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Team-based Continuity of Care for Patients with Hypertension: A Retrospective Cohort Study in Primary Care

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Abstract

Background

Continuity of care (COC) is associated with improved health outcomes in hypertension patients.
Team-based COC allows more flexibility in service delivery but there is a lack of research on its effectiveness for hypertension patients.

Aim

This study aimed to investigate the effectiveness of team-based COC on cardiovascular disease prevention in patients with hypertension.

Design and setting

A retrospective cohort study in primary care setting.

Methods

421,640 patients visiting public primary care clinics in Hong Kong from 2008 to 2018 were included in the study. The usual provider continuity index (UPCI) was used to measure the COC provided by the most visited physician team. Cox regression and restricted cubic splines (RCS) were applied to model the association between the COC and the risk for CVDs and all-cause mortality.

Results

Compared to participants in the lowest quartile of UPCI, the hazard ratio for overall CVD was 0.94 (0.92,0.96), 0.91 (0.89,0.93), and 0.90 (0.88,0.92) in the 2nd, 3rd and 4th quartile, respectively. A greater effect size on CVD risk reduction was observed among the patients with unsatisfactory blood pressure control, the patients<65 years old and those with a Charlson Comorbidity Index<4 at baseline (P_interaction<0.05), but the effect was insignificant among the participants with an estimated glomerular filtration rate of <60ml/min/1.73m² at baseline.

Conclusions
Team-based COC via a coordinated physician team was associated with reduced risks of CVD and all-cause mortality among hypertension patients, especially for the patients with unsatisfactory blood pressure control. Early initiation of team-based COC may also achieve extra benefits.

**Keywords:** continuity of care, hypertension, cardiovascular diseases, primary care

**How this fits in:**

Continuity of care (COC) is associated with improved health outcomes in hypertension patients. Team-based COC can transform the previous one-to-one physician-patient relationship by connecting the patient to a coordinated group of physicians, thereby helping to sustain the COC for patients with hypertension in the long-term follow-up. Our study showed clinically significant effects of team-based COC in reducing the risks of CVD incidence and mortality among patients with hypertension. Team-based COC via a physician group can serve as a feasible and effective approach for achieving COC in healthcare systems with limited resources.
1 Introduction

Hypertension (HT) is a highly prevalent medical condition worldwide(1), which is also one of the most critical risk factors of cardiovascular disease (CVD) and premature death(2). The monitoring and care for hypertension patients rely mainly on the primary care system, where continuity of care (COC) is considered as a crucial component of primary care practice(3). Continuity of care refers to the relational, informational and managerial continuity in the provision of care for patients. Traditional COC in primary care is mainly viewed as the relationship between the patient and a designated practitioner that extends beyond specific episodes of illness or diseases(4), which could also be termed individual-based COC. COC was found to increase the chance of achieving blood pressure targets and improved quality of life(5-7) in patients with hypertension. However, assigning a physician to the patient for long-term COC requires the primary care system to be adequately and appropriately staffed, which is challenging in many public healthcare sectors, especially for those in resource-restricted settings(8).

In contending with the tension mentioned above, achieving COC on the team-based level has gained attention in primary care, as the physician group practice has getting popularized in the current climate around the world(9, 10). The physician group practice has been shown to improve the quality and efficiency of care because the previous one-to-one physician-patient relationship is leveraged to connect the patient to a team of physicians(11, 12). With more flexibility in scheduling appointments for physician encounters, team-based COC via a coordinated physician team can also be a feasible alternative to provide longitudinal continuous care for patients(11). Such an approach places greater emphasis on managerial and informational continuity, where shared management plans, care protocol and information sharing within the physician team can serve as complementary manners to achieve COC(4, 13). Team-based COC via a physician team has been found to effectively prevent CVD incidence and mortality among diabetes patients(14). However, the effectiveness of team-based COC for patients with hypertension remains unknown. Therefore, this study aimed to investigate the effect of team-based COC on the risk of CVDs and mortality among patients with hypertension.
2 Methods

