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Original Research

Association Between Systolic Blood Pressure and Cardiovascular Inpatient Cost Moderated by Peer-Support Intervention Among Adult Patients with Type 2 Diabetes: A 2-Cohort Study

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Key Messages

- It is unclear whether systolic blood pressure level impacts cardiovascular disease inpatient costs and could be altered by peer support in people with diabetes.
- The association between systolic blood pressure and cardiovascular disease inpatient payment showed a "hockey-stick" shape with a threshold at 133 to 141 mmHg.
- A novel 2-part model revealed that combined peer-support intervention altered this association.

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ABSTRACT

Objectives: People with type 2 diabetes and increased systolic blood pressure (SBP) are at high risk of cardiovascular disease (CVD). In this study, we aimed to investigate the association between CVD-related hospital payments and SBP and tested whether this association is influenced by diabetes peer support.
Methods: Two cohorts comprising people with type 2 diabetes were included in the study. The first cohort comprised 4,704 patients with type 2 diabetes assessed between 2008 and 2009 from 18 general practices in Cambridgeshire and followed up to 2009–2011. The second cohort comprised 1,121 patients with type 2 diabetes from post-trial follow-up data, recruited between 2011 and 2012 and followed up to 2015. SBP was measured at baseline. Inpatient payments for CVD hospitalization within 2 years since baseline was the main outcome. The impact of 1:1, group or combined diabetes peer support and usual care were investigated in the second cohort. Adjusted mean CVD inpatient payments per person were estimated using a 2-part model after adjusting for baseline characteristics.
Results: A "hockey-stick" relationship between baseline SBP and estimated CVD inpatient payment was identified in both cohorts, with a threshold at 133 to 141 mmHg, suggesting increased payments for patients with SBP below and above the threshold. The combined peer-support intervention altered the aforementioned association, with no increased payment with SBP above the threshold, and payment slightly decreased with SBP beyond the threshold.
Conclusions: SBP maintained between 133 and 141 mmHg is associated with the lowest CVD disease management costs for patients with type 2 diabetes. Combined peer-support intervention could significantly decrease CVD-related hospital payments.

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RÉSUMÉ

Objectifs : Les personnes ayant le diabète de type 2 et une augmentation de la pression artérielle systolique (PAS) sont exposées à un risque élevé de maladies cardiovasculaires (MCV). Dans la présente étude, nous avions pour objectif d'examiner l'association entre les paiements des frais d'hospitalisation liés à la MCV et la PAS, et de vérifier si l'entraide entre pairs diabétiques influence cette association.
Méthodes : Nous avons inclus à l'étude 2 cohortes de personnes atteintes du diabète de type 2. La première cohorte regroupait 4704 patients atteints du diabète de type 2 de 18 cabinets de généralistes de Cambridgeshire qui avaient été évalués entre 2008 et 2009 et suivis jusqu'en 2009–2011. La deuxième cohorte regroupait 1121 patients atteints du diabète de type 2 qui avaient été recrutés entre 2011 et 2012 et suivis jusqu'en 2015 et dont les renseignements provenaient des données du suivi post-étude. Nous avons mesuré la PAS au début. Les paiements des frais d'hospitalisation liés à la MCV dans les 2 ans depuis le début étaient le critère principal d'évaluation. Nous avons examiné les répercussions de l'entraide entre pairs diabétiques 1:1, combinée ou en groupe et les soins courants de la seconde cohorte. Nous avons estimé à l'aide d'un modèle en 2 parties les paiements moyens ajustés des frais d'hospitalisation liés à la MCV par personne après l'ajustement des caractéristiques initiales.
Résultats : Nous avons établi une relation en « bâton de hockey » entre la PAS initiale et le paiement estimé des frais d'hospitalisation liés à la MCV dans les 2 cohortes, selon un seuil de 133 à 141 mmHg, c'est-à-dire à une hausse des paiements chez les patients ayant une PAS sous et au-dessus du seuil. L'intervention combinée de l'entraide entre pairs a modifié l'association mentionnée plus haut, soit aucune augmentation de paiement lors de PAS au-dessus du seuil et une légère diminution de paiement lors de PAS au-delà du seuil.
Conclusions : La PAS maintenue entre 133 et 141 mmHg est associée aux coûts de prise en charge des MCV les plus faibles chez les patients atteints de diabète de type 2. L'intervention combinée de l'entraide entre pairs pourrait diminuer de façon significative les paiements des frais d'hospitalisation liés à la MCV.

