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Population-level impact of diabetes integrated care on commissioner payments for inpatient care among people with type 2 diabetes in Cambridgeshire: a postintervention cohort follow-up study

Dahai Yu,1,2 Wei Yang,1,3 Yamei Cai,1 Zhanzheng Zhao,1 David Simmons4

ABSTRACT

Objectives Few studies have estimated the effect of diabetes integrated care at a population level. We have assessed the impact of introducing a community service-led diabetes integrated care programme on commissioner payments (tariff) for inpatient care in rural England.

Methods The Diabetes Integrated Care Initiative was delivered by a separate enhanced community diabetes service, increasing specialist nursing, dietetic, podiatry and medical support to primary care and patients, while linking into other diabetes specialist services. Commissioner data were provided by the local authority. The difference in area between the two overlapping distribution curves of inpatient payments at baseline and follow-up (at 3 years) was used to estimate the effect of integrated care on commissioner inpatient payments on a population level.

Results Over the 3-year period, reduced inpatient payments occurred in 2.7% (1.3% to 5.8%) of patients with diabetes aged more than 70 years in the intervention area. However, reduced diabetes inpatient payments occurred in 3.20% (1.77% to 7.20%) of patients aged <70 years and 4.1% (2.3% to 7.9%) of patients ≥70 years in one of the two adjacent areas.

Conclusion This enhanced community diabetes services was not associated with substantially reduced inpatient payments. Alternative diabetes integrated care approaches (eg, with direct primary and secondary care collaboration rather than with a community service) should be tested.

INTRODUCTION

As the social and economic impact of diabetes grows, so does the variety of attempts to improve care quality and reduce healthcare costs among those affected.1–4 One approach, which is able to provide at least equivalent care to routine medical care with some types of patients, has been the introduction of nurses working within protocols, within medical services.5 Other models known as ‘intermediate care’, including general practitioners with a special interest,6 and community diabetes nursing services6 have been implemented, but without robust evaluation. As a proposed system, integrated care articulates all health workers and health systems around the needs of each patient and should be associated with improved outcomes and less cost.7

However, the impact of a population-based integrated care intervention is difficult to measure on an individual level. One randomised trial of an intermediate care service achieved minimal actual incremental benefit.8 By their nature, randomised controlled trials are difficult to use when assessing the impact of a complete system change at a population level. Sarkadi et al have proposed a method to look at population outcomes in their own right in the quest of understanding how interventions work at a population level.9 Under the English National Health Service (NHS), public inpatient care is paid for from taxation through local commissioners. These payments do not generally cover the hospital costs of inpatients...
with diabetes, but can provide an NHS commissioner perspective that reflects both acuity and complexity, beyond, for example, length of stay. We have now used the Sarkadi approach to assess whether any changes in population-based commissioner inpatient payment data occurred during a diabetes integrated care intervention by viewing the level and distribution of commissioner inpatient payments in the population as the unit of interest.

**METHODS**

East Cambridgeshire and Fenland (ECF: 2009 population 160 000, diabetes population 7790) is largely rural, with a small number of socioeconomically deprived communities. There is no local major hospital (with, eg, an emergency department) falling within the catchment areas of four hospitals outside of the area. Some diabetes outcomes have been historically poor. A separate, local, diabetes specialist nurse-led community service was introduced in 2003. From April 2009, this was replaced with a new Diabetes Integrated Care Initiative (DICI) using additional finance (£250 000 pa), in an attempt to address continuing health disparities. The components of the DICI have been described in the previous publications.

The health district includes two other areas, Huntingdonshire and Greater Cambridge, which did not receive the full intermediate team and are able to serve as ‘control’ areas, although each hospital-based service would have continued with its own internal service developments. We have previously reported no impact on metabolic control or hospitalisation rates in spite of full implementation of the service.