2.1 Study design and participants

This is a retrospective cohort study conducted in patients with hypertension in Hong Kong, China, where physician team practice has been implemented in some pilot public primary care clinics over the past decade(14). There are around three physicians in one typical physician team at one time, and each physician is posted to a clinic for 2-5 years, during which they work in a fixed physician team. Patients are allowed to book appointments for office visits across different physicians within the same team(14). In the event of a temporary absence of a physician, the patients are advised to reschedule their appointments or to make appointments with another physician in the same team; For the longer absence of physicians, locum tenens would fill in temporarily to ensure the operation of team-based COC. Electronic medical records were extracted from the Clinical Management System (CMS) of the Hospital Authority (HA). The CMS is the centralized electronic medical databases of public health sectors since 1994 and has been validated with high coding accuracy in cardiovascular diseases(15).

Eligible participants were adult patients with hypertension who had at least one attendance at a public general outpatient clinic between 2008 and 2018. The earliest attendance date from 2008 to 2018 was set as the baseline date for each patient. A two-year period before the baseline was defined as the measurement period to measure the degree of team-based COC, where the patients with fewer than 3 visits were excluded from the analysis to avoid the misclassification of COC degree due to small number of visits. Patients with diabetes or cardiovascular diseases were also excluded from the analysis. Further details in the study design were illustrated in Figure 1. The list of case definitions based on ICD-9-CM/ICPC-2 codes is detailed in Supplementary Table 1. Each participant was followed till the occurrence of outcomes of interest, death, or 31st December 2019, whichever was earlier.

2.2 Measurement of exposure, outcomes, and covariates

The usual provider continuity index (UPCI) is a common measure of continuity of care(16), which was modified to measure team-based COC. The modified UPCI to measure team-based COC is
calculated by dividing the number of visits to the patient’s most visited physician team by the total number of physician consultations they attended within the measurement period (2 years before the baseline date). The UPCI was selected as the measurement for the primary analysis owing to its simplicity in interpretation, as it represents the proportion of a patient's visits to the most frequently visited physician team. The team-based UPCI ranges from 0 to 1, with 0.5 indicating that the patient visited the same team for 5 out of every 10 attendances. The primary outcome was the risks of CVD events over the follow-up period (i.e., any of the CHD, stroke, and heart failure). The risks of CVD subtypes mentioned above and all-cause mortality were examined as secondary outcomes. Information on mortality was collected from the Hong Kong Death Registry. Details on baseline covariates were collected from the CMS database.

2.3 Statistical analysis

We classified the participants into four groups based on the UPCI quartiles: i) <0.50, ii) 0.50-0.70, iii) 0.71-0.91, and iv) 0.92-1.0 to compare the risk of complications and mortality among varying degrees of COC. To minimize selection bias among groups, baseline characteristics were adjusted using fine stratified weights(17), in which propensity scores were generated with a multivariable logistic regression between the patient groups and baseline characteristics. A standardised mean difference (SMD) <0.1 indicates a good balance across groups(18). The hazard ratios (HR) for groups with higher UCPI relative to the group with UPCI <0.50 (the reference group) were examined using a multivariable Cox proportional hazard model with adjustments for baseline characteristics, including age, sex, smoking status, fasting glucose, blood pressure, lipid profile, body mass index, estimated glomerular filtration rate (eGFR), the Charlson Comorbidity Index (CCI), the total number of attendances within two years before the baseline, and the usage of anti-hypertensive medications and lipid-lowering agents. Additionally, to test the linearity of the exposure-response relationship, the restricted cubic splines (3 knots) was applied to flexibly model the association between the COC and the outcomes of interest(19). Multiple imputation was applied to handle missing values at baseline (Supplementary Table 2). Five sets of imputations were used and results were combined based on the Rubin’s rule(20).
Subgroup analyses were performed based on the patient’s gender, age (<65 vs ≥65 years), smoking status (current smoker vs non-smoker), the Charlson Comorbidity Index (CCI) (<4 vs ≥4), fasting glucose (≤5.6 vs. >5.6mmol/L), blood pressure (SBP<140 and DBP<90mmHg vs SBP≥140 or DBP ≥90mmHg), BMI (<23 vs ≥23kg/m²), and eGFR (≥60 vs <60ml/min/1.73m²). Several sensitivity analyses on CVD risk were conducted, including an analysis without weighting, an analysis with complete cases, and an analysis that included only patients with at least three years of follow-up. Additional sensitivity analyses were conducted by dividing the patients into quartiles defined by the alternative measurements of continuity of care (Supplementary table 3) to test if the approach of continuity measurement would influence the results, including the Continuity of care index (COCI)(21), the Modified modified continuity index (MMCI)(22), and the Sequential continuity index (SECON)(23). To affirm that the inclusion criteria of at least three attendances had a negligible impact on the results, the associations were examined again by including patients with at least five attendances and at least eight attendances. To test if different prescribing patterns would influence the results, we conducted a sensitivity analysis additionally adjusted for the four prevalent types of antihypertensives (angiotensin-converting enzyme inhibitor and angiotensin receptor blocker (ACEI/ARBs), β-blocker, calcium channel blockers, and diuretic) and two commonly prescribed lipid-lowering agents (statin and fibrate) in the primary care settings. All analyses were performed using Stata 16.1. A two-tailed $p<0.05$ was defined as statistically significant.