Introduction

The rapid increase in prevalence and health costs associated with type 2 diabetes has been observed worldwide (1). It has been estimated that the risk of hospitalization is 2-fold higher in people with diabetes vs those without diabetes, and the proportion with diabetes is >10% in those admitted to hospital at any one time (2). Among some specific age strata, this proportion is >20% (3). The associated costs of excess admissions, as well as increased costs per admission, are significant contributors to the financial burden borne by health-care systems from diabetes and often reflect preventable morbidity suffered by patients (4). Systolic blood pressure (SBP), as the most common modifiable risk factor, has been found to be associated both with cardiovascular disease (CVD) mortality and CVD hospitalization among people with type 2 diabetes (5,6). However, no established association between SBP and inpatient cost due to CVD hospitalization has been shown among people with type 2 diabetes. Although a target SBP has been agreed upon to lower the risk of, for example, CVD mortality and CVD hospitalization, it is unclear whether this threshold has an impact on inpatient costs due to CVD mortality.

Diabetes peer support involves people with diabetes assisting each other to improve their social, mental and physical well-being. Peer support can be provided through individual or group approaches and by either face-to-face or telephone or online contact. It is generally seen as a low-cost intervention and has been suggested to reduce health-care costs (7). Some studies have reported that peer support can reduce health-care costs among people with type 2 diabetes (8,9). The RAndomised controlled trial of Peer Support In type 2 Diabetes (RAPSID) was the largest randomized, controlled trial (RCT) of type 2 diabetes peer support to date (10). The intervention was recently shown to be cost-effective during the trial based on self-reported costs (11) and also from prospective hospital costs (12). In RAPSID, group peer support was associated with 2- to 3-mmHg lower SBP; however, it was unclear whether this was a mediator of the reduction in inpatient costs, and whether this was through an effect on CVD hospitalization specifically.

In this study, we investigated the association between SBP measured in primary care settings and inpatient cost for CVD hospitalization over the next 2 years, accounting for the risk of hospitalization among people with type 2 diabetes, using data from 2 cohorts. We then examined the impact of peer support on this association.

Methods

Data source and study population

We followed the methods of Yu et al for data and data collection (12). Briefly, we utilized 2 cohorts from Cambridgeshire, England: one (main cohort) based on the electronic health record data from primary care settings to develop our CVD hospitalization and rehospitalization risk scores, and another (replication cohort) based on post-trial cohort data for external validation.

Main cohort

Patient lists from 18 general practices across Cambridgeshire, England, in 2008–2009 were collated and linked with hospital admissions (Secondary Uses Service) data as part of an evaluation of diabetes care across the county by the local health board, the National Health Service (NHS) Cambridgeshire. This cohort was limited to volunteer practices using the Egton Medical Information Systems general practitioner software system, from which a predefined set of data could be extracted. There was no systematic selection process for these surgeries, and data extracted were for their entire diabetes population. All patients with diabetes had follow-up hospitalization data to 2010–2011. Hospital admissions to the NHS and private hospitals within and outside Cambridgeshire were followed up. No personal identifiers were released to

researchers, and all subsequent analyses were conducted on anonymized data sets. Baseline blood pressure and clinical measurements were recorded as part of clinical practice in primary care settings (6).

Replication cohort

The design and methods of the RAPSID have been published previously (10), including its Consolidated Standards of Reporting Trials diagram and the results of its primary outcomes (10). Briefly, RAPSID was a 2×2 factorial cluster RCT comparing 4 groups: controls, 1:1 (individual) peer support, group peer support and combined 1:1 and group peer support among patients with type 2 diabetes. Participants had their diabetes for at least 12 months and those with dementia or mental 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 neighbouring areas of Hertfordshire that are served by the Cambridgeshire and Peterborough Clinical Commissioning Group (CCG). Clusters were defined by local government (parish council) boundaries. The intervention was developed following a pilot, using a framework defined by Peers for Progress (11). Peers facilitating peer support were termed peer-support facilitators and their selection, training, support and the overall program have been described elsewhere (10). The intervention lasted 8 to 12 months and was commenced and concluded, cluster by cluster, between June 2, 2011 to April 12, 2012.

Demographics, blood pressure, glycated hemoglobin (A1C) and lipid profile information were collected at baseline. Blood pressure was measured using an Omron electronic blood pressure monitor (Model 705IT, Omron Corp, Kyoto, Japan) (13). Each participant was followed up until June 2015 (0.91 to 4.07 years of follow up from beginning/entry into the trial). Hospitalization (NHS hospitals and private hospitals), accident and emergency and outpatient visits within/outside Cambridgeshire and the included areas of Hertfordshire were collected through the Cambridgeshire and Peterborough CCG (14) as well as elective/nonelective status and *International Classification of Diseases—10th revision* (ICD-10) codes (6).

