date and time of discharge minus the date and time of admission. Secondary outcome was 30-day emergency readmission rate.

Baseline characteristics were presented as mean (standard deviation) or median (interquartile range) for continuous variables, and as proportions for categorical/binary variables.

Crude (unadjusted) and adjusted odds ratios for mortality, comparing pre- and post-DICE in patients both with and without diabetes, were calculated using logistic regression.

Length of stay data was found to be skewed; crude and adjusted relative ratios were therefore calculated using generalized estimating equations (GEE) with log link normal distribution. This modelling accounted for patients readmitted multiple times to the trust within the 6-month periods analysed.

Emergency readmission rates up to 30 days after discharge for both elective and non-elective care were analysed to assess for any negative impact from possible premature discharges. Crude and adjusted odds ratios for 30-day readmissions were calculated using logistic regression.

For all outcomes, the following potential confounders were included in the adjusted models: age, sex, ethnic group, IMD quintile, HRG category, ITU episode, modified Charlson comorbidity score, and emergency/elective admission.

Time series analysis

An interrupted time series (ITS) analysis was performed using segmented regression to adjust for any underlying secular trend.

Data was available for 66 months prior to the intervention and 30 months post-intervention. An aggregate dataset containing monthly averages was created for the analysis. For mortality and 30-day readmission, the number of people who had died or who were readmitted within 30 days were calculated. For length of stay, the monthly mean was calculated using the raw length of stay data.

Mortality and readmission count data were analysed using generalised estimating equation (GEE) Poisson models with an offset for the monthly admissions population. For length of stay a GEE linear model was fitted to the data. Fixed effects were included for: time, intervention initiation, and intervention termination. Two interactions were included: time and intervention initiation; and time and intervention termination (Appendix 2). To allow for autocorrelation, we checked autocorrelation and partial autocorrelation plots. A first order

autocorrelation (AR 1) was included. The analysis was conducted independently for people with and without diabetes.

All statistical analysis was carried out using Stata 14 and 15. The ITS analysis was carried out using the GEE command in Stata, which allows the specification of a first order correlation.

RESULTS

Before and after analysis

In the 6 months before implementation, 2337 patients with diabetes and 13765 patients without diabetes were admitted to the trust in the included specialities. In the 6 months after implementation, 2433 patients with and 14290 patients without diabetes were admitted. Patients with diabetes were older, and a higher proportion were male, had one or more comorbidities and had an emergency admission compared to patients without diabetes (Table 1).

In patients with diabetes, mortality rate decreased from 6.4% in the pre-intervention period to 4.4% in the post-intervention period; in patients without diabetes, mortality rate decreased from 3.7% to 3.1%. The adjusted odds ratio for the change in mortality pre- and post-intervention was 0.63 (95% CI 0.48, 0.82) in patients with diabetes and 0.81 (95% CI 0.70, 0.93) in patients without.

Mean length of stay reduced from 7.5 to 6.7 days in those with diabetes and from 5.0 to 4.7 days in patients without. The median reduction in length of stay was 0.4 and 0.1 days, respectively. The adjusted relative ratio for length of stay before and after intervention was 0.89 (95% CI 0.83, 0.97) and 0.93 (95% CI 0.90, 0.96) in patients with and without diabetes respectively.

Adjusted odds ratios for 30-day readmissions were not statistically significant: 0.96 (95% CI 0.82, 1.12) and 1.04 (95% CI 0.96, 1.12) in patients with and without diabetes respectively (Table 2).

Interrupted time series analysis

The number and demographic characteristics (sex and age) of patients included in the ITS analysis are shown in Table 3. The ITS analysis demonstrated a statistically significant ($p=0.017$) acceleration in the trend for reducing length of stay in patients with diabetes following the intervention; in patients without diabetes there was no evidence of any change in trend in the post-intervention period ($p=0.48$). Readmissions for patients both with and without diabetes showed a statistically significant increase following the intervention ($p<0.001$ and $p<0.001$ respectively) (Figure 1).

The before and after analysis demonstrated a reduction in mortality rates in both those with and without diabetes; however, in the time series analysis, there was absence of evidence for

a difference in mortality in patients with diabetes (p=0.305), whereas in patients without diabetes there was an apparent increase (p = 0.007) (Figure 1). Detailed time series model findings with explanatory notes are given in Supplementary Table 1.