3 Results

3.1 Patient characteristics

A total of 421,640 eligible patients were identified from the CMS database. Descriptive statistics of the baseline characteristics before weighting were displayed in Supplementary Table 4. The mean age of patients was 64, and 43.4% were males. The prescribing patterns regarding the antihypertensives and lipid-lowering agents were similar across different UPCI quartiles among the eligible patients. After multiple imputation and weighting, 95 patients were excluded due to the lack of an available
match. Baseline characteristics of patients after weighting were presented in Table 1. All baseline characteristics had a SMD of less than 0.1, indicating an adequate balance between groups.

### 3.2 Association between UPCI and outcomes of interest

The HRs (95% CI) for CVD for patients with UPCI in the 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} quartile, relative to the reference group (UPCI<0.5) was 0.94(0.92, 0.96), 0.91(0.89, 0.93), and 0.90(0.88, 0.92) respectively (Figure 2). Similar patterns were observed for CHD and stroke. However, only a marginally significant difference (0.95(0.91, 1.00) was found for the risk of heart failure between the patients in the 2\textsuperscript{nd} quartile and the reference group. Risks of all-cause mortality were slightly lower in patients with a moderate degree of COC (2\textsuperscript{nd} and 3\textsuperscript{rd} quartile) compared to those in the reference group (HR: 0.96(0.94, 0.99), 0.96(0.93, 0.98), respectively. A linear negative association was observed between the UPCI and overall CVD risk, as well as the risk for CHD and stroke, but not for the heart failure and all-cause mortality, which suggested that the risk for heart failure and all-cause mortality did not decrease proportionately as the degree of team-based COC increased (Figure 3).

### 3.3 Subgroup and sensitivity analysis

Figure 4 illustrates the results from the subgroup analysis. The risk reduction of CVD among patients with higher team-based COC was preserved in most subgroups except for patients with baseline eGFR<60ml/min/1.73m\textsuperscript{2}. For patients in the highest UPCI quartile, the association between the UPCI and the reduced risk of overall CVD was significantly stronger in patients with unsatisfactory blood pressure control at baseline (SBP≥140 or DBP ≥90mmHg), those younger than 65 years of age or those with a CCI<4 (P\textsubscript{interaction}<0.05), and no significant differences in the effect size for COC was found between subgroups in terms of sex, smoking status, fasting glucose, and BMI (P\textsubscript{interaction}>0.05). The risk of overall CVD was significantly reduced in the groups in the higher quartiles of UPCI in all sensitivity analyses (Supplementary Figure 1).
4. Discussion

4.1 Summary

Higher team-based COC was associated with reduced risk for overall CVD and all-cause mortality among patients with hypertension. A linear association was observed between the degree of team-based COC and reduced risks of overall CVD, CHD and stroke. A greater effect of team-based COC on CVD risk was observed in patients younger than 65 years old and those with fewer comorbidities (CCI<4), whereas the effect was statistically insignificant in patients with impaired kidney function.

4.2 Strengths and limitations

This study is the first population-based cohort study to investigate the relationship between team-based COC and risks of CVD in patients with hypertension. The key strength of our study is the large sample size and long follow-up period, which enhances the strength of the evidence on the long-term effects of team-based COC. Additionally, we have included multiple endpoints and stratified hypertension patients into subgroups, which provided a more detailed understanding of the effects of team-based COC among this highly heterogenous population group.