Ethics approval

Ethics approval was received from the Cambridgeshire REC2 Committee (10/H0308/72), and signed consent included agreement for access to hospital data.

Defining CVD hospitalization

The primary outcome of the study was having at least 1 hospitalization with CVD as the primary diagnosis (ICD-10 codes I20 to I25, I60 to I69 and I73 in the first ICD field) over the 2-year follow-up period.

Statistical analysis

A large proportion of the diabetes population do not attend hospital as an inpatient or outpatient in any given year and, therefore, health-care payment data demonstrate a skewed utilization/payment pattern (15). To take into account the problem of "zero mass" and skewed outcomes, the demand functions were modelled using a 2-part model (16). In this 2-part model, a probit model was estimated for the probability of observing "zero" vs positive medical expenditure. Positive medical expenditure is defined as any health-care expenditure greater than zero. A generalized linear model was estimated, conditional on having health-care 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 retransforming to the raw scale (17). The results of the modified Park test verified that the use of a gamma distribution, with a log link, was the best-fitted generalized linear model for consistent estimation of coefficients (18). The variance inflation factor for all predictors used in the 2-part model indicated no presence of multicollinearity (19). The F-test result for the 2-part regression models was found to be significant, which indicated the overall significance of the regression model. Predicted inpatient cost was estimated in the 2-part model by the level of baseline SBP with adjustment of other covariables. The 95% confidence intervals for estimated payments were estimated by a bootstrap process with 1,000 samples. Analysis restricted analyses in each financial year were carried out as sensitivity analyses. All analyses were performed with STATA version 14.0 (StataCorp, College Station, Texas, United States).

Results

In our main cohort, we analyzed information on 4,704 type 2 diabetes patients with 588 CVD hospitalizations within 2 years. Our replication cohort had information on 1,121 type 2 diabetes patients with 183 CVD hospitalizations. Table 1 summarizes the basic characteristics and clinical measurements of the study population. Patients with type 2 diabetes in both cohorts had similar age, gender, blood pressure and total cholesterol. Patients in the

Table 1
Baseline characteristics of study cohorts

	Main cohort	Replication cohort				
		All	Control	1:1	Group	Combined
N	4,702	1,121	291	261	288	281
CVD hospitalization, n (%)	588 (12.5)	183 (16.3)	59 (20.3)	45 (17.2)	42 (14.6)	37 (13.2)
Age, years	65.0±16.3	65.5±11.4	65.9±12.8	65.3±9.8	65.8±11.9	65.0±10.4
Female, n (%)	1,919 (40.8)	444 (39.6)	122 (41.9)	109 (41.8)	101 (35.1)	112 (39.9)
Systolic blood pressure, mmHg	134.5±16.0	139.7±20.2	140.0±20.6	140.4±20.6	140.8±19.5	137.9±20.3
Diastolic blood pressure, mmHg	76.3±10.0	75.5±11.5	75.0±11.6	75.8±10.9	75.1±11.3	75.6±11.9
Total cholesterol, mmol/L	4.3±1.2	4.2±1.7	4.3±1.5	4.3±1.3	4.1±2.0	4.3±1.7
High-density lipoprotein, mmol/L	1.3±0.6	1.1±1.2	1.2±0.9	1.2±1.0	1.0±1.5	1.1±1.1
Low-density lipoprotein, mmol/L	2.5±1.4	1.4±3.0	1.3±3.2	1.5±2.8	1.5±2.8	1.5±3.0
Body mass index, kg/m^2	30.8±6.9	32.2±6.0	32.3±6.0	32.6±6.5	32.0±5.9	32.2±5.9
A1C, mmol/mol	61.5±17.2	56.2±15.1	55.6±16.2	56.5±15.0	57.3±14.7	55.3±13.8
Lipid-lowering treatment, n (%)	3,342 (71.4)	731 (65.2)	180 (61.9)	173 (66.3)	191 (66.3)	187 (66.6)

A1C, glycated hemoglobin; *CVD*, cardiovascular disease.
Note: Data expressed as number, number (%) or mean ± standard deviation.

