Impact of primary care usual provider type and provider interdependence on outcomes for patients with diabetes: a cohort study

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ABSTRACT

Background Interprofessional primary care (PC) teams are key to the provision of high-quality care. PC providers often ‘share’ patients (eg, a patient may see multiple providers in the same clinic), resulting in between-visit interdependence between providers. However, concern remains that PC provider interdependence will reduce quality of care, causing some organisations to hesitate in creating multiple provider teams. If PC provider teams are formalised, the PC usual provider of care (UPC) type (physician, nurse practitioner (NP) or physician assistant/associate (PA)) should be determined for patients with varying levels of medical complexity.

Objective To evaluate the impact of PC provider interdependence, UPC type and patient complexity on diabetes-specific outcomes for adult patients with diabetes.

Design Cohort study using electronic health record data from 26 PC practices in central North Carolina, USA.

Participants Adult patients with diabetes (N=10 498) who received PC in 2016 and 2017.

Outcome Testing for diabetes control, testing for lipid levels, mean glycated haemoglobin (HbA1c) values and mean low-density lipoprotein (LDL) values in 2017.

Results Receipt of guideline recommended testing was high (72% for HbA1c and 66% for LDL testing), HbA1c values were 7.5% and LDL values were 88.5 mg/dL. When controlling for a range of patient and panel level variables, increases in PC provider interdependence were not significantly associated with diabetes-specific outcomes. Similarly, there were no significant differences in the diabetes outcomes for patients with NP/PA UPCs when compared with physicians. The number and type of a patient’s chronic conditions did impact the receipt of testing, but not average values for HbA1c and LDL.

Conclusions A range of UPC types on PC multiple provider teams can deliver guideline-recommended diabetes care. However, the number and type of a patient’s chronic conditions alone impacted the receipt of testing, but not average values for HbA1c and LDL.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Interprofessional primary care (PC) teams are key to the provision of high-quality PC.
⇒ Physicians, nurse practitioners and physician assistant/associates provide similar quality of diabetes care when acting as the usual provider of care (UPC), or team leader, of interprofessional teams.
⇒ In multiple provider teams, PC providers often ‘share’ common patients (eg, a patient may see another provider in the same clinic who is not their UPC), resulting in interdependence between providers. Recent evidence suggests that having multiple, interdependent PC providers from different professions on a team may improve quality of care delivery.
⇒ The number and type of chronic conditions that a patient with diabetes has been associated with the quality of diabetes care received.

WHAT THIS STUDY ADDS

⇒ An initial evaluation of the impact of UPC type, provider interdependence, and patient complexity on diabetes-specific outcomes for adult patients with diabetes.
⇒ We include many patient and panel level variables in the models to quantify their contribution to quality of diabetes care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This information can be used to design and implement PC teams that deliver high-quality care for complex patients in primary care.

BACKGROUND

Interprofessional primary care (PC) teams are key to the provision of high-quality PC.1–4 A PC team consists of two or more PC professionals that work collaboratively to deliver whole-person, integrated care to patients.1 5 These teams generally fall into two categories: teams with a single provider (ie, the extended teamlet) and teams with multiple providers.6 7 The team compositions most frequently of interest to PC organisations is the extended teamlet, in which a single PC provider (physician, nurse
practitioner (NP) or physician assistant (PA)) works with other professionals such as medical assistants, nurses, pharmacists and social workers. This focus on adding team members to work with a PC provider is consistent with the historical approach of PC provider panels to support continuity of care (CoC) through the patient’s relationship with a single provider (ie, the usual provider of care (UPC)).

In multiple provider teams, PC providers rely on each other by ‘sharing’ common patients (eg, a patient may see another provider in the same clinic who is not their UPC), resulting in between-visit interdependence between providers. Interdependence is considered a critical feature of team structure due to its potential impact on team performance. Interdependence can be manipulated by team leaders and members to provide the most beneficial outcomes for patients. In order to reduce interdependence and build patient–provider relationships (ie, increase CoC), patients have historically been divided into panels under a single provider (ie, the UPC) who has responsibility for the care delivered to the patients on their panel. However, because PC is comprehensive and longitudinal, a panel’s UPC is often unable to provide all the care to all the patients on their panel.