There are several limitations in this study. Firstly, clustering bias might exist since team-based COC was only implemented in some primary care clinics. However, standardized guidelines for hypertension management in primary care practices have been implemented in Hong Kong for over a decade(24), and thus differences in clinical practices across clinics should be negligible. Secondly, an intention-to-treat approach was adopted, in which possible changes in the degree of team-based COC during the follow-up period have not been accounted for in the analysis. The visit patterns were assumed to remain relatively stable since patients with chronic diseases generally have higher COC during follow-up care(25). Thirdly, information on socio-economic status was unavailable in our database for confounding adjustment. However, the local public general outpatient clinics were heavily subsidized(26), so the bias in access to care should be limited. Additionally, the information to identify the individual-based COC (visit the same individual physician) was not available for analysis due to the privacy policy, and thus we could not provide an examination of potential overlap.
between team-based COC and individual-based COC. However, the patients’ chance of visiting the
same doctor during the long-term follow-up period and its influence on the analysis should be limited
to a small extent because it was difficult to sustain the individual-based COC due to physicians’
temporary absences, rotations and retirement.

4.3 Comparison with existing literature

Our results are largely consistent with a previous cohort study investigating the effects of COC
provided by the same medical institutes in newly diagnosed hypertension patients in Korea, where a
higher COC index was associated with a reduced risk of overall CVD (adjusted HR: 0.76 (0.73-0.79))
(27). Another cohort study in patients with newly diagnosed cardiovascular risk factors (including
hypertension) also reported similar findings: participants with a COC index below the median had
significantly greater risks for incident myocardial infarction (adjusted HR 1.57(1.28-1.95)), ischemic
stroke (1.44(1.27-1.63), as well as all-cause and cardiovascular mortality (adjusted HR: 1.12(1.04-
1.21) and 1.30(1.13-1.50) respectively)(28). Compared to these two studies, we have additionally
observed a linear association between the UPCI and the risk reduction for overall CVD, CHD and
stroke, suggesting the potential benefits of intensifying the degree of team-based COC for
hypertension patients.

A stronger association between team-based COC and CVD risk reduction was found among patients
with unsatisfactory blood pressure control, those <65 years old and those with fewer comorbidities
(CCI<4) at baseline. It has been shown in the previous study that COC can help to achieve the blood
pressure control, and thus improve the overall health of the patients with hypertension(6). As an
alternative pattern for individual-based COC, the team-based COC can be more effective for the
patients with poor blood pressure control, who deserve higher priority in the delivery of COC service.
The cohort study conducted by Daein et al. similarly reported a slightly larger effect size of higher
COC on CVD prevention among patients<60 years old (adjusted HR: 0.72(0.68, 0.76) compared to
those≥60 years old (adjusted HR: 0.77(0.74, 0.80))(27). The older patients and those with more
comorbidities were more likely to have deteriorated health status, for whom the team-based COC
might have limited efficacy on the endpoint of CVD incidence. However, the risk reduction for CVDs
in these patients was still significant and noteworthy given their population size and the higher incidence rates for CVDs. Further studies are also needed to investigate other efficacy endpoints such as the improvement in quality of life for a more comprehensive understanding of the benefits of team-based COC for patients with different health status. From another perspective, the relatively stronger effect of team-based COC in younger patients and those with less comorbidities suggested that early initiation of team-based COC during a patients’ course of treatment, or before the deterioration of health status, would contribute to greater benefits in preventing future CVD events, which follows the principle of early prevention for CVD(29). Additional attention should be directed towards younger adult patients to advocate for a continuous relationship with their physician team, in order to maximize the benefits of team-based COC.

