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Research: Care Delivery

Impact of peer support on inpatient and outpatient

payments among people with Type 2 diabetes: a

prospective cohort study

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What's new?

- Peer support, whether delivered using a one-to-one, group or combined approach, was associated with reduced inpatient care utilization and payments.
- An intervention that combined individual and group peer-support had a consistent and potentially long-term impact on health payments.
- These data support the incorporation of invitation to structured peer support into modern Type 2 diabetes management.
- A two-part model adjusting patients' potential probability of utilising the health system is a practical tool to evaluate the health payment accurately.

Abstract

Aim To investigate the impact of a low-cost diabetes peer-support intervention, aimed at reducing inpatient and outpatient care utilization and healthcare payments, by conducting a cohort study that followed up a randomized controlled trial.

Methods A total of 1121 adults with Type 2 diabetes were recruited through general practices in Cambridgeshire and Hertfordshire, UK, and were followed up for 3.25 financial years after 8–12 months of one-to-one, group or combined diabetes peer support and usual care. Use of, and payments for inpatient and outpatient services were fully recorded in the follow-up. Adjusted mean inpatient and outpatient payments per person were estimated using a two-part model after adjusting for baseline characteristics.

Results The mean age of the recruited adults was 65.6±11.4 years, 60.4% were male, and 16.8% were insulin-treated. Compared with the control group, less healthcare utilization (especially non-elective inpatient care and outpatient consultations) was observed in each of the intervention groups, particularly the combined intervention group. Over the course of 3.25 financial years, significant reductions of 41% (£909.20 per head) were observed for overall inpatient payments ($P<0.0001$), 51% (£514.67 per head) for non-elective inpatient payments ($P=0.005$) in the combined intervention group, and 34% (£413.30 per head) and 32% (£388.99 per head) for elective inpatient payments in the one-to-one ($P=0.029$) and combined intervention ($P=0.048$) groups, respectively.

Conclusions Type 2 diabetes peer support, whether delivered using a one-to-one, group or combined approach was associated with reduced inpatient care utilization (particularly non-elective admissions) and payments over 3.25 years.

Introduction

Diabetes is associated with morbidity and premature death [1]. The health economic burden attributable to diabetes and its complications is an increasing challenge [2]. The benefits of behavioural interventions on metabolic, mental health and psychological issues have been variable [3,4].

Diabetes peer support involves people with diabetes assisting each other to improve their social, mental and physical wellbeing. Peer support can be provided through individual or group approaches and either face-to-face, telephone or online contact. Peer support is a low-cost intervention, and has been suggested to reduce healthcare costs [4], including among people with Type 2 diabetes [5,6]. Analyses in studies on such interventions, however, either

were only based on patients over the study period, without consideration of healthcare utilization across the whole study population [5], or findings were not derived from a trial [6].

The Randomized Controlled Trial of Peer Support in Type 2 Diabetes (RAPSID) was the largest randomized controlled trial (RCT) on Type 2 diabetes peer support to date [7]. The intervention was recently shown to be cost-effective during the trial, based on self-reported costs [8]. Medication costs were excluded as these were not collected in detail.

In the present study, we aimed to investigate whether peer support reduces utilization of, and payments for, secondary care services over 3.25 years of follow-up, including a comparison of the impact of different approaches to face-to-face support (one-to-one, group or combination of both). The logic model to link peer support with hospitalization is presented in Fig. S1.

Materials and Methods

Research design, participants and intervention

The design, methods and primary outcomes of the RAPSID trial have been published previously [7], including its CONSORT (Consolidated Standards of Reporting Trials) diagram [7]. Briefly, RAPSID was a 2×2 factorial cluster RCT comparing four groups of participants with Type 2 diabetes: one-to-one (individual) peer support; group peer support; combined one-to-one and group peer support; and a control group. Participants had been diagnosed with diabetes for at least 12 months. Those with dementia or psychotic illness were excluded. Participants were recruited from communities across Cambridgeshire and neighbouring areas of Essex and Hertfordshire. Follow-up data were only available for participants in Cambridgeshire and the neighbouring areas of Hertfordshire that are served by

the Cambridgeshire and Peterborough Clinical Commissioning Group. Clusters were defined by local government ('parish council') boundaries. The intervention was developed after a pilot study [9], using a framework defined by Peers for Progress [10]. Peers who delivered peer support were termed 'peer support facilitators' and their selection, training, support and the overall programme are described elsewhere [7].