Provider interdependence and CoC are related, but the relationship varies by panel and patient characteristics. CoC is fundamental feature of PC, is often defined as the ongoing relationship between an individual provider and a patient, and is measured at the level of the patient. Provider interdependence is a form of task interdependence between PC providers in the same clinic that can be measured as patient sharing at the panel level. Provider interdependence is one of the panel characteristics that can reduce CoC. However, not all patients are equally impacted by provider interdependence. Medically complex women with higher PC usage can see greater reductions in CoC with increasing provider interdependence. However, this impact can be reduced by manipulating other factors such as panel size and number of supplemental providers.

Despite the potential to reduce CoC, recent evidence suggests that having interdependent PC providers on a team may improve quality of care delivery. In one of the first studies of PC provider teams, Medicare claims and electronic health record (EHR) data from adult patients with diabetes at a large academic medical centre demonstrated that PC providers do work in multiple provider teams without sacrificing quality of care. These findings have been replicated in a national study that looked at EHR data for newly diagnosed patients with diabetes. In this study, patients that received care from multiple provider PC teams received higher quality care for diabetes and other chronic illnesses than patients receiving care from single providers. However, some organisations hesitate to adopt this multiple provider team structure due to concerns that PC provider interdependence will reduce the quality of care. Unfortunately, no studies have evaluated the impact of provider interdependence on quality of care.

If multiple provider PC teams are formalised, the decision of what type of PC provider (physician, NP or PA) can be the team lead, particularly for complex patients, must be addressed. Single institution and national studies have demonstrated that quality of diabetes care is similar when different PC provider types (physicians, NPs and PAs) act as UPCs, even for medically and socially complex patients. Despite the evidence, concern is often raised regarding the impact of medical complexity, or having multiple chronic conditions, on the care and outcomes of patients with conditions such as diabetes. Studies suggest diabetes outcomes are impacted not only by the number of chronic conditions, but also whether or not the treatment for a given condition supports (concordant) or competes (discordant) with diabetes.

This study focuses on the relationship between team design features, including PC team UPC type, interdependence and patient complexity, on outcomes for adult patients with diabetes.

**METHODS**

**Study design**

This cohort study uses EHR data from adult patients with diabetes who received PC in participating clinics in 2016 and 2017.

**Study setting**

This study was conducted at 26 health-system affiliated PC practices in central North Carolina in the USA. The results are based on the in-person visits delivered by 111 physicians and 20 NPs and PAs with patient panels at family medicine and internal medicine clinics. These clinics provide over 500 000 visits per year to 193 000 patients.

**Sample and data sources**

The sample included adult patients with diabetes having at least two in-person PC visits a year and the same UPC in 2016 and 2017 (N=10 498). All data were obtained from the EHR. Patients were identified as having diabetes using billing codes from outpatient and inpatient data. The UPC was determined by a previously published approach. Briefly, the usual clinic of each patient was identified as the PC clinic that provided the majority of their in-person PC visits. Next, the provider (physician, NP or PA) that delivered the majority of the in-person visits within the usual clinic was identified as the UPC. In the event of ties, patients were assigned to the clinic and provider with the most recent visit. A provider panel was defined by patients for whom that provider delivered the majority of in-person PC visits.
Variables

Patient-level variables

Patient variables included the dependent and independent variables. Four dependent variables were used that reflect quality of diabetes care. Binary variables were created to reflect adequate testing for diabetes control (≥2 glycated haemoglobin (HbA1c) tests) and lipid levels (≥1 low-density lipoprotein (LDL) test) in 2017. Two continuous variables for mean of all outpatient HbA1c and LDL values were calculated from outpatient tests conducted in 2017. Independent patient variables include sociodemographic and clinical variables. Sociodemographic variables included age, sex, race (Caucasian/white or black/African American or other/not reported) and insurance (private or Medicare or Medicaid/other government/uninsured/missing). Two count measures of overall morbidity burden were used to indicate whether comorbid conditions were concordant or discordant with diabetes. Diabetes-concordant conditions have treatments that are aligned with the treatment of diabetes (eg, hypertension). Diabetes-discordant conditions have treatments that compete with diabetes (eg, irritable bowel syndrome).