The insignificant effect of team-based COC among hypertension patients with impaired kidney function could be due to their deteriorated health status thus higher underlying risk for CVD(30). A previous study on patients with hypertension and chronic kidney disease showed that greater COC from the same general practitioner could increase the likelihood of achieving the recommended blood pressure targets(5). Thus, further studies are still needed to evaluate the effectiveness of team-based COC in this patient subgroup since hypertension frequently co-existed with CKD(31). Additionally, the protective effect of team-based COC for heart failure and all-cause mortality was insignificant in the highest UPCI quartile. The hypertension patients with a higher risk of heart failure and/or all-cause mortality were more likely to have deteriorated health and tended to seek care from the same provider, such as the patients at the end-of-life stage(32), for whom further intensification in team-based COC might have been of limited efficacy on reducing the risks of relatively severe endpoints such as heart failure and all-cause mortality.

4.4 Implications for research and practice

Our study showed clinically significant effects of team-based COC in reducing the risks of CVD incidence and mortality among patients with hypertension. The patients with hypertension required life-long follow-up visits to monitor the treatment and refill medications(33). Team-based COC can transform the previous one-to-one physician-patient relationship by connecting the patients to a
coordinated group of physicians, thereby helping to sustain the COC for patients with hypertension in real-life clinical practice. By working collaboratively with other team members, the physician can ensure the long-term continuity in disease monitoring (e.g., blood pressure and medication effect) and patients’ adherence to the treatment plan, which can ultimately benefit the patients’ health outcomes in the long run. Additionally, the team-based COC can also improve communications among physicians, allowing them to share their knowledge and expertise related to the treatment of the patients, which can help the physicians develop a shared understanding of the best practices for managing specific patients and benefit patients’ outcomes ultimately.

Theoretically, the benefits of team-based COC should be transferable across the common chronic conditions in primary care. COC is critical in successful chronic disease management and the COC provided by a coordinated physician team enhances the sustainability of COC for the conditions that required long-term follow-up, such as Type 2 diabetes mellitus (T2DM)(14), hypertension, chronic obstructive pulmonary disease and so on. Related policies will be needed to support the team-based COC in individualized health systems. The development of coordinated physician teams and workforce training are crucial components in human resource management to realize the team-based COC. The enhancement of the infrastructure and the supporting system is also critical in improving the efficiency of team-based COC delivery in both informational and managerial aspects, which includes upgrades to the information technology to improve the information-sharing within the physician team and facilitate the appointment schedule for patients seeking care from the same physician teams(13).

4.5 Conclusion

As an alternative to the traditional individual-based COC, higher team-based COC via a physician group was found to be associated with lower risks of overall CVD and all-cause mortality among patients with hypertension, especially for patients with poor blood pressure control at baseline. Team-based COC via a physician group can serve as a feasible and effective approach for achieving COC in healthcare systems with limited resources. However, the protective effect of team-based COC was not as apparent for heart failure and all-cause mortality, and so was the prevention of overall CVD among
the patients with impaired kidney function, which implies the extra benefits of the early initiation of team-based COC in patients with hypertension.
Author Contributions

Miss Xu and Dr Wan had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Wan, Yu, Lam.
Acquisition of data: Wan, Lam.
Drafting the manuscript: Xu.
Critical revision of the manuscript for important intellectual content: Yu, Chin, Mak.
Statistical analysis: Chan, Wan, Xu.
Obtained funding: Lam.
Supervision: Wan.

Funding

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Role of the Funder/Sponsor

No funding organization had any role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation of the manuscript.

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Conflict of interest

Wan has received research grants from the Food and Health Bureau of the Government of the Hong Kong SAR and the Hong Kong Research Grant Council, outside the submitted work. Yu has received research grants from the Food and Health Bureau of the Government of the Hong Kong SAR, outside the submitted work. Lam has received research grants from the Health Bureau of the Government of the Hong Kong SAR, the Hong Kong Research Grant Council, the Hong Kong College of Family Physicians, and Kerry Group Kuok Foundation outside the submitted work.
Data availability