DISCUSSION

When considered together, the before and after study and interrupted time series analysis demonstrate that the DICE project led to a significant reduction in length of stay for patients with diabetes beyond that observed in patients without diabetes. The reduction in mortality observed in the before and after analysis was not seen in the ITS analysis. Of note, in the ITS analysis mortality increased in those without diabetes in contrast to those with diabetes. Readmissions, as expected, were significantly higher in patients with diabetes than in those without diabetes, though lower than reported in other studies (23). Following the intervention, readmissions continued to increase in parallel with inpatients without diabetes.

Diabetes presents a significant burden for inpatient services and people with diabetes have increased inpatient mortality, morbidity, hospital acquired complications, length of stay and readmission rates (12; 24). As well as the obvious benefits to patients with diabetes, improvement in these outcomes could have very significant financial benefits. A limited number of studies suggest that diabetes teams reduce length of stay, but these are historic and relate to a time when length of stay was considerably greater than today. The impact of diabetes inpatient teams on readmission rates has been evaluated in studies with differing outcomes reported (23; 25). One such study found reduced 30-day readmissions in patients admitted to medical services while readmissions to surgical services increased (26); in this study, only a relatively small proportion of the inpatients with diabetes were included in the intervention, in contrast to the present study, which impacted the whole diabetes inpatient population and additionally factored in the changes in the length of stay and readmissions of those without diabetes into the analyses.

The present study is the first to evaluate the effect of a whole systems approach to inpatient diabetes care on length of stay, mortality and readmissions across all medical and surgical adult wards in an acute general hospital. A key element of the DICE programme was the involvement of all members of the diabetes team in the design and implementation of novel interventions aimed at delivering rapid, evidence based, high quality care and education of non-specialist health care staff. Unlike other studies, it is unique in that it uses ITS analysis to adjust for changes in the background population.

The results of the ITS analysis highlight the limitations of the before and after study design, which is widely used to assess the impact of healthcare interventions. The before and after analysis indicated a significant reduction in length of stay and mortality, which was greater in patients with diabetes than without. However, in the ITS analysis, while reduction in length of stay remained significant and was shown to be attributable to implementation of the DICE project, the reduction in mortality was not. In the case of mortality, using the 6-month pre-intervention group alone as a control would have produced a false positive result. Furthermore, the ITS analysis revealed a wider issue of increasing 30-day readmissions in all

patients, indicating the presence of systemic factors, outside of the DICE project, influencing readmissions to the trust.

Previous studies have reported a median reduction in length of stay of 3 days on employing a DISN for inpatient care (16). However, the most recent of these was conducted in 2008 and with changes in practice, stretched resources and pressures on hospital beds, it is not clear whether similar improvements would be seen today. The results of this analysis showed a more modest, but significant and ongoing, reduction in length of stay. With a bed day estimated to cost the NHS £400 per day this sustained reduction in length of stay will have saved the trust over £2 million in the 3 years since the DICE project was implemented (27).

There are few studies employing the quasi-experimental methodology of ITS analysis to assess the impact of care interventions in the clinical setting, with before and after analysis being the more widely utilised method (18). This is the first to use ITS analysis to examine length of stay, readmission and mortality after implementation of a whole systems approach to inpatient diabetes care. However, ITS analysis is gaining favour and has been used to assess the impact and successful implementation of national guidance (28).

Strengths and limitations

This analysis combined two analytical methodologies to address the limitations associated with using before and after analysis in isolation, and to account for unknown confounders outside the intervention which might affect the observed outcomes. The study utilised routinely collected data taken from inpatient medical records; this captures patients' hospital stay and the majority of information and clinical codes are therefore well recorded. However, it is possible that recording of some comorbidities might be incomplete. Furthermore, the intervention and analysis are based on data from a single hospital trust; it is therefore not clear whether the results would be generalisable to other hospital trusts. Finally, being a multi-systems approach it is not possible to determine which of the multiple interventions had the greatest impact on patient outcomes, nevertheless it is unlikely that any of the interventions would be detrimental to diabetes care.

Conclusions

The DICE project showed that a well-staffed inpatient team, delivering care through a whole systems approach and weekend working led to a sustained reduction in length of stay for inpatients with diabetes which has important financial implications. With multiple factors influencing patient length of stay and mortality in the inpatient setting, the methodology used in this study shows the additional information that can be gained by using interrupted time series analysis, and highlights the benefit of using a negative control group comprising patients without a diagnosis of diabetes. The authors of this study advocate the use of this quasi-experimental methodology for assessing the impact of interventions in the clinical setting.