Three measures of PC usage were created including the count of PC visits to the usual clinic, the number of supplemental PC providers and CoC. CoC is a density measure of continuity ranging from 0 to 1.0, with 1.0 being perfect CoC. This measure was calculated as the per cent of PC visits with the patient’s UPC within the year. Four additional usage measures were calculated including an indicator variable for at least one endocrinology visit in 2017, a count of other outpatient specialty visits, a count of emergency department visits and a count of hospitalisations (categorised as 0, 1, 2+).

Panel-level variables

Panel-level (ie, patients with the same usual provider) measures were constructed by aggregating (ie, averaging) patient-level measures. Panel variables include provider variables and panel characteristics. UPC type is a binary measure indicating either a physician (attending MD/DO) or a PA/NP. Interdependence is a continuous measure of patient sharing between the usual provider and other providers within the same clinic (number of shared patients:number of supplemental providers). Interdependence was categorised into quartiles for use in regression analyses.

Analysis

All analyses were completed using STATA SE V.16.0 (StataCorp LLC, College Station, Texas, USA). Descriptive analyses (means, SD and percentages) were calculated for all patient and panel level variables. To evaluate the association between PC provider type, interdependence and diabetes outcomes, four regression models were performed. Logistic regression was performed for the HbA1c and LDL testing. Linear regression was performed for the mean HbA1c and LDL values. All regressions included the complete complement of control variables listed earlier and were performed with clustering by clinic.

RESULTS

Study population-patient characteristics

The sample included 10 498 adult patients with diabetes (figure 1 and table 1). The average age was approximately 66 years old. Fifty-five per cent were identified as female. Fifty-six per cent of the sample identified as Caucasian/white, 38% black or African American and 6% other race or not reported. Less than 6% report having Medicaid, being uninsured or having missing insurance status data. Patients in the sample had, on average, 90% of their PC visits with their UPC (ie, interpersonal CoC) and 0.5 supplemental providers per year. Some slight demographic differences were seen by UPC type. Patients with physicians as UPC types had older mean ages than those of PA/NPs (65.2 years vs 60.7 years).

The receipt of guideline recommended testing was high, with 72% of patients receiving ≥2 HbA1c tests, and 66% receiving ≥1 LDL test. Average HbA1c values were 7.5% and average LDL values were 88.5 mg/dL. Values for all quality outcomes were statistically and clinically similar for patients with physicians or PA/NPs as usual providers.

Panel characteristics

The average panel size was 80 adult patients with diabetes who met inclusion criteria. Average panel interdependence was 9 (nine patients per supplemental provider). Panels with PA/NP usual providers were smaller than physician panels (52 vs 85 patients) and with lower interdependence (eight patients/supplemental provider vs nine patients per supplemental provider, table 2).

Missing data

This study used existing data for patients that used PC within the system being studied. Therefore, missing data for the patients included in the cohort was meaningful (eg, missing A1c tests reflected zero testing performed) and captured in patient and panel-level variable creation.
Association between usual provider type, interdependence, patient complexity and diabetes-specific outcomes

When controlling for PC provider interdependence, count of concordant and discordant conditions, and all other patient and panel variables, there was no significant difference between the quality of diabetes care delivered to patients with PA/NPs as UPCs compared with physicians (tables 3 and 4). When compared with