The data underlying this article were provided by the Hospital Authority of Hong Kong. The data can be accessed upon request to the Hospital Authority of Hong Kong.
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| Table 1 Baseline characteristics by continuity of care quartiles after multiple imputation and weighting |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                  | Total           | UPCI <0.50       | UPCI 0.50-0.70   | UPCI 0.71-0.91   | UPCI 0.92-1.0    | SMD             |
|                  | (N = 421,545)   | (N = 100,915)    | (N = 107,971)    | (N = 103,487)    | (N = 109,172)    |                 |
| Sex, male        |                 |                 |                 |                 |                 |                 |
|                  | 183,050 (43.4%) | 43,966 (43.6%)  | 47,071 (43.6%)  | 44,917 (43.4%)  | 47,097 (43.1%)  | <0.01           |
| Age, year        | 64.0 (12.2)     | 63.8 (12.1)     | 63.9 (12.3)     | 64.2 (12.0)     | 64.2 (12.2)     | 0.03            |
| Smoker           | 22,692 (5.4%)   | 5,434 (5.4%)    | 5,602 (5.2%)    | 5,592 (5.4%)    | 6,064 (5.6%)    | 0.02            |
| SBP, mmHg        | 134.6 (15.8)    | 134.7 (16.1)    | 134.4 (15.9)    | 134.6 (15.5)    | 134.7 (15.5)    | 0.02            |
| DBP, mmHg        | 76.3 (10.6)     | 76.5 (10.7)     | 76.3 (10.7)     | 76.3 (10.4)     | 76.3 (10.5)     | 0.02            |
| Fasting glucose, mmol/L | 5.3 (0.6) | 5.3 (0.6) | 5.3 (0.6) | 5.3 (0.6) | 5.3 (0.5) | <0.01           |
| BMI, kg/m²       | 25.2 (3.8)      | 25.2 (3.8)      | 25.2 (3.9)      | 25.1 (3.8)      | 25.1 (3.9)      | <0.01           |
| LDL-C, mmol/L    | 3.2 (0.8)       | 3.2 (0.8)       | 3.2 (0.8)       | 3.2 (0.8)       | 3.2 (0.8)       | <0.01           |
| eGFR, ml/min/1.73m² | 102.5 (63.3) | 102.8 (29.4)    | 102.4 (29.6)    | 102.4 (72.8)    | 102.5 (93.8)    | 0.01            |
| Charlson’s Comorbidity Index | 3.4 (2.8) | 3.4 (2.8) | 3.4 (2.8) | 3.4 (2.8) | 3.4 (2.8) | 0.02            |
| Use of anti-hypertensive drugs | 401,385 (95.2%) | 96,485 (95.6%) | 103,371 (95.7%) | 98,440 (95.1%) | 103,088 (94.4%) | 0.06            |
| Use of lipid-lowering agents | 40,622 (9.6%) | 9,741 (9.7%) | 10,459 (9.7%) | 9,977 (9.6%) | 10,445 (9.6%) | <0.01           |
| Number of appointments | 11.7 (4.9) | 11.7 (5.5) | 11.7 (4.9) | 11.8 (4.4) | 11.7 (4.6) | 0.02            |
| UPCI              | 0.69 (0.24)     | 0.36 (0.08)     | 0.58 (0.06)     | 0.80 (0.06)     | 0.98 (0.03)     | NA              |

Notes: The values are presented as mean(SD) or number(%), as appropriate. The Standardized mean difference (SMD) listed is the largest SMD between any pairs of the groups. UPCI: Usual provider of care index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; LDL-C: Low density lipoprotein - cholesterol; eGFR: Estimated glomerular filtration rate
First physician consultation during Jan 2008 – Dec 2018

Baseline

Follow-up till the earliest of
• occurrence of an CVD event
• mortality
• 31st December 2019

Follow-up period

Exclude patients with
• With diabetes on/before baseline;
• With CVDs on or before baseline;
• < 3 visits in the measurement period;
• aged < 18 at baseline

Notes: Team-based UPCI (Usual provider continuity index) was calculated by dividing the number of attendances at the most visited physician team by the total number of attendances within the two-year measurement period. Patients with fewer than 3 visits within the measurement period were excluded from the analysis to assure the accurate measurement of the UPCI.
Figure 2. Association of team-based continuity of care with risks of CVD and all-cause mortality among patients with hypertension