Table 2
Distribution of baseline characteristics and inpatient cost due to CVD hospitalization in the study cohorts

	Category of systolic blood pressure, mmHg					
	<120	120–129	130–139	140–149	150–159	≥160
Main cohort	564	795	1,204	1,059	324	756
Replication cohort, overall	134 (12.0)	174 (15.5)	244 (21.8)	255 (22.8)	167 (14.9)	147 (13.1)
Replication cohort, control	35 (11.9)	46 (15.8)	64 (22.1)	68 (23.5)	46 (15.8)	32 (10.9)
Replication cohort, group	33 (12.5)	35 (13.6)	50 (19.1)	66 (25.4)	35 (13.6)	41 (15.8)
Replication cohort, 1:1	30 (10.5)	43 (15.0)	67 (23.3)	62 (21.6)	43 (15.0)	42 (14.6)
Replication cohort, combined	37 (13.0)	50 (17.7)	63 (22.4)	58 (20.6)	43 (15.2)	31 (11.2)
Age, years	59.9±18.0	62.7±15.8	65.1±14.0	67.7±12.9	68.6±13.2	65.7±19.2
Female, n (%)	244 (35.0)	382 (39.4)	611 (42.2)	572 (43.5)	208 (42.3)	347 (38.4)
Systolic blood pressure, mmHg	110.3±8.3	123.8±3.1	133.7±3.1	143.0±3.0	153.4±3.1	169.4±10.9
Diastolic blood pressure, mmHg	68.0±9.2	73.4±8.4	76.0±8.3	78.5±8.7	81.2±9.5	85.0±11.3
Total cholesterol, mmol/L	4.2±1.2	4.2±1.1	4.3±1.1	4.3±1.2	4.5±1.2	4.6±1.3
High-density lipoprotein, mmol/L	1.3±0.5	1.2±0.4	1.3±0.5	1.3±0.5	1.3±0.5	1.3±0.5
Low-density lipoprotein, mmol/L	2.4±1.0	2.4±1.0	2.5±1.0	2.5±1.0	2.5±1.0	2.6±1.0
Body mass index, kg/m^2	29.8±6.3	30.5±6.7	31.5±6.9	31.5±6.6	31.7±6.4	30.4±7.3
A1C, mmol/mol	61.5±19.5	60.2±16.9	60.9±15.6	60.5±16.0	61.0±15.8	62.4±16.7
Lipid-lowering treatment, n (%)	459 (65.8)	688 (71.0)	1,066 (73.6)	1,010 (76.9)	364 (74.2)	484 (53.6)
People with zero payment, n (%)	602 (11.9)	865 (29.0)	1,263 (25.0)	1,109 (22.0)	382 (7.6)	832 (16.5)
Cost among people with nonzero payment, £	2,436.37 (629.40–5,277.45)	2,017.75 (763.53–3,561.62)	1,781.41 (644.42–4,931.43)	2,507.73 (1,318.58–4,786.15)	2,801.81 (893.70–4,008.91)	3,485.46 (1,362.57–4,956.08)

A1C, glycated hemoglobin; *CVD*, cardiovascular disease.
Note: Data expressed as number, number (%), mean ± standard deviation or median (interquartile range).

main cohort had a higher level of high-density lipoprotein, low-density lipoprotein and A1C. Compared with the main cohort, those in the replication cohort were more likely to be prescribed lipid-lowering medications. Baseline data for the 4 groups of the replication cohort were well matched (Table 1). The sample size of the main cohort and intervention groups of the replication cohort, characteristics of participants and median cost in 2 cohorts by baseline SBP categories (<120, 120 to 129, 130 to 139, 140 to 149, 150 to 159 and >160 mmHg) are presented in Table 2.

As shown in Supplementary Table 1, inpatient cost data from CVD hospitalization were typically skewed due to the mass of "zero" payments and a relatively small proportion of patients incurring extremely high expenditure. Of the participants in the main and replication cohort, 87.5% and 83.7%, respectively, were not hospitalized due to CVD diseases over the 2-year of follow up. Within the replication cohort, 79.7% of controls and 82.8%, 85.4% and 86.8% of patients in the 1:1 group and combined intervention groups, respectively, were not hospitalized due to CVD disease. Among patients hospitalized due to CVD diseases, median inpatient costs were £4348.35 (interquartile range [IQR]: 1,623.50 to 8,766.75) and £2,430.72 (IQR: 793.06 to 4,026.20) for the main and replication cohorts, respectively. With the replication cohort, median inpatient costs were £2,419.60 (IQR: 1,006.91 to 4,387.66), £2,489.40 (IQR: 770.69 to 4,387.66), £1,963.56 (IQR: 714.93 to 4,032.55) and £2,436.00 (IQR: 885.19 to 3,473.12) for the controls, 1:1 group and combined intervention groups, respectively. Compared with patients without inpatient costs due to CVD hospitalization, patients with such costs were more likely to be older; male; have higher SBP, body mass index and A1C; and less likely to have been prescribed lipid-lowering treatment (Supplementary Table 2).