Deidentified electronic Secondary Uses Service data for across Cambridgeshire were obtained for recorded inpatient tariff between April 2007 (ie, 2 years before the DICI contract commenced) and March 2012. Practice, patient age, elective/non-elective status, International Classification of Diseases 10th revision (ICD10) and Health Related Group coding were included in the dataset. Diabetes was considered present if E10–E14 was coded in the first field, in an attempt to address continuing health disparities. The probability of observing estimations less than or equal to zero is calculated, and used as the approximation of the P value for testing whether health gain is significantly larger than zero.

No personal identifiers were released to researchers, and all subsequent analyses were conducted on anonymised datasets. Age data were provided allowing analyses to be undertaken above and below the median age (70 years) to assess any related variation.

The work had approval from the Cambridgeshire research ethics committee as part of a wider service evaluation and, as such, was deemed not to require personal informed consent.

All analyses were conducted in R (V.3.1).

**RESULTS**

The sample size of inpatient payment records during the baseline and the intervention period in each region is presented in table 1. The inpatient payments during the baseline period and the intervention period are shown in table 2 by area and age group. In each area and age group, a lower individual median inpatient payment was more likely to be found in the intervention period.

Figure 1 shows the distribution of the inpatient payments in people with type 2 diabetes in the baseline and intervention periods. This illustrates the effect of the integrated care intervention, as the left-moving curve in the intervention period indicates the potential inpatient payment saving at a population level.
distribution of log-transformed payment data) were attempted to fit the payment data as presented in online supplementary table 1. The normal distribution of log-transformed payment data was chosen to estimate the impact on the intervention for its minimum AIC and BIC and its maximum log-likelihood.

The magnitude of the intervention at the population level is presented in table 3. Significant ‘health gain’ was observed both in the intervention area and control areas, especially among patients aged less than 70 years. In the intervention area, East Cambridge and Fenland, 7.69% (95 CI 5.89% to 9.74%) and 2.05% (0.72% to 4.13%) of patients aged less than 70 years and aged more than 70 years, respectively, had a reduced inpatient payment, compared with the population in the baseline period. In Huntingdonshire, the ‘health gain’ was 6.90% (5.63% to 8.68%) and 4.62% (2.22% to 7.23%) among patients aged less than 70 years and patients aged more than 70 years, respectively. In Greater Cambridge, the ‘health gain’ was 7.59% (5.63% to 9.94%) and 2.49% (1.46% to 4.58%) among patients aged less than 70 years and patients aged more than 70 years, respectively.

To allow comparisons, the estimated impact, based on a normal distribution, is presented in online supplementary table 2. In the intervention area, East Cambridge and Fenland, 2.74% (1.29% to 5.81%) of patients aged more than 70 years had a reduced inpatient payment, compared with the population in the baseline period. In one of the control areas, Greater Cambridge, ‘health gain’ was also observed in 3.20% (1.77% to 7.20) of patients aged less than 70 years and aged more than 70 years, respectively. In Greater Cambridge, the ‘health gain’ was 7.69% (5.89% to 9.74%) and 2.05% (0.72% to 4.13%) of patients aged less than 70 years and aged more than 70 years, respectively. Significant ‘health gain’ was not identified within the population in Huntingdonshire over the study period.

**Table 1** Sample size of the inpatient payment records

<table>
<thead>
<tr>
<th></th>
<th>East Cambridge and Fenland</th>
<th>Huntingdonshire</th>
<th>Great Cambridge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;70 years</td>
<td>≥70 years</td>
<td>&lt;70 years</td>
</tr>
<tr>
<td>2008–2009</td>
<td>2012</td>
<td>2028</td>
<td>1494</td>
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**DISCUSSION**

We have used a novel way, calculating the total health gain (proportion of people with reduced inpatient payments) assuming a Gaussian distribution, to assess the results of integrated care in the diabetic population of areas in Cambridgeshire through a population lens. The study revealed a possible effect of the new integrated care approach on inpatient payments, as 7.7% of patients aged less than 70 years and 2.1% of patients aged more than 70 years had reduced inpatient payments in the intervention area, East Cambridge and Fenland. However, reductions were also seen in the control areas, in Huntingdonshire, 6.9% of patients aged less than 70 years and 4.6% of patients aged less than 70 years had reduced inpatient payment; in Greater Cambridge, 7.6% of patients aged less than 70 years and 2.5% of patients aged less than 70 years had reduced inpatient. The 95% CIs overlapped across the three areas, so we have not shown any differences between the areas.