<table>
<thead>
<tr>
<th>Usual provider of Care Index (UPCI)</th>
<th>Number of events</th>
<th>Median Follow-up period (months)</th>
<th>Person-year Incidence rate (cases/1000 person-years)</th>
<th>HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular diseases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>&lt;0.50</td>
<td>16071</td>
<td>75.5</td>
<td>646,885</td>
<td>24.84</td>
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<tr>
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<td>17366</td>
<td>77.5</td>
<td>722,546</td>
<td>24.03</td>
</tr>
<tr>
<td>0.71-0.91</td>
<td>16352</td>
<td>74.5</td>
<td>691,102</td>
<td>23.66</td>
</tr>
<tr>
<td>0.92-1.0</td>
<td>18150</td>
<td>81.5</td>
<td>781,449</td>
<td>23.23</td>
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<tr>
<td><strong>Coronary heart disease</strong></td>
<td></td>
<td></td>
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<tr>
<td>&lt;0.50</td>
<td>6873</td>
<td>80.5</td>
<td>660,241</td>
<td>10.10</td>
</tr>
<tr>
<td>0.50-0.70</td>
<td>7541</td>
<td>84.5</td>
<td>758,379</td>
<td>9.94</td>
</tr>
<tr>
<td>0.71-0.91</td>
<td>6937</td>
<td>80.5</td>
<td>725,968</td>
<td>9.56</td>
</tr>
<tr>
<td>0.92-1.0</td>
<td>7735</td>
<td>88.5</td>
<td>820,280</td>
<td>9.43</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.50</td>
<td>8274</td>
<td>80.5</td>
<td>675,539</td>
<td>12.25</td>
</tr>
<tr>
<td>0.50-0.70</td>
<td>8648</td>
<td>83.5</td>
<td>755,119</td>
<td>11.45</td>
</tr>
<tr>
<td>0.71-0.91</td>
<td>8177</td>
<td>79.5</td>
<td>721,169</td>
<td>11.34</td>
</tr>
<tr>
<td>0.92-1.0</td>
<td>8082</td>
<td>87.5</td>
<td>815,935</td>
<td>11.01</td>
</tr>
<tr>
<td><strong>Heart failure</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.50</td>
<td>3964</td>
<td>83.5</td>
<td>693,482</td>
<td>5.72</td>
</tr>
<tr>
<td>0.50-0.70</td>
<td>4429</td>
<td>86.5</td>
<td>773,492</td>
<td>5.73</td>
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<tr>
<td>0.71-0.91</td>
<td>4339</td>
<td>82.5</td>
<td>738,234</td>
<td>5.88</td>
</tr>
<tr>
<td>0.92-1.0</td>
<td>5051</td>
<td>91.5</td>
<td>834,517</td>
<td>6.05</td>
</tr>
<tr>
<td><strong>All-cause mortality</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.50</td>
<td>13138</td>
<td>84.5</td>
<td>704,669</td>
<td>18.64</td>
</tr>
<tr>
<td>0.50-0.70</td>
<td>14834</td>
<td>89.5</td>
<td>786,025</td>
<td>18.87</td>
</tr>
<tr>
<td>0.71-0.91</td>
<td>14196</td>
<td>84.5</td>
<td>750,556</td>
<td>18.92</td>
</tr>
<tr>
<td>0.92-1.0</td>
<td>16719</td>
<td>93.5</td>
<td>848,668</td>
<td>19.70</td>
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</tbody>
</table>

Hazard ratios were adjusted for age, sex, smoking status, systolic and diastolic blood pressure, body mass index, fasting glucose, low-density lipoprotein cholesterol, estimated glomerular filtration rate, Charlson Comorbidity Index, number of medical attendances, use of anti-hypertensive drug, use of lipid-lowering drug and use of anti-diabetic drug at baseline.

CVD includes coronary heart disease, heart failure and stroke. CI, confidence interval; CVD, cardiovascular disease; HR, hazard ratio.
Figure 3. Restricted cubic Splines on the association between the UPCI and the risks of cardiovascular diseases or mortality

Notes: Analysis was adjusted for age, sex, smoking status, systolic and diastolic blood pressure, body mass index, fasting glucose, low-density lipoprotein cholesterol, estimated glomerular filtration rate, Charlson Comorbidity Index, number of medical attendances, use of anti-hypertensive drug, use of lipid-lowering drug and use of anti-diabetic drug at baseline.
Figure 4. Subgroup analyses on the association between team-based continuity of care and cardiovascular diseases among patients with hypertension