Results from 2-part model

Dose–response relationship curves between SBP and predicted inpatient cost for CVD hospitalization derived from the 2-part models after accounting for the risk of CVD hospitalization with adjustment of covariables in Table 1 are presented in Figure 1 for the main cohort and the replication cohort. SBP was nonlinearly associated with adjusted predicted inpatient cost for CVD hospitalization (linearity test: $p<0.00001$ for all) in both the main and replication cohorts. The threshold was estimated at 137 (133 to 141) mmHg for SBP in both the main sample and replication sample, with consistent stable adjusted predicted inpatient cost for CVD hospitalization below the threshold and increased predicted inpatient cost above the threshold.

Within the replication cohort, dose–response relationship curves between SBP and adjusted predicted inpatient cost for CVD hospitalization in each group are presented in Figure 2. A nonlinear association between SBP and adjusted predicted inpatient cost was found in the control, 1:1 and intervention groups (linearity test: $p<0.00001$ for all). The threshold at 137 (133 to 141) mmHg for SBP was found consistently in each group, with consistent stable adjusted predicted inpatient cost for CVD hospitalization below the threshold and increased predicted inpatient cost above the threshold. In the combined intervention group, the adjusted predicted inpatient cost was linearly stable as SBP increased (linearity test: $p=0.05263$). Associations between baseline systolic blood pressure and predicted inpatient cost due to CVD hospitalization in those receiving 1:1 peer support and among the others within the replication cohort are presented in Supplementary Figure 1. For each baseline SBP level, patients who received the 1:1 peer-support intervention (as 1:1 alone or as the combined intervention) were more likely to have lower inpatient costs due to CVD hospitalization.