Significant improvements in diabetes care can occur with multifaceted interventions including disease management in the USA and integrated care in Germany, and these can be associated with reductions in hospital costs. The integrated care intervention was successfully implemented across the area, with positive patient experience, improved practice nurse clinical confidence and early reports of clinical benefit. It is therefore surprising that although some (small) positive benefit was observed in the intervention area, the return on the investment of £250,000 was not greater and possibly less than in one of the control areas. Elsewhere, diabetes integrated care interventions have generally been more effective within single providers or in contexts where multiple primary care organisations work with a single specialist provider under an integrated insurance scheme. The integrated care intervention carried out in ECF followed a nurse-led service with one of the goals reducing referrals (ie, payments) to hospital outpatient. This philosophy, rather than progressing to truly integrated services, carried through the intervention period, although as part of a wider programme that included ‘vertical integration’ developments. It was perhaps to be expected that attempts at creating such greater ‘vertical’ integration in information management, clinical governance, budget and overall management were agreed, but not implemented, actions more achievable within a single organisation. There was an attempt to create a single equal partner network model nearing the end of the intervention period, but this was not funded by the local commissioners.

The failure to implement integrated information management almost certainly contributed to communication and integration difficulties. Most integrated care initiatives attempt to include data sharing and this was not possible within the local information governance arrangements. This was noticed by the patients and was a source of frustration. Interestingly, integration was perceived as happening when there was one person ‘fronting up’ for all those involved. Case management has been proposed as one approach to integration, and requires the case manager to corral and coordinate the services for a given individual.
Table 2 Distribution of age and inpatient payment among people with type 2 diabetes by region and year

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>East Cambridge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>59 (48–64)</td>
<td>67 (48–66)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>78 (74–82)</td>
<td>80 (77–83)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>115 (111–263)</td>
<td>103 (96–250)</td>
</tr>
<tr>
<td>Huntingtonshire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>61 (60–65)</td>
<td>66 (60–66)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>77 (73–83)</td>
<td>78 (74–83)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>82 (73–83)</td>
<td>80 (73–83)</td>
</tr>
<tr>
<td>Great Cambridge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>78 (74–82)</td>
<td>78 (74–82)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>77 (73–83)</td>
<td>77 (73–83)</td>
</tr>
<tr>
<td>≥70 years</td>
<td>83 (78–88)</td>
<td>83 (78–88)</td>
</tr>
</tbody>
</table>

Whether our findings are due to a unique set of circumstances or expected as part of a three-compartment model (primary care, intermediate care and secondary care) is unclear, but there are indications that the circumstances are not special. There are calls for more integration and less fragmentation in healthcare, yet the evidence on what works in England is limited. The latest changes in commissioning in the English NHS, with emphasis on the need to consider ‘Any qualified Provider’ in service delivery, and associated market procurement approaches, could well impair the quality of diabetes care while increasing overall cost, if the experience here is reproduced elsewhere.

Similarly, as a ‘natural experiment’, it was not possible to measure the impact of integrated care on inpatient payments at an individual level. Instead, we estimated the proportion of the population showing ‘health gain’ (reduced inpatient payments) from the integrated care intervention by using the distribution curve of inpatient payment. Although the method was within the conceptual framework proposed by Sarkardi, some modifications to the methodology were made to overcome methodological drawbacks, for example, requiring the same SD for two Gaussian curves: something unlikely to occur in real scenarios. We believe this revised method would be more applicable to evaluate the ‘health gain’ for interventions at a population level.