The intervention involved peer support delivered by trained facilitators in a community venue. Within the first 6 months, discussion focused on three essential elements of diabetes management; namely, overcoming practical obstacles encountered while dealing with diabetes, coping with the social and emotional aspects of diabetes, and the type of medical therapy used in caring for diabetes. Just over 60% (61.4%) attended a session involving face-to-face contact with a peer support facilitator [7], but most participants (92.6%) were at least in contact by telephone. After this period, topics were discussed at the discretion of the peer support facilitator and peers. A monthly meeting was held between peer support facilitators and a health professional (diabetes specialist nurse or dietitian) to discuss any issues that had arisen.

The intervention lasted 8–12 months and was commenced and concluded, cluster by cluster, between 2 June 2011 and 12 April 2012. Ethics approval was received from the Cambridgeshire REC2 Committee (10/H0308/72), and signed consent included agreement for access to hospital data.

Assessments and outcomes

At baseline, demographic data, duration of diabetes and treatment information were collected by self-report. Each participant was followed up until June 2015 (0.91–4.07 years' follow-up from entry into the trial).

Data on hospitalization [funded by the National Health Service (NHS) at public and private hospitals], accident and emergency department and outpatient visits within the

Cambridgeshire and Peterborough Clinical Commissioning Group (CCG) catchment were collected through the CCG and classified into 3.25 financial years based on the CCG audit timeframe: 1) first financial year: April 2012 to March 2013; 2) second financial year: April 2013 to March 2014; and 3) last 1.25 financial year: April 2014 to June 2015. The

elective/non-elective status, International Classification of Diseases (ICD-10) codes, Health Related Group codes and Office of Population Censuses and Surveys Version-4 (OPCS-4) procedure codes for each episode for the above hospital-based healthcare were recorded by hospital staff and each would have attracted a nominated tariff or payment [11].

Hospitalization (NHS hospitals and private hospitals), accident and emergency department and outpatient visits were classified according to elective/non-elective status and primary reasons (cardiovascular disease and diabetes-related disorders), as defined by ICD-10 codes.

Health payments were defined by Health Related Group group and OPCS-4 codes; however, these often do not cover the provider 'cost' of the care for people with diabetes [12] and the term 'health payments' is therefore used.

Statistical analysis

A large proportion of the population do not attend hospital as an inpatient or outpatient in any given year and therefore healthcare payment data demonstrate a skewed utilization/payment pattern [13]. To take into account the problem of 'zero mass' and skewed outcomes, the demand functions were modelled using a two-part model [14]. In this two-part model, a probit model was estimated for the probability of observing 'zero' vs positive medical expenditure. Positive medical expenditure is defined as any healthcare expenditure greater than zero. A generalized linear model was estimated, conditional on having healthcare expenditure. The generalized linear model was used, instead of log ordinary least squares regression, because it relaxes the normality and homoscedasticity assumption, and avoids bias associated with re-transforming to the raw scale [15]. The results of the modified Park test [14] verified that the use of a gamma distribution, with a log link, was the best fitted generalized linear model for consistent estimation of coefficients and marginal effects of medical expenditure [16]. Multicollinearity was tested for predictors of the two-part model, taking into account the complex survey design [13]. The variance inflation factor for all predictors used in the two-part model indicated no-existence of multicollinearity [17]. The F-test for the two-part regression models was found to be significant, which indicated the overall significance of the regression model. Marginal effects were then estimated as the mean health payment from the combined first and second parts of the final model [16]. The payment ratio for each intervention group compared with the control group was also calculated. To control for confounding, baseline characteristics were included in the fully adjusted model (Table 1). The 95% CIs for estimated payments were estimated using a bootstrap process with 1000 samples. In the sensitivity analysis, all analyses were repeated for each financial year. All analyses were performed with STATA (STATA/SE 14.0 StataCorp, College Station, TX, USA).

Results

Baseline characteristics

Overall, 1121 patients in Cambridgeshire/Hertfordshire were recruited and randomized across 120 clusters. Baseline data for the four arms were well matched (Table 1). The majority of participants reported antihypertensive (727; 65%), lipid-lowering (752; 67%) and diabetes medication (892; 80%). Compared with those without, participants with an endpoint HbA_{1c} were older [mean (SD) 65 (9) vs 63 (10) years; $P = 0.018$], had longer diabetes duration [mean (SD) 9 (11) vs 8 (8) years; $P = 0.016$], lower BMI [mean (SD) 31.9 (6.8) vs 33.6 (6.7) kg/m²; $P < 0.001$] and were more likely to be treated with anti-hyperglycaemic tablets (81.6% vs 73.2%; $P = 0.004$), hypertension treatment (66.2 vs 59.4%; $P = 0.004$) and lipid-lowering treatment (68.5% vs 60.7%; $P = 0.021$) at baseline.