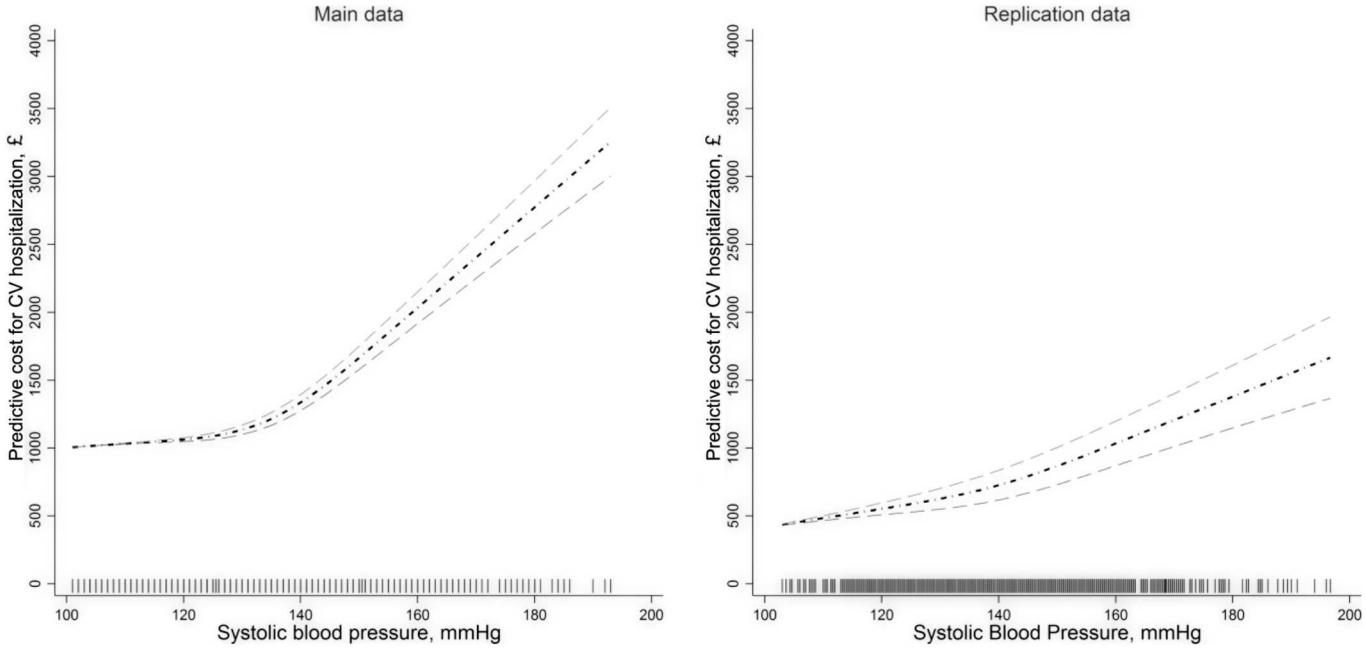

Figure 1. Adjusted association between baseline systolic blood pressure and predicted inpatient cost due to CV disease hospitalization in the main cohort and replication cohort. *CV*, cardiovascular.

Discussion

In this study, using 2 prospective cohorts, we found a nonlinear association between SBP measured in United Kingdom populations with type 2 diabetes and the adjusted predicted inpatient cost for CVD hospitalization over 2 years of follow up, after accounting for the risk of CVD hospitalization both in the main and replication cohort. Further investigation revealed that SBP <137 mmHg was associated with stable lowest inpatient cost, and inpatient cost increased with an increase in SBP >137 mmHg. The peer-support intervention, especially group intervention combined with 1:1 support, had a significant impact on the association between inpatient cost for CVD hospitalization and SBP.

Comparison with previous studies

It is well established that SBP is the major determinant of CVD risk in the population >50 years of age (20). In patients with type 2 diabetes, previous studies have revealed a J-shape relationship between SBP and CVD event risk; for example, the United Kingdom Prospective Diabetes Study (21) showed a lowered CVD event rate with an attained lower blood pressure goal of 144/82 mm Hg. The International Verapamil SR—Trandolapril (22) and the Avoiding CVD Events in Combination Therapy in Patients Living with Systolic Hypertension (23) trials also failed to demonstrate a CVD outcome benefit at a blood pressure of <130/80 mmHg. We have previously shown that an SBP between 133 and 141 mmHg was associated with the lowest risk of CVD hospitalization among patients with type 2 diabetes (6). However, it was not clear whether this J-shape relationship exists between SBP and inpatient costs for CVD hospitalization as most studies analyzed health cost/payments that had a skewed distribution. Ours is the first study among patients with type 2 diabetes mellitus, following adjustment for the individual probability of being hospitalized, and we have now shown a "hockey-stick"-shaped relationship between SBP and CVD inpatient payment. This finding suggests that CVD inpatient payments are stable for SBP below 133 to 141 mmHg and linearly increase above this range. This in turn supports an SBP target between 133 and 141 mmHg to minimize future risk of CVD hospitalization and associated inpatient payments.

Although we have shown that CVD hospital payments increase with a baseline SBP above 133 to 144 mmHg, this was not observed in the 2-year posttrial period for RAPSID intervention participants. In RAPSID, peer group support was associated with a significant reduction in SBP after 8- to 12-month follow up from baseline and we speculate that it was this lower SBP that was responsible for this finding. Hospitalization was shown to be reduced in Hong Kong with peer support among those who had high diabetes distress

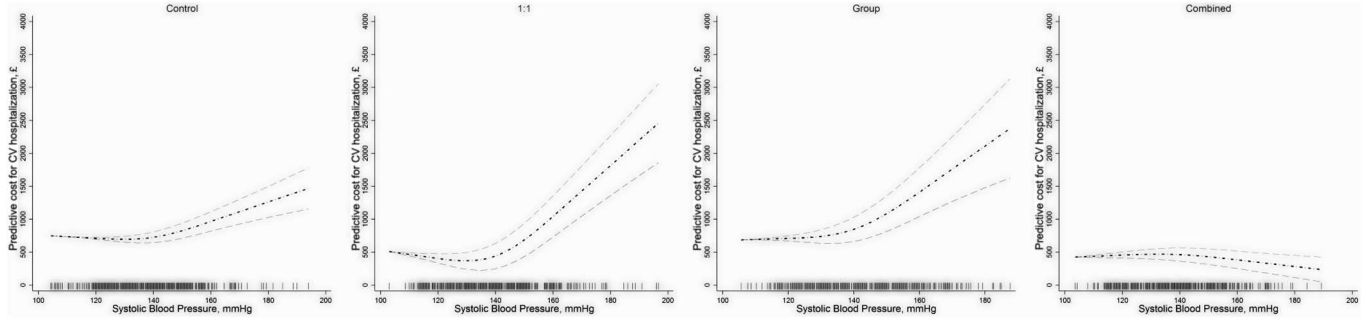

Figure 2. Adjusted association between baseline systolic blood pressure and predicted inpatient cost due to CV disease hospitalization in groups of the replication cohort. *CV*, cardiovascular.