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>UPCI 0.5-0.70</th>
<th>UPCI 0.71-0.91</th>
<th>UPCI 0.92-1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI)</td>
<td>HR (95% CI)</td>
<td>HR (95% CI)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.94 (0.92, 0.97)</td>
<td>0.91 (0.88, 0.94)</td>
<td>0.90 (0.67, 0.92)</td>
</tr>
<tr>
<td>Male</td>
<td>0.94 (0.91, 0.97)</td>
<td>0.91 (0.88, 0.94)</td>
<td>0.90 (0.87, 0.93)</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 65</td>
<td>0.93 (0.88, 0.97)</td>
<td>0.88 (0.84, 0.92)</td>
<td>0.84 (0.80, 0.88)</td>
</tr>
<tr>
<td>≥ 65</td>
<td>0.95 (0.93, 0.97)</td>
<td>0.92 (0.90, 0.94)</td>
<td>0.92 (0.90, 0.94)</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-smoker</td>
<td>0.94 (0.92, 0.96)</td>
<td>0.91 (0.89, 0.93)</td>
<td>0.90 (0.88, 0.92)</td>
</tr>
<tr>
<td>Smoker</td>
<td>0.90 (0.83, 0.99)</td>
<td>0.92 (0.84, 1.00)</td>
<td>0.86 (0.79, 0.94)</td>
</tr>
<tr>
<td>CCI</td>
<td></td>
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<tr>
<td>&lt; 4</td>
<td>0.95 (0.91, 1.00)</td>
<td>0.89 (0.85, 0.93)</td>
<td>0.83 (0.79, 0.87)</td>
</tr>
<tr>
<td>≥ 4</td>
<td>0.94 (0.92, 0.96)</td>
<td>0.91 (0.89, 0.94)</td>
<td>0.92 (0.89, 0.94)</td>
</tr>
<tr>
<td>Fasting glucose, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 5.7</td>
<td>0.95 (0.92, 0.98)</td>
<td>0.92 (0.89, 0.95)</td>
<td>0.91 (0.88, 0.94)</td>
</tr>
<tr>
<td>&gt; 5.7</td>
<td>0.94 (0.89, 0.99)</td>
<td>0.89 (0.84, 0.94)</td>
<td>0.89 (0.85, 0.94)</td>
</tr>
<tr>
<td>Blood pressure, mmHg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP &lt; 140 &amp; DBP &lt; 90</td>
<td>0.96 (0.93, 0.99)</td>
<td>0.92 (0.89, 0.95)</td>
<td>0.92 (0.89, 0.95)</td>
</tr>
<tr>
<td>SBP ≥ 140 / DBP ≥ 90</td>
<td>0.92 (0.89, 0.95)</td>
<td>0.90 (0.87, 0.93)</td>
<td>0.87 (0.84, 0.90)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 23</td>
<td>0.96 (0.93, 1.04)</td>
<td>0.90 (0.85, 0.95)</td>
<td>0.89 (0.84, 0.94)</td>
</tr>
<tr>
<td>≥ 23</td>
<td>0.91 (0.88, 0.95)</td>
<td>0.91 (0.88, 0.94)</td>
<td>0.87 (0.84, 0.91)</td>
</tr>
<tr>
<td>eGFR, ml/min/1.73m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 60</td>
<td>0.93 (0.91, 0.96)</td>
<td>0.91 (0.89, 0.94)</td>
<td>0.90 (0.88, 0.93)</td>
</tr>
<tr>
<td>&lt; 60</td>
<td>1.00 (0.93, 1.08)</td>
<td>0.92 (0.85, 1.00)</td>
<td>0.99 (0.91, 1.07)</td>
</tr>
</tbody>
</table>

Hazard ratios were adjusted by age, sex, smoking status, SBP and DBP, BMI, fasting glucose, low-density lipoprotein cholesterol, eGFR, CCI, number of attendances, use of anti-hypertensive drug, use of lipid-lowering drug and use of anti-diabetic drug at baseline.

CVD includes coronary heart disease, heart failure and stroke. BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; eGFR, estimated glomerular filtration rate; HR, hazard ratio; UPCI, usual provider continuity index.