Health service payments

Health payment data were typically skewed (Table 2) as a result of the mass of ‘zero’ payments and a relatively small proportion of patients incurring extremely high expenditure. Between 2012 and June 2015, 54.30% of controls and 62.45%, 60.76% and 61.57% of participants in the one-to-one group, and combined intervention groups, respectively, were associated with zero inpatient payments. Among patients hospitalized in the period April 2012 to June 2015, the median (interquartile range) inpatient payments were £2488.42 (1118.57 to 5198.51), £2201.20 (846.38 to 5704.23), £2009.06 (888.53 to 5169.54) and £2421.94 (903.20 to 5236.43) for the control, one-to-one, group, and combined intervention groups, respectively. Outpatient attendance was relatively common in each group, with 33.68%, 39.46%, 35.76% and 39.15% of patients attending in the control, one-to-one, group, and combined intervention groups, respectively.

and combined intervention group, respectively. The median (interquartile range) outpatient payments were also skewed at £708.04 (316.75 to 1461.71), £645.22 (268.32 to 1270.91), £657.54 (285.58 to 1407.21), and £757.41 (320.77 to 1255.93) for the control, one-to-one, group, and combined intervention groups, respectively.

Similar patterns of health payment distribution in the financial years 2012–2013, 2013–2014 and 2014–June 2015 were found (Table S1).

Results from the two-part model

The results of the final two-part models are shown in Table 3. In the follow-up period 2012–June 2015, compared with patients in the control group and based on logit model estimations, significantly lower overall inpatient hospitalization was observed in the group intervention ($P=0.033$). The rate of non-elective hospitalization was significantly lower in the group ($P=0.009$) and combined ($P=0.029$) interventions. A lower rate of hospitalization for cardiovascular disease was found in the combined intervention and for diabetes in the one-to-one ($P<0.0001$) and combined ($P=0.021$) interventions. There were no reductions in outpatient utilization or costs.

Compared with patients in the control group, based on generalized linear model estimation, payments for overall inpatient hospitalization was more likely to be reduced in the combined intervention ($P<0.0001$). Reduced payments for elective hospitalization were observed in the one-to-one ($P=0.029$) and combined interventions ($P=0.048$). Reduced payments for non-elective hospitalization were observed in the combined intervention ($P=0.005$) and for hospitalization for diabetes with the group intervention ($P=0.015$).

Sensitivity analysis was carried out in each calendar year and similar findings were observed, especially in the financial years 2013–2014 and 2014–June 2015 (Table S2).

Estimated mean inpatient and outpatient payments

Inpatient and outpatient payments, with payment ratios by intervention group, were estimated from the combined first and second parts of the two-part model with adjustment of baseline characteristics (Tables 3 and 4). In comparison with the control group, significantly lower overall inpatient payments were observed in the combined intervention group for the period April 2012–June 2015 [payment ratio = 0.59 (41% of saving = £909.20 per head; $P < 0.0001$)]. A significant elective inpatient payment reduction was found both for the one-to-one intervention [payment ratio = 0.66 (34% of saving = £413.30 per head; $P = 0.029$)] and the combined intervention [payment ratio = 0.68 (32% of saving = £388.99 per head; $P = 0.048$)], respectively. A significant non-elective inpatient payment reduction was observed only for the combined intervention [payment ratio = 0.49 (51% of saving = £514.67 per head; $P = 0.005$)].

In the sensitivity analysis (Tables 2 and 3), overall inpatient payment reduction was statistically significant in the financial year 2013–2014 for the combined intervention [payment ratio = 0.49 (51% of saving = £749.87 per head, $P = 0.004$)]. Elective inpatient payment reduction was statistically significant in the financial year 2013–2014 for both the one-to-one intervention [payment ratio = 0.54 (46% of saving = £374.12 per head; $P = 0.033$)] and combined intervention [payment ratio = 0.53 (47% of saving = £382.25 per head; $P = 0.008$)]. A reduction in payment for hospitalization primarily attributable to diabetes was observed in the financial year 2013–2014 for the combined intervention group [payment ratio = 0.48 (52% reduction = £211.80 per head; $P = 0.010$)].