(24). We have not been able to elucidate the mechanism behind the lower SBP in RAPSID and have excluded a greater effect among those with high diabetes distress and medication adherence. There was also no evidence of changes in lifestyle as measured by questionnaires, or crudely by body weight (a small reduction in waist circumference was found in the per-protocol analyses). The current finding of reduced CVD hospitalization costs does provide some validity that the lower SBP described was not simply due to chance.

The data suggest that the peer-support intervention was associated with a reduced inpatient payment; however, in the 2-year post-trial follow up among patients in the combined intervention group, CVD inpatient payment did not increase along with the increase of SBP, especially beyond 133 to 141 mmHg. The slight reduction in CVD inpatient payment suggests that patients whose SBP was beyond 133 to 141 mmHg were less likely to trigger the CVD hospitalization, with this primarily due to the combined peer-support intervention. It could be that patients in the combined intervention group adhered to a healthy lifestyle in the post-trial follow up, which could have impacted patients' obesity status and then SBP, as observed in the trial follow up. However, no post-trial obesity measurement was done to validate this hypothesis. In the trial follow up the SBP reduction could not be explained by increased medication adherence, as this was previously found to be unchanged (10). It is unclear whether the antihypertensive treatment adherence pattern was modified in the post-trial follow-up restricted by the post-trial information on the medication adherence.

Strength and limitations

One strength of our analysis is that the association between SBP and CVD inpatient payment was examined in 2 independent cohorts. Another strength is the minimal information bias, with the outcome used, recorded inpatient payments, having been fully recorded by the CCG (14). In particular, as these are payment details, both NHS hospitals and private hospital admissions were able to be included. There would have been some loss for patients where no component of care was paid for by the CCG.

Some limitations must also be considered in the interpretation of our findings. Unlike pharmaceutical interventions, where adherence can be assessed using pill counters, it is difficult to evaluate the magnitude of peer-support intervention on an individual level, and, although we did record attendance and telephone calls, we did not assess engagement. The payment/savings from similar peer-support interventions should be further investigated in other post-trial observation studies. Another limitation is the inconsistent blood pressure measurement approaches between those used in primary care (main cohort) and those used in the trial (replication cohort) in terms of attended vs unattended, standardized protocol vs usual measurement and automated vs mercury sphygmomanometer. A final limitation of our study is that we obtained information on the activities of the participants after the trial was completed. All participants were sent the results, and we are aware that some intervention (e.g. peer-support groups) continued, including support from the Diabetes UK Type 2 Together program (11).

In conclusion, to our knowledge, this study is the first to examine the prospective association between SBP and 2-year estimated CVD inpatient payments. A "hockey-stick" relationship between SBP and 2-year estimated CVD inpatient payment was identified in 2 independent cohorts, with a consistent threshold at 133 to 141 mmHg and a linearly increasing payment beyond the threshold. An alteration in this relationship after a combined peer-support intervention (group and 1:1 interventions) is suggested by the lack of increase in estimated CVD payment. Our findings suggest that, among people with type 2 diabetes, blood pressure management should target an SBP of 133 to 141 mmHg. Integration of this threshold into clinical practice could lower both individual risk of and associated payments for CVD hospitalization.

Acknowledgments

Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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Author Disclosures

Conflicts of interest: None.

Author Contributions

D.Y., Y.C., Z.Z. and D.S. contributed to the conception and design of this work and to interpretation of the data. D.Y. performed the data management and analysis and drafted the initial manuscript. D.Y., Y.C., Z.Z., D.H., J.G. and D.S. reviewed, revised and approved the final manuscript.