ACKNOWLEGMENTS

Contributions

The clinical project was carried out by the DICE team at Ipswich hospital under the supervision of GR and RR. The DICE team consisted of R Round, C Kerry, S Barker. Data interpretation was carried out by FA and JM with assistance from KG and NA under the guidance of TM, GaR, GR and KN. FA, KN and GR conceptualised the manuscript and it was written by FA with contributions from JM, NA, KN and GR.

Dr. Funke Akiboye is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis**.**

All authors approved the final manuscript for submission.

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Table 1. Baseline characteristics of patients included in the before and after analysis

	2013		2014	
	Non-diabetes	**Diabetes**	**Non-diabetes**	**Diabetes**
Age				
Median (IQR)	65 (45-80)	75 (63-82)	65 (45-80)	75 (64-83)
Mean	61.37	70.86	61.44	71.53
Sex (male), n (%)	6221 (45.19)	1231 (52.67)	6309 (44.15)	1326 (54.50)
Ethnic Group, n (%)				
White	11881 (86.31)	2062 (88.24)	11444 (80.08)	2038 (83.76)
Black African and Caribbean	85 (0.62)	28 (1.2)	70 (0.49)	29 (1.19)
Asian	132 (0.96)	38 (1.63)	106 (0.74)	28 (1.15)
Not categorised	1667 (12.11)	209 (8.94)	2670 (18.68)	338 (13.89)
Admission type, n (%)				
Emergency	10608 (77.07)	1970 (84.30)	11061 (77.4)	2072 (85.16)
Elective	3157 (22.93)	367 (15.7)	3229 (22.6)	361(14.84)
ITU during admission, n (%)	301 (2.19)	73 (3.12)	329 (2.30)	69 (2.84)
HRG, n (%)				
A (Nervous system, pain management)	910 (6.61)	146 (6.24)	997 (6.98)	157 (6.45)
B (Eyes and periorbital)	47 (0.34)	5 (0.21)	67 (0.47)	9 (0.37)
C (Mouth, head, neck, ears)	587 (4.26)	61 (2.61)	527 (3.69)	57 (2.34)
D (Thoracic)	1472 (10.69)	303 (12.97)	1415 (9.9)	287 (11.8)
E (Cardiac)	1919 (13.94)	415 (17.76)	2152 (15.06)	423 (17.39)
F (Digestive system)	2093 (15.21)	303 (12.97)	2098 (14.68)	294 (12.08)
G (Hepatobiliary and pancreatic system)	476 (3.46)	60 (2.57)	509 (3.56)	74 (3.04)
H (Orthopaedic)	2022 (14.69)	227 (9.71)	1934 (13.53)	269 (11.06)
J (Skin)	346 (2.51)	52 (2.23)	357 (2.50)	80 (3.29)
K (Endocrine system)	151 (1.1)	156 (6.68)	162 (1.13)	148 (6.08)
L (Renal, urological, male reproductive system)	1034 (7.51)	252 (10.78)	1147 (8.03)	230 (9.45)
M (Female reproductive system)	705 (5.12)	30 (1.28)	728 (5.09)	47 (1.93)
N (Obstetric)	91 (0.66)	1 (0.04)	113 (0.79)	1 (0.04)
P (Paediatric)	166 (1.21)	15 (0.64)	178 (1.25)	6 (0.25)
Q (Vascular)	183 (1.33)	82 (3.51)	125 (0.87)	56 (2.3)
R (Diagnostic imaging)	46 (0.33)	15 (0.64)	70 (0.49)	15 (0.62)
S (Haematological, chemotherapy, radiotherapy, specialist palliative care)	288 (2.09)	32 (1.37)	305 (2.13)	34 (1.4)
U (Undefined groups)	1 (0.01)	0	10 (0.07)	0
V (Trauma, emergency medicine, rehabilitation)	97 (0.7)	8 (0.34)	113 (0.79)	31 (1.27)
W (Immunology, infectious diseases, other healthcare contacts)	1131 (8.22)	174 (7.45)	1283 (8.98)	215 (8.83)
IMD, n (%)				
0 (most deprived)	2871 (20.97)	590 (25.43)	2911 (20.53)	640 (26.45)
1	2871 (20.97)	478 (20.60)	2840 (20.03)	518 (21.40)
2	2766 (20.21)	435 (18.75)	2763 (19.49)	475 (19.63)
3	2530 (18.48)	387 (16.68)	2621 (18.49)	404 (16.69)
4 (least deprived)	2650 (19.36)	430 (18.53)	3046 (21.46)	384 (15.83)

Charlson Comorbidity score, n (%)				
0	9390 (68.22)	1093 (46.77)	9558 (66.89)	1104 (45.38)
1	1970 (14.31)	445 (19.04)	2126 (14.86)	461 (18.95)
2+	2405 (17.47)	799 (34.19)	2606 (18.24)	868 (35.68)

HRG = Health Resource Group; IMD = index of multiple deprivation.