Discussion

The RAPSID intervention produced sustained reductions in inpatient service utilization and healthcare payments compared with the control group over the 3.25 years of follow-up after the intervention. This is in contrast to an absence, or weak effects on primary (HbA_{1c}) or secondary outcomes (e.g. diabetes distress, medication adherence, depression, quality of life, weight, self-efficacy, diabetes knowledge), except blood pressure, as previously identified in RAPSID [7], and the effects were observed particularly with the combined intervention.

Elective inpatient healthcare payments and inpatient healthcare payments primarily attributable to cardiovascular diseases were significantly lower in the intervention groups.

The consistently lower inpatient healthcare payments were observed in the combined intervention group in each financial year.

The present RAPSID study was well-powered to test its hypothesis, not only because it achieved its recruitment targets and size, but also because of its high retention rates. The intervention was fully implemented, with high fidelity, having established peer support and delivered the planned content in almost all areas. Another strength of the present study is the minimal information bias regarding the outcome used in this study; both inpatient and outpatient payments were fully recorded by the CCG [11]. In particular, as these are payment details, both NHS hospitals and private hospital admissions were recorded. There would have been some loss for patients where no component of care was paid for by the CCG.

The study also has some limitations which should be considered when interpreting the findings. Unlike pharmaceutical interventions, where adherence can be assessed using pill counters, it is difficult to evaluate the magnitude of a peer-support intervention on an individual level, and although we did record attendance and telephone calls, we did not assess engagement. Although the follow-up time was relatively short in the study, especially with

only a half-year health payment available in the third financial year, this is still the longest follow-up after an RCT to date in diabetes peer-support trials. The payment/savings from similar peer-support interventions should be further investigated in other post-trial observation studies. A further limitation of the study is that we were unable to describe the activities of participants after the trial was completed. All participants were sent the results, and we are aware that some interventions (e.g. peer-support groups) continued, with support from the Diabetes UK 'Type 2 Together' programme [18]. Further limitations include the lack of data relating to medication costs, for example, and default from hospital and other appointments, and that the study cohort may be atypical with its relatively 'good' mean HbA_{1c}, ethnic homogeneity and greater proportion of professional/managerial participants. The number of participants with a higher HbA_{1c} [$\geq 8\%$ (64 mmol/mol), $n=272$] were too few to assess whether the peer-support effect on utilization/payments was greater in these participants than in those with less hyperglycaemia, although HbA_{1c} was not a significant entrant in the multivariate analyses (Table 3). The presence of diabetes-related complications was not formerly assessed, and self-report was not considered robust enough to differentiate between presence/absence and significant/less significant severity (e.g. background vs proliferative retinopathy). Furthermore, as an observation study, there might be some unknown confounders that could have some impact on the post-trial healthcare utilization and health payments. Further validation studies are warranted.

The clinical effectiveness of peer-support interventions among people with Type 2 diabetes has been identified by several trials [19,20]. For example, Tang *et al.* [21] reported that Latino adults with Type 2 diabetes in a peer-led intervention group achieved a reduction in mean HbA_{1c} that was maintained at 18 months. In RAPSID, a reduction in blood pressure was identified in the combined intervention group [7]. Few studies, however, have addressed the payment/savings for inpatient and outpatient expenditure as a result of peer-support

interventions. Our original cost-effectiveness study showed cost-saving, but this was based on self-reported utilization data and only at the end of the trial [8]. One group-based peer-support intervention trial in Ireland found that a group-based peer-support intervention led to a €637.43 of lifetime saving in health payment [22]. In another Austrian trial, the 24 months' group-based peer support intervention reduced the length of hospital stay, which was estimated as €1660.60 per patient [5]. The present study is the first study to show payment reductions/savings of £350.76 of (£306.71 for inpatient and £44.05 for outpatient) at 3.25 years after the intervention had been completed. Although the study design and populations were different and chance of utilization of healthcare was not taken into consideration in most studies, these findings evidently support the application of peer-support interventions in people with Type 2 diabetes. Another study [6] reported that non-healthcare costs were reduced during the 3 years after implementation of the peer-support intervention, but these findings were not derived from an RCT [6].

In the present study, compared with the control group, reductions in hospitalization and relevant payments were observed in the group and combined interventions. In the JADE and PEARL programmes in Hong Kong, hospitalization was reduced among those with high diabetes distress, suggesting a raised threshold for attendance for non-elective care (i.e. reduced healthcare-seeking) [23].