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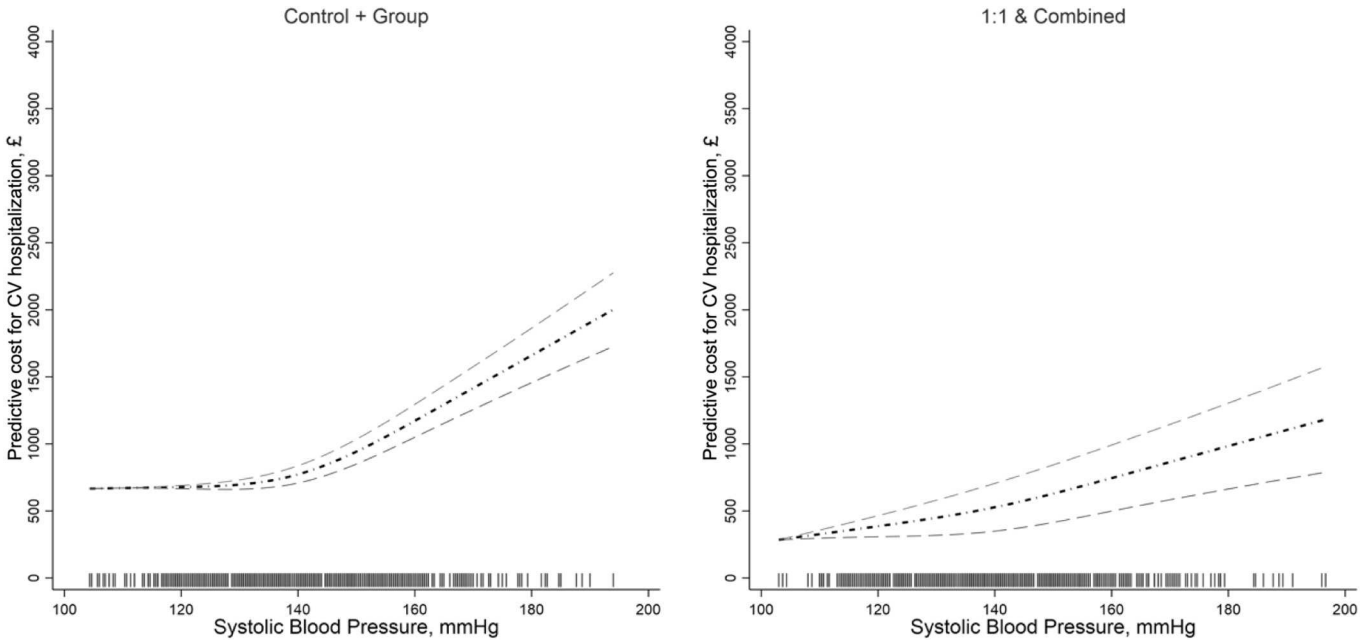

Supplementary Figure 1. Adjusted association between baseline systolic blood pressure and predicted inpatient cost due to cardiovascular disease hospitalization in those receiving 1:1 support intervention (1:1 and combined intervention) and the others (control and group intervention). *CV*, cardiovascular.

Supplementary Table 1
Distribution of baseline characteristics and inpatient cost due to CVD hospitalization in the study cohorts

	Median cost (interquartile range) among people with nonzero payment, £	People with zero payment, N (%)
Main cohort	4,348.35 (1,623.50–8,766.75)	4,116 (87.5%)
Replication cohort, overall	2,430.72 (793.06–4,026.20)	938 (83.7%)
Replication cohort, control	2,419.60 (1,006.91–4,387.66)	232 (79.7%)
Replication cohort, group	2,489.40 (770.69–4,387.66)	216 (82.8%)
Replication cohort, 1:1	1,963.56 (714.93–4,032.55)	246 (85.4%%)
Replication cohort, combined	2,436.00 (885.19–3,473.12)	244 (86.8%)

CVD, cardiovascular disease.

Supplementary Table 2
Distribution of baseline characteristics among patients with and without inpatient cost due to CVD hospitalization

	People with payment	People with zero payment	P value
N	769	5,054	
Age, years	71.4±11.8	64.0±16.0	<0.0001
Female, n (%)	282 (36.6)	2,084 (41.2)	<0.0001
Systolic blood pressure, mmHg	138.3±16.9	135.2±16.2	<0.0001
Diastolic blood pressure, mmHg	75.3±10.0	76.4±9.9	<0.0001
Total cholesterol, mmol/L	4.3±1.1	4.3±1.2	0.0356
High-density lipoprotein, mmol/L	1.2±0.4	1.3±0.5	<0.0001
Low-density lipoprotein, mmol/L	2.3±0.9	2.5±1.0	<0.0001
Body mass index, kg/m^2	31.9±6.9	30.8±6.8	<0.0001
A1C, mmol/mol	61.7±16.7	60.7±16.6	<0.0001
Lipid-lowering treatment, n (%)	141 (18.3)	1,596 (31.6)	<0.0001

A1C, glycated hemoglobin; *CVD*, cardiovascular disease.