<table>
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<tr>
<th>Table 1 Patient descriptive statistics</th>
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<tr>
<td>Patients (n=10 498)</td>
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<tr>
<td>Demographics</td>
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<td>Age</td>
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<td>Female</td>
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<td>Race</td>
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<td>Caucasian/white</td>
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<td>Black or African American</td>
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<td>Other/not reported</td>
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<td>Insurance</td>
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<td>Medicaid/other government/uninsured/missing</td>
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<td>Clinical</td>
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<tr>
<td>Count of chronic conditions</td>
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<td>Discordant condition count</td>
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<td>Concordant condition count</td>
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<td>Primary care usage</td>
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<tr>
<td>Total visits</td>
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<td>Visits with usual provider</td>
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<td>Number of supplemental providers</td>
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<td>Interpersonal continuity of care</td>
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<td>Specialty usage</td>
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<td>Endocrinology visits (at least one visit)</td>
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<td>Count of other specialty visits</td>
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<td>Hospitalisations</td>
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<td>2+</td>
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<td>ED visits</td>
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<td>1</td>
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<tr>
<td>2+</td>
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<td>Test counts</td>
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<td>HbA1c</td>
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<td>≥2 tests</td>
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<td>LDL</td>
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<td>≥1 test</td>
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<tr>
<td>Test values</td>
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<tr>
<td>HbA1c</td>
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<tr>
<td>LDL</td>
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ED, emergency department; HbA1c, glycated haemoglobin; LDL, low-density lipoprotein; NP, nurse practitioner; PA, physician assistant/associate.
patients with physicians as UPCs, patients with PA/NPs as UPCs had similar odds of receiving the recommended testing for HbA1c (OR=1.0; 95% CI 0.54 to 1.83; p=0.99) and LDL (OR=0.64; 95% CI 0.36 to 1.14; p=0.13) (table 3 and online supplemental tables 1 and 2). The difference in mean HbA1c and LDL for patients with PA/NP UPCs compared with physicians were −0.04% (95% CI −0.15 to 0.07; p=0.44) and 0.97 mg/dL (95% CI −1.84 to 3.77; p=0.48) (table 4 and online supplemental tables 3 and 4).

Similarly, there was no significant difference in quality of diabetes care by quartile of PC provider interdependence when controlling for UPC type, concordant and discordant conditions, and all other patient and panel level variables (table 3 and online supplemental tables 1–4). For every increase in interdependence quartile, the odds of receiving ≥2 HbA1c and ≥1 LDL tests in 2017 were 0.86 (95% CI 0.70 to 1.25; p=0.44) and 0.92 (95% CI 0.70 to 1.13; p=0.57) (table 3). Mean difference in HbA1c and LDL values was 0.03% (p=0.27) and −0.40 mg/dL (p=0.46) with each increase in quartile of PC provider interdependence (table 4).

Differences in HbA1c and LDL testing, but not mean values, were observed by number and type of chronic conditions, when controlling for all other variables (tables 3 and 4 and online supplemental tables 1–4). For every additional discordant chronic condition, the odds of having ≥2 HbA1c tests and ≥1 LDL test in the year were reduced by 14% (OR=0.86. 95% CI 0.76 to 0.98; p=0.03) and 17% (OR=0.83. 95% CI 0.74 to 0.94; p=0.003), respectively. For each additional concordant condition, the odds of receiving ≥1 LDL test was increased by 12% (p=0.04) when controlling for all other patient and panel level variables. There was no significant difference in mean HbA1c or LDL with the addition of concordant or discordant conditions.

**DISCUSSION**

**Summary**
This study simultaneously evaluates the impact of PC provider interdependence, UPC type and patient complexity on diabetes-specific outcomes for adult patients with diabetes. We found that, when controlling
for UPC type, patient complexity and other variables, increases in PC provider interdependence were not significantly associated with diabetes-specific outcomes. Similarly, there was no significant difference in the diabetes outcomes for patients with NP/PA UPCs when compared with patients of physicians. The number and type of a patient’s chronic conditions did impact the receipt of testing, but not average values for HbA1c and LDL.

Comparison with previous literature
Increases in PC provider interdependence were not associated with significant differences in diabetes quality metrics. This is the first paper to look at the association between PC provider interdependence and diabetes outcomes. Within the greater team literature, interdependence is considered to be a key feature of team structure due to its potential impact on team performance. Limited evidence in healthcare suggests that PC provider interdependence varies widely and impacts CoC, particularly for medically complex patients. Our findings suggest that formalising teams with multiple providers will be unlikely to reduce quality of disease-specific care. However, recent evidence suggests that CoC and the number of supplemental providers may influence this relationship, particularly for patients with higher levels of medical complexity. Our findings also suggest that PC provider interdependence is similar by UPC type, suggesting that the professional composition of multiple provider teams can be based on factors other than quality concerns, such as patient preferences.