Although the decline in outpatient consultation in the intervention group might also reflect a reduced likelihood of healthcare-seeking as a result of increased support or knowledge of diabetes through the peer-support intervention [4], no reductions in outpatient utilization and payments were observed in the present study. Conversely, in the JADE and PEARL studies

outpatient attendances were reduced by 16% with their peer-support group intervention [23].

The authors explained this by suggesting that peer support reduced non-adherence and negative emotions among people with diabetes, which contributed to their low rate of hospitalization.

Hospitalization for cardiovascular diseases occurred less frequently in the combined intervention, which might be attributed to the significant improvement in blood pressure during the trial, with a mean systolic blood pressure reduction of 2–3 mmHg [7]. Another explanation could be an improvement in chronic disease self-management behaviour, as observed in a 6-month study, in which patients with multiple morbidities who received coaching on chronic disease self-management had healthier behaviour and health status (and spent 0.8 fewer hospital nights) compared with the control group [24]. In a US study, lower levels of family and social support and mental illness were associated with frequent hospitalization [25]. Apart from reduced blood pressure, we found no other possible mechanisms for the reduced hospitalization rate (Fig. S1), although not all pathways could be tested.

The impact of reduced utilization of healthcare and associated health expenditure/payments suggests an additive effect of individual peer-support intervention and group peer-support intervention, which may indicate that long-term health economic benefits could be expected by combining individual and group peer-support interventions [3,4].

In conclusion, random assignment of people with Type 2 diabetes to different peer-support interventions resulted in less utilization of inpatient and outpatient care and reduced payments for inpatient and outpatient attendances in the 3.25 years after the interventions. Combining individual and group peer-support intervention had the most consistent and potentially long-term impact on health payments. Commissioners/funders should consider including diabetes

peer support as part of their local diabetes programme. Further studies should evaluate approaches to scale up the RAPSID approach.

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Competing interests

None declared.

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References

- 1 GBD 2013 DALYs and HALE Collaborators, Murray CJ, Barber RM, Foreman KJ, Abbasoglu Ozgoren A, Abd-Allah F *et al.* Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990-2013: Quantifying the epidemiological transition. *Lancet* 2015;**386**: 2145–2191.
- 2 van Dieren S, Beulens JW, van der Schouw YT, Grobbee DE, Neal B. The global burden of diabetes and its complications: An emerging pandemic. *Eur J Cardiovasc Prev Rehabil* 2010;**17** (Suppl. 1): S3–8.
- 3 Mahlke CI, Kramer UM, Becker T, Bock T. Peer support in mental health services. *Curr Opin Psychiatry* 2014;**27**: 276–281.
- 4 Dale JR, Williams SM, Bowyer V. What is the effect of peer support on diabetes outcomes in adults? A systematic review. *Diabet Med* 2012;**29**: 1361–1377.
- 5 Johansson T, Keller S, Sonnichsen AC, Weitgasser R. Cost analysis of a peer support programme for patients with type 2 diabetes: A secondary analysis of a controlled trial. *Eur J Public Health* 2017;**27**: 256–261.

6 Burton J, Eggleston B, Brenner J, Truchil A, Zulkiewicz BA, Lewis MA. Community-based health education programs designed to improve clinical measures are unlikely to reduce short-term costs or utilization without additional features targeting these outcomes. *Popul Health Manag* 2017;**20**: 93–98.

7 Simmons D, Prevost AT, Bunn C, Holman D, Parker RA, Cohn S *et al.* Impact of community based peer support in type 2 diabetes: A cluster randomised controlled trial of individual and/or group approaches. *PLoS One* 2015;**10**: e0120277.

8 Simmons D, Cohn S, Bunn C, Birch K, Donald S, Paddison C *et al.* Testing a peer support intervention for people with type 2 diabetes: A pilot for a randomised controlled trial. *BMC Fam Pract* 2013;**14**: 5.

9 Wingate L, Graffy J, Holman D, Simmons D. Can peer support be cost saving? an economic evaluation of RAPSID: A randomized controlled trial of peer support in diabetes compared to usual care alone in east of england communities. *BMJ Open Diabetes Res Care* 2017;**5**: e000328.

10 Fisher EB, Ayala GX, Ibarra L, Cherrington AL, Elder JP, Tang TS *et al.* Contributions of peer support to health, health care, and prevention: Papers from peers for progress. *Ann Fam Med* 2015;**13** (Suppl. 1): S2–8.