There are limitations to our study. This was not a randomised trial, so any changes could be due to secular trends, although we do compare with the two other areas in Cambridgeshire. The data depended on the completeness of the coding of diabetes, and there being no systematic change in coding over this time period. We found that at least one provider had high diabetes ascertainment. Data access restrictions prevented adjustment for some important covariates. As the data used was record based rather than individual based, repeat inpatient records were unable to be linked; however, the record-based data still provide a range of plausible estimations. Moreover, within a relatively fixed diabetes population served by a local ‘closed’ inpatient care and tariff system, the likelihood for patients having a second hospital admission would still be relatively low (although higher than those without diabetes). In other words, inpatient payments at two time points are considered completely independent of each other. We acknowledge that this current analysis still yields findings subject to confounding bias unable to be measured in this study. The ‘impact’ observed in our study may therefore only reflect measured changes in the DICI and ‘control’ regions, respectively, rather than due to the DICI itself, as the DICI care model was not randomly assigned. As a result of data access restrictions, it is not possible in this study to identify those with multiple admissions (and payments) that would provide ‘redundant information’. The application of bootstrapping ignoring such redundant information might lead to a misapplication of Sarkadi’s tool and might inadvertently increase the false-positive rate: something to be
Figure 1 Using the normal (Gaussian) curve to demonstrate the distribution of inpatient payment in people with type 2 diabetes and possible effects of an integrated care on the curve. The differences between the respective areas under the curve are shaded. Health gains for participants with lower inpatient payment. Left top: East Cambridge and Fenland, <70 years; right top: East Cambridge and Fenland, ≥70 years. Left middle: Great Cambridge, <70 years; right middle: Great Cambridge, ≥70 years. Left bottom: Huntingdonshire, <70 years; right bottom: Huntingdonshire, ≥70 years.

Table 3 The estimated absolute ‘health gain (impact)’ after the intervention by age and region: estimation based on normal distribution of log-transferred inpatient payment data

<table>
<thead>
<tr>
<th>Region</th>
<th>Impact, %</th>
<th>95% CI, %</th>
<th>P value (bootstrapping)</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Cambridge and Fenland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>7.69</td>
<td>(5.89 to 9.74)</td>
<td>0</td>
</tr>
<tr>
<td>≥70 years</td>
<td>2.05</td>
<td>(0.72 to 4.13)</td>
<td>0.044796</td>
</tr>
<tr>
<td>Huntingdonshire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>6.90</td>
<td>(5.63 to 8.68)</td>
<td>0</td>
</tr>
<tr>
<td>≥70 years</td>
<td>4.62</td>
<td>(2.22 to 7.23)</td>
<td>0.001300</td>
</tr>
<tr>
<td>Greater Cambridge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70 years</td>
<td>7.59</td>
<td>(5.63 to 9.94)</td>
<td>0</td>
</tr>
<tr>
<td>≥70 years</td>
<td>2.49</td>
<td>(1.46 to 4.58)</td>
<td>0.037096</td>
</tr>
</tbody>
</table>

The health gain (impact) was defined as percentage of people with type 2 diabetes and hospital admission having reduced inpatient payment after the integrated care at population level.

In conclusion, we have applied a modified novel strategy to measure ‘health gain’ associated with an integrated care intervention at a population level. We found that there were no differences in inpatient payments. Our findings suggest that irrespective of the ideal principles behind integration, linking multiple health providers to

taken into consideration when interpreting the findings in this study. There might be other potential unidentified confounders in this study and evaluation seeking other confounding factors would be possible in future studies with more variables in the dataset including a way to identify those confounders.
deliver population-based diabetes care is complex and improvements in health outcomes remain difficult to achieve.

**Author affiliations**

1 Department of Nephrology, The First Affiliated Hospital, Chengzhou University, Chengzhou, China
2 Arthritis Research UK Primary Care Centre, Research Institute for Primary Care and Health Sciences, Keele University, Keele, UK
3 School of Medicine, Washington University in St Louis, St Louis, Missouri, USA
4 Macarthur Clinical School, Western Sydney University, Sydney, Australia

**Contributors** DY analysed the data and drafted the manuscript; WY revised the statistical methods and revised the manuscript; YC validated the method and reanalysed the data independently; ZZ designed the study, revised the analysis framework, revised the manuscript and interpreted the findings.

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**Competing interests** None declared.

**Ethics approval** National Research Ethics Service Committee—East of England.

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**Data sharing statement** No additional data are available.

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