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

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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

Strengths and limitations of this study

► The ‘health gain’ in the revised method was clearly defined with a formulated algorithm of evaluation, which broadened the utilisation scenarios especially when negative values were raised.

► The data used in this study depended on the completeness of the coding for diabetes in the general practitioner records. The impact of this potential ascertainment bias should have been steady as no systematic change in coding was known to have occurred over this time period.

► Data on some important confounders such as lipid profiles were not available in this study.
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). This was used 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 recorded in 2008–2009 as baseline, to compare with that recorded in 2011–2012 as the end of the intervention period. Using the Sarkadi et al method, the mean and SD for normal distributions before and after the intervention can be estimated. The ‘health gain’ is defined as the area between the two distribution curves on the right side, where the distribution density after intervention is lower (the shaded area in online supplementary figure 1 left). In our study, ‘health gain’ represents the proportion of patients with reduced inpatient payments between the baseline and intervention period. The reduction in commissioner payments reflects reduced needs in care and thus improvement in health.

Sarkadi’s method has outlined ways to calculate the impact when the two distributions have the same SD, or when the follow-up group has smaller mean and smaller SD at the same time. However, we have noticed when using real data that the follow-up group might have smaller mean but larger SD. To accommodate this situation, we have modified the Sarkadi’s method as described in online supplementary technical appendix and online supplementary figure 1. The health gain distributions are presented in online supplementary figure 2 to illustrate the health gains at a population level.

In addition to the normal distribution originally used in Sarkadi’s method, three other distributions, gamma distribution, log-normal distribution and normal distribution of log-transferred payment data, were attempted to fit the data. The goodness-of-fit statistics, Akaike information criterion (AIC), Bayesian information criterion (BIC) and log-likelihood were tested over four distributions and the distribution with the minimum AIC, BIC and maximum log-likelihood was chosen as the final distribution to examine the impact.

Bootstrapping is used to obtain a P value for the probability of health gain larger than zero. We randomly sampled data points with replacements from the original data separately for the baseline and follow-up, so that we obtain bootstrapped data with the same numbers of data points. These are used to obtain an estimation of the health gain after perturbation. This process is repeated 1000 times. 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 periods 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.

Four distributions (normal distribution, gamma distribution, log-normal distribution and normal distribution) can be seen in online supplementary figure 2 to illustrate the health gains at a population level.
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

| Region                | Age, year |      | Age, year |      | Age, year |      |
|-----------------------|-----------|------|-----------|------|-----------|------|
|                       | <70 years | ≥70 years | <70 years | ≥70 years | <70 years | ≥70 years |
| East Cambridge and Fenland | 2008–2009 | 60 (51–65) | 78 (74–82) | 819 (5061–860) | 911 (531–2473) | 2011–2012 | 60 (51–65) | 78 (74–83) | 683 (468–1635) | 823 (498–2475) |
| Huntingdonshire       | 2008–2009 | 61 (52–65) | 77 (73–83) | 808 (504–1707) | 808 (531–2251) | 2011–2012 | 60 (48–66) | 77 (73–83) | 677 (502–1666) | 808 (469–2220) |
| Great Cambridge       | 2008–2009 | 58 (48–64) | 78 (74–82) | 933 (597–1997) | 1151 (611–2638) | 2011–2012 | 59 (50–66) | 79 (75–84) | 781 (505–1688) | 1031 (611–2508) |

The median (IQR) was presented for both age and inpatient payment.
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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

| Region                        | <70 years | 95% CI, % | ≥70 years | 95% CI, % | P value (bootstrapping) |
|-------------------------------|-----------|-----------|-----------|-----------|-------------------------|
| East Cambridge and Fenland    | 7.69      | (5.89 to 9.74) | 2.05      | (0.72 to 4.13) | 0.044796 |
| Huntingdonshire               | 6.90      | (5.63 to 8.68) | 4.62      | (2.22 to 7.23) | 0.001300 |
| Greater Cambridge             | 7.59      | (5.63 to 9.94) | 2.49      | (1.46 to 4.58) | 0.037096 |

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.

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.
deliver population-based diabetes care is complex and improvements in health outcomes remain difficult to achieve.

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