Table 2. Results of the before and after analysis

	Diabetes patients 2013	**Diabetes patients 2014**	**Patients without diabetes 2013**	**Patients without diabetes 2014**
Population	2337	2433	13765	14290
Mortality (n)	152	106	503	436
Mortality rate	6.5%	4.4%	3.7%	3.1%
Unadjusted mortality odds ratio	0.66 (0.51, 0.85)		0.82 (0.72, 0.93)	
Adjusted^ odds ratio (95% CI)	0.63 (0.48, 0.82)		0.81 (0.70, 0.93)	
Median length of stay (days)	3.5	3.0	2.0	1.9
Mean length of stay (days)	7.5	6.7	5.0	4.7
Unadjusted length of stay relative ratio (95% CI)	0.92 (0.84, 0.99)		0.93 (0.90, 0.96)	
Adjusted^ length of stay relative ratio (95% CI)	0.89 (0.83, 0.97)		0.93 (0.90, 0.96)	
30 day readmissions (n)	401	389	1614	1693
Readmission rate	17.2%	16.0%	11.7%	11.9%
Unadjusted readmission odds ratio (95% CI)	0.92 (0.79, 1.07)		1.02 (0.94, 1.09)	
Adjusted^ readmission odds ratio (95% CI)	0.96 (0.82, 1.12)		1.04 (0.96, 1.12)	

^Adjusted for age, sex, ethnic group, IMD quintile, HRG category, ITU episode, modified Charlson comorbidity score, and emergency/elective admission

Table 3. Baseline characteristics of patients included in the ITS analysis

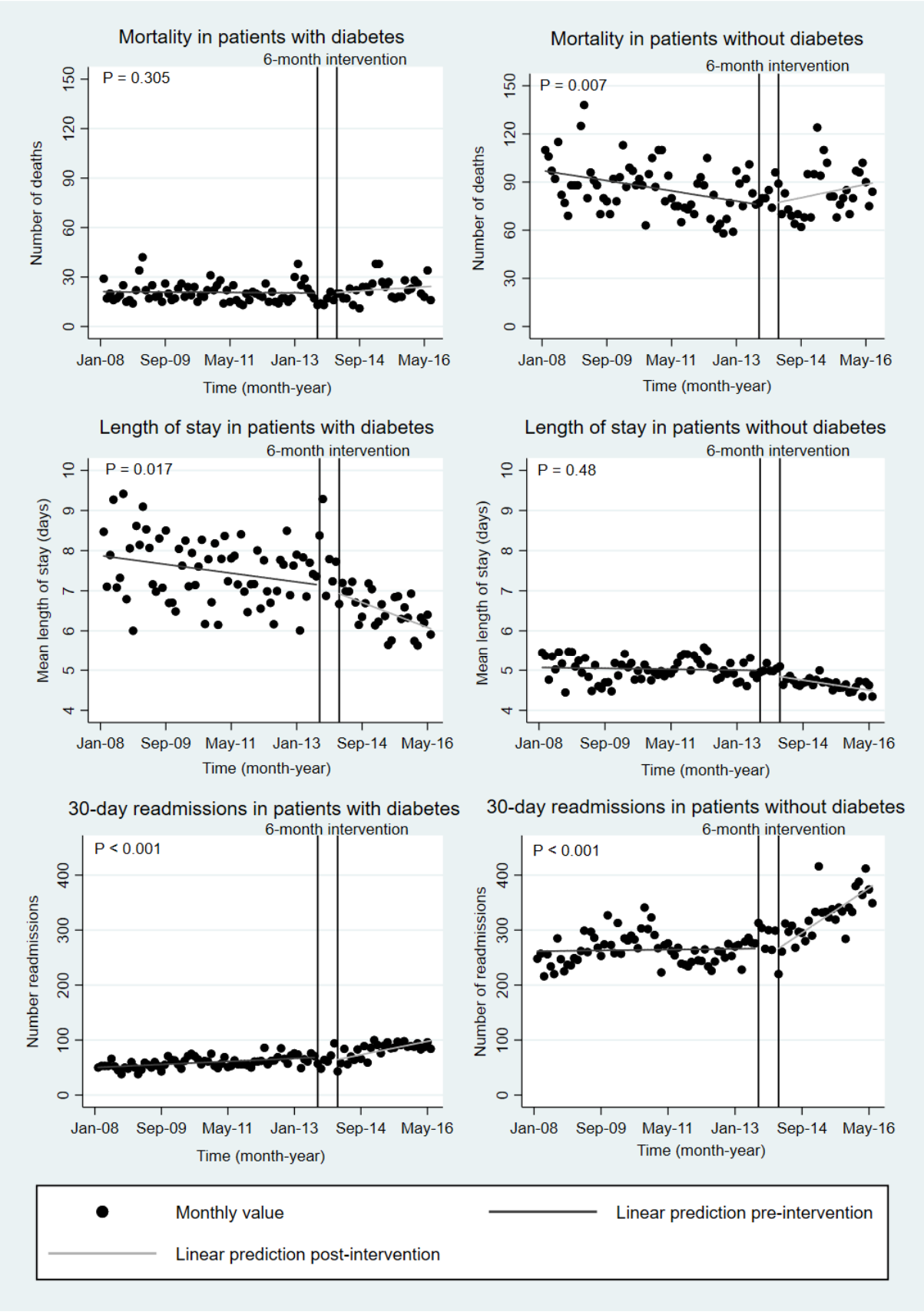
	2008		2009		2010	
	Non-diabetes	**Diabetes**	**Non-diabetes**	**Diabetes**	**Non-diabetes**	**Diabetes**
Population, n	27360	3724	29437	3982	29644	4491
Sex (male, %)	12152 (44.42)	2064 (55.4)	13146 (44.7)	2038 (51.2)	13000 (43.9)	2339 (52.1)
Age						
Mean (SD)	61.2 (21)	71.0 (14.6)	60.65 (21.5)	70.6 (15.4)	61.2 (21.5)	70.7 (15.7)
Median (IQR)	64 (25, 79)	74 (63, 81)	64 (44, 79)	73 (63, 81)	65 (45, 79)	74 (63, 82)