11 Simmons D, Yu D, Wenzel H. Changes in hospital admissions and inpatient tariff associated with a diabetes integrated care initiative: Preliminary findings. *J Diabetes* 2014;**6**: 81–89.

12 Simmons D, Wenzel H. Diabetes inpatients: A case of lose, lose, lose. is it time to use a 'diabetes-attributable hospitalization cost' to assess the impact of diabetes? *Diabet Med* 2011;**28**: 1123–1130.

13 Andrade LF, Rapp T, Sevilla-Dedieu C. Exploring the determinants of endocrinologist visits by patients with diabetes. *Eur J Health Econ* 2016; **17**:1173–1184.

14 Egede LE, Walker RJ, Bishu K, Dismuke CE. Trends in costs of depression in adults with diabetes in the united states: Medical expenditure panel survey, 2004-2011. *J Gen Intern Med* 2016;**31**: 615–622.

15 Bruno G, Picariello R, Petrelli A, Panero F, Costa G, Cavallo-Perin P *et al.* Direct costs in diabetic and non diabetic people: The population-based turin study, italy. *Nutr Metab Cardiovasc Dis* 2012;**22**: 684–690.

16 Smith VA, Preisser JS, Neelon B, Maciejewski ML. A marginalized two-part model for semicontinuous data. *Stat Med* 2014;**33**: 4891–4903.

17 Rudisill C, Charlton J, Booth HP, Gulliford MC. Are healthcare costs from obesity associated with body mass index, comorbidity or depression? cohort study using electronic health records. *Clin Obes* 2016;**6**: 225–231.

18 Simmons D. Together: Rolling out a peer support initiative based upon RAPSID- RANdomised controlled trial of peer support in type 2 diabetes. *Proceedings of the Society of Behavioural Medicine 37th Annual Meeting & Scientific Sessions* 2016.

19 Zhang X, Yang S, Sun K, Fisher EB, Sun X. How to achieve better effect of peer support among adults with type 2 diabetes: A meta-analysis of randomized clinical trials. *Patient Educ Couns* 2016;**99**: 186–197.

20 Deng K, Ren Y, Luo Z, Du K, Zhang X, Zhang Q. Peer support training improved the glyceic control, insulin management, and diabetic behaviors of patients with type 2 diabetes in rural communities of central china: A randomized controlled trial. *Med Sci Monit* 2016;**22**: 267–275.

21 Tang TS, Funnell M, Sinco B, Piatt G, Palmisano G, Spencer MS *et al.* Comparative effectiveness of peer leaders and community health workers in diabetes self-management support: Results of a randomized controlled trial. *Diabetes Care* 2014; **37**: 1525–1534.

22 Gillespie P, O'Shea E, Paul G, O'Dowd T, Smith SM. Cost effectiveness of peer support for type 2 diabetes. *Int J Technol Assess Health Care* 2012;**28**: 3–11.

23 Chan JC, Sui Y, Oldenburg B, Zhang Y, Chung HH, Goggins W *et al*. Effects of telephone-based peer support in patients with type 2 diabetes mellitus receiving integrated care: A randomized clinical trial. *JAMA Intern Med* 2014;**174**: 972–981.

24 Lorig KR, Sobel DS, Stewart AL, Brown BW Jr, Bandura A, Ritter P *et al*. Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization: A randomized trial. *Med Care* 1999;**37**: 5–14.

25 Byrne M, Murphy AW, Plunkett PK, McGee HM, Murray A, Bury G. Frequent attenders to an emergency department: A study of primary health care use, medical profile, and psychosocial characteristics. *Ann Emerg Med* 2003;**41**: 309–318.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Logic model of study hypotheses to link diabetes peer support with reduced hospitalization.

Table S1. Distribution of inpatient and outpatient cost by intervention group in Cambridgeshire, by financial year

Table S2. Adjusted estimations from two-part models that modelling health cost by intervention group, analysis among patients resident in Cambridgeshire, by financial year.

Table S3. Estimated mean health cost from two-part models accounting for probability of generating health cost with adjustment of covariables, analysis among patients resident in Cambridgeshire, by financial year.