	2011		2012		2013	
	Non-diabetes	**Diabetes**	**Non-diabetes**	**Diabetes**	**Non-diabetes**	**Diabetes**
Population, n	27338	4266	26551	4363	27712	4646
Sex (male, %)	12203 (44.64)	2252 (52.8)	11764 (44.31)	2370 (54.3)	12656 (45.67)	2445 (52.63)
Age						
Mean (SD)	61.5 (21.5)	70.7 (15.4)	61.3 (21.6)	70.7 (15.6)	61.6 (21.6)	71.1 (15.6)
Median (IQR)	65 (45, 80)	74 (62, 82)	65 (45, 80)	74 (63, 82)	65 (45, 80)	75 (63, 82)

	2014		2015		2016*	
	Non-diabetes	**Diabetes**	**Non-diabetes**	**Diabetes**	**Non-diabetes**	**Diabetes**
Population, n	28929	5111	30483	5665	13159	2343
Sex (male, %)	12889 (44.5)	2772 (54.24)	13860 (45.5)	3089 (54.53)	1250 (53.35)	5951 (45.2)
Age						
Mean (SD)	61.9 (21.8)	71.9 (15.2)	62.7 (21.6)	72.2 (14.8)	61.9 (21.7)	71.4 (15.7)
Median (IQR)	66 (45, 80)	75 (65, 83)	67 (47, 81)	75 (65, 83)	66 (46, 80)	74 (63, 83)

*6 months of data included (January to June).

Figure 1


Mortality in patients with diabetes
6-month intervention
P = 0.305
Number of deaths
0
30
60
90
120
150
Jan-08
Sep-09
May-11
Jan-13
Sep-14
May-16
Time (month-year)
Mortality in patients without diabetes
6-month intervention
P = 0.007
Number of deaths
Time (month-year)
Length of stay in patients with diabetes
6-month intervention
P = 0.017
Mean length of stay (days)
4
5
6
7
8
9
10
Time (month-year)
Length of stay in patients without diabetes
6-month intervention
P = 0.48
Mean length of stay (days)
Time (month-year)
30-day readmissions in patients with diabetes
6-month intervention
P < 0.001
Number readmissions
0
100
200
300
400
Time (month-year)
30-day readmissions in patients without diabetes
6-month intervention
P < 0.001
Number of readmissions
Time (month-year)
Monthly value
Linear prediction pre-intervention
Linear prediction post-intervention