Table 1 Baseline characteristics of participants by intervention assignment

	Intervention			
	Control N=291	One-to-one N=261	Group N=288	Combined N=281
Males, <i>n</i> (%)	168 (57.7)	158 (60.5)	190 (66.0)	164 (58.4)
Mean (SD) age, years	65.9 (12.9)	65.0 (9.7)	66.0 (11.8)	65.8 (10.3)
Median (IQR) duration of diabetes, years	6.5 (3.0 to 12.0)	7.0 (3.0 to 12.0)	7.0 (3.0 to 12.0)	6.0 (3.0 to 11.0)
Profession/managerial, <i>n</i> (%)	195 (67.0)	176 (67.4)	193 (67.0)	186 (66.2)
Married/cohabiting, <i>n</i> (%)	218 (74.9)	196 (75.1)	227 (78.8)	213 (75.8)
Self-reported smoking, <i>n</i> (%)	34 (11.7)	24 (9.2)	25 (8.7)	23 (8.2)
Insulin treated, <i>n</i> (%)	42 (14.4)	52 (19.9)	46 (16.0)	48 (17.1)
Diabetes tablets, <i>n</i> (%)	223 (76.6)	230 (88.1)	226 (78.5)	213 (75.8)
Insulin and tablets, <i>n</i> (%)	31 (10.7)	17 (6.7)	36 (12.5)	34 (12.1)
Hypertension treatment, <i>n</i> (%)	174 (59.8)	185 (70.9)	181 (62.8)	187 (66.5)
Dyslipidaemia treatment, <i>n</i> (%)	180 (61.9)	186 (71.3)	191 (66.3)	195 (69.4)
Mean (SD) BMI, kg/m ²	32.3 (6.2)	32.6 (6.3)	32.1 (5.9)	32.1 (5.9)
Mean (SD) HbA _{1c} mmol/mol %	56.8 (12.7) 7.3 (1.2)	57.6 (13.3) 7.4 (1.2)	58.1 (13.0) 7.5 (1.2)	56.1 (12.8) 7.3 (1.2)
Mean (SD) systolic blood pressure, mmHg	140.3 (18.1)	140.6 (18.3)	141.7 (17.3)	139.4 (16.7)
Mean (SD) diastolic blood pressure, mmHg	75.5 (10.6)	76.1 (9.7)	75.6 (10.2)	76.4 (9.5)
Mean (SD) total cholesterol, mmol/l	4.41 (1.07)	4.39 (1.01)	4.33 (1.07)	4.41 (1.06)

IQR, interquartile range.

Table 2 Distribution of inpatient and outpatient health payments in financial years 2012 to June 2015, by intervention group

	Median cost (interquartile range of cost), £ among people with non-zero payment				People with zero payment N (%)			
	Control	One-to-one	Group	Combined	Control	One-to-one	Group	Combined
Overall inpatient cost	2488.42 (1118.57 to 5198.51)	2201.20 (846.38 to 5704.23)	2009.06 (888.53 to 5169.54)	2421.94 (903.20 to 5236.43)	158 (54.30)	163 (62.45)	175 (60.76)	173 (61.57)
Elective inpatient cost	1644.17 (877.25 to 3961.06)	1429.20 (668.33 to 3445.25)	1459.23 (763.34 to 3883.17)	1506.72 (636.02 to 3873.66)	177 (60.82)	182 (69.73)	189 (65.63)	189 (67.26)
Non-elective inpatient cost	2565.61 (790.34 to 6243.07)	3167.88 (1050.70 to 5984.87)	2198.81 (790.22 to 5837.33)	2749.98 (742.39 to 4758.61)	226 (77.66)	224 (85.82)	240 (83.33)	235 (83.63)
Inpatient cost primarily due to cardiovascular diseases	2128.20 (826.03 to 4819.95)	2307.62 (1005.11 to 5511.12)	1892.40 (771.58 to 4442.97)	2995.68 (770.69 to 3961.41)	225 (77.32)	216 (82.76)	235 (81.60)	240 (85.41)
Inpatient cost primarily due to diabetes	1118.57 (664.57 to 2705.06)	1310.61 (743.24 to 4276.81)	1230.32 (560.84 to 3607.65)	1381.61 (694.51 to 3048.72)	217 (74.57)	231 (88.51)	226 (78.47)	225 (80.07)
Overall outpatient cost	708.04 (316.75 to 1461.71)	645.22 (268.32 to 1270.91)	657.54 (285.58 to 1407.21)	757.41 (320.77 to 1255.93)	98 (33.68)	103 (39.46)	103 (35.76)	110 (39.15)

Table 3 Adjusted estimations from two-part models of healthcare payment by intervention group: analysis among patients resident in Cambridgeshire, for the financial years 2012 and June 2015

	One-to-one						Group						Combined					
	Logit			GLM			Logit			GLM			Logit			GLM		
	Coefficient	SE	<i>P</i>	Coefficient	SE	<i>P</i>	Coefficient	SE	<i>P</i>	Coefficient	SE	<i>P</i>	Coefficient	SE	<i>P</i>	Coefficient	SE	<i>P</i>
Overall inpatient payment	-0.122	0.074	0.100	-0.147	0.115	0.203	-0.156	0.073	0.033	0.003	0.146	0.986	-0.145	0.074	0.051	-0.374	0.106	<0.0001
Elective inpatient payment	-0.129	0.077	0.092	-0.272	0.125	0.029	-0.127	0.075	0.090	-0.078	0.139	0.573	-0.139	0.076	0.068	-0.226	0.114	0.048
Non-elective inpatient payment	-0.167	0.085	0.051	0.138	0.156	0.378	-0.220	0.084	0.009	0.236	0.196	0.230	-0.186	0.085	0.029	-0.424	0.152	0.005
Inpatient payment primarily due to cardiovascular diseases	-0.069	0.085	0.415	0.232	0.149	0.120	-0.148	0.084	0.078	-0.142	0.145	0.329	-0.263	0.088	0.003	-0.013	0.151	0.929
Inpatient payment primarily due to diabetes	-0.309	0.086	<0.0001	0.163	0.148	0.270	-0.147	0.081	0.069	0.386	0.159	0.015	-0.193	0.083	0.021	-0.151	0.134	0.261
Overall outpatient payment	-0.070	0.072	0.330	-0.068	0.062	0.272	-0.075	0.071	0.292	-0.039	0.057	0.498	-0.069	0.072	0.334	-0.050	0.061	0.417

GLM, generalized linear model.

Two-part models model the probability of generating health payment (probit) separately from the payment of healthcare conditional on having been hospitalized or consulted at least once (GLM), adjusted for baseline characteristics (age, gender, duration of diabetes, occupation, marital status, diabetes treatment, hypertension treatment, dyslipidaemia treatment, BMI, HbA_{1c}, systolic blood pressure, diastolic blood pressure, total cholesterol and BMI. SE derived by bootstrapping method.

Table 4 Estimated mean health payment from two-part models accounting for probability of generating health payment after adjustment for covariates among patients resident in Cambridgeshire, in the financial years 2012 to June 2015

	Estimated health payment, (95% CI)				Payment ratio			
	Control	One-to-one	Group	Combined	Control	One-to-one	Group	Combined
Overall inpatient payment, £	2217.57 (1789.32 to 2645.81)	1675.21 (1330.24 to 2020.19)	1872.29 (1377.75 to 2366.83)	1300.80 (1056.80 to 1544.80)	1	0.76	0.84	0.59
Elective inpatient payment, £	1215.60 (956.25 to 1474.95)	797.52 (623.48 to 971.56)	970.61 (735.64 to 1205.58)	824.61 (649.76 to 999.47)	1	0.66	0.80	0.68
Non-elective inpatient payment, £	1009.15 (745.42 to 1272.88)	902.72 (631.45 to 1174.00)	915.26 (556.40 to 1274.12)	499.21 (353.23 to 645.20)	1	0.89	0.91	0.49
Inpatient payment primarily attributable to cardiovascular diseases, £	714.76 (522.17 to 907.35)	817.13 (600.85 to 1033.40)	500.66 (366.32 to 634.99)	476.35 (329.45 to 623.25)	1	1.14	0.70	0.67
Inpatient payment primarily attributable to diabetes, £	514.42 (387.03 to 641.81)	390.16 (277.01 to 503.32)	618.74 (438.71 to 798.77)	338.98 (254.87 to 423.09)	1	0.76	1.20	0.66
Overall outpatient payment, £	846.46 (764.18 to 928.75)	761.98 (681.89 to 842.07)	783.12 (712.51 to 853.72)	776.91 (698.74 to 855.08)	1	0.90	0.93	0.92

Two-part models model the probability of generating health payment (probit) separately from the payment of healthcare conditional on having been hospitalized or consulted at least once (generalized linear model), adjusted for baseline characteristics (age, gender, duration of diabetes, occupation, marital status, diabetes treatment, hypertension treatment, dyslipidaemia treatment, BMI, HbA_{1c}, systolic blood pressure, diastolic blood pressure, total cholesterol and BMI). CI was derived by bootstrapping method.