Table 4  Regression results for HbA1c and LDL values

<table>
<thead>
<tr>
<th></th>
<th>Mean HbA1c (%) (N=9408)</th>
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<th>Mean LDL (mg/dL) (N=6946)</th>
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<tr>
<td></td>
<td>Coefficient (SE) P value</td>
<td>95% CI</td>
<td>Coefficient (SE) P value</td>
<td>95% CI</td>
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<tr>
<td>PCP type (physician reference)</td>
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<tr>
<td>PA/NP</td>
<td>-0.04 (0.05) 0.44</td>
<td>-0.15 to 0.07</td>
<td>0.97 (1.36) 0.48</td>
<td>-1.84 to 3.77</td>
</tr>
<tr>
<td>Interdependence (quartile)</td>
<td>0.03 (0.03) 0.27</td>
<td>-0.03 to 0.09</td>
<td>-0.40 (0.53) 0.46</td>
<td>-1.49 to 0.69</td>
</tr>
<tr>
<td>Count of concordant chronic conditions</td>
<td>-0.02 (0.02) 0.22</td>
<td>-0.07 to 0.02</td>
<td>-0.06 (0.50) 0.91</td>
<td>-1.10 to 0.98</td>
</tr>
<tr>
<td>Count of discordant chronic conditions</td>
<td>0.04 (0.03) 0.11</td>
<td>-0.01 to 0.10</td>
<td>0.03 (1.13) 0.98</td>
<td>-2.30 to 2.36</td>
</tr>
</tbody>
</table>

Regressions controlled for all patient and panel level variables in tables 1 and 2.

HbA1c, glycated haemoglobin; LDL, low-density lipoprotein; NP, nurse practitioner; PA, physician assistant/associate.

Strengths and limitations
This is the first study to simultaneously assess the association between usual provider type, provider interdependence, patient complexity and diabetes-specific patient outcomes. Several study strengths allow for a better understanding of the complex relationship between these factors. First, observational study was conducted in a health system with variation in geographic location (rural/urban/suburban), clinic staffing and patient characteristics. Second, the cohort definition requires patients to have a stable PC provider over 2 years. Third, this study also incorporated CoC. This incorporation allowed us to evaluate the association of provider interdependence on patient outcomes while controlling for how provider interdependence may influence the patients PC experience (ie, CoC). Finally, the large sample size provided with physician UPCs. One caveat remains. This study did not take into consideration years of practice experience, so that may be an important factor when considering which providers should lead PC teams.

The number and type of chronic conditions did impact diabetes quality metrics, but only the receipt of testing. We found that, with each additional diabetes discordant chronic condition (eg, asthma), the odds of receiving HbA1c and LDL testing were reduced. However, with each additional diabetes concordant condition (eg, hypertension), the odds of receiving an LDL test increased and there was no association with HbA1c testing. This finding is consistent with existing literature, and likely reflects a patient-centred, whole-person approach to prioritising an individual’s health goals. This finding, however, is unique in that it also took into consideration UPC type and PC provider interdependence. This suggests that for all PC provider types, regardless of level of provider interdependence, the primary focus is patient-centred and not disease-specific. Such prioritisation can be particularly important for complex, older patients, who can be negatively impacted by aggressive diabetes management.
sufficient power to identify differences in diabetes-specific patient outcomes.

This study has several key limitations. First, we had to group NPs and PAs together due to sample size. These are two separate professions with different training models and are regulated by different state boards, so it would have been ideal to keep them separated. However, in this organisation, NPs and PAs practice under the same administrative line and policies and perform the same roles. Similarly, the state in which this organisation resides has similar scope of practice for PAs and NPs. Second, the study uses data from the EHR only. Therefore, important variables, such as years of experience for each provider, are not in the analysis. Third, the data are from 2016 and 2017. While there have not been significant changes in the epidemiology or treatment of diabetes in the USA since that period, changes to the healthcare workforce and care delivery during the COVID-19 pandemic may alter the generalisability of these findings to today's PC teams. Fourth, this study is limited to adult patients with diabetes who used PC at one organisation, potentially limiting generalisability. However, the sample is from 26 clinics with varying size, staffing patterns and geographic locations (rural, urban, suburban, etc). Similarly, while patients with diabetes may not reflect all PC patients, diabetes is prevalent, costly and a condition that is frequently used as an indicator of overall quality of care delivery. Finally, this study conceptualises all covariates as moderators. As a result, mediation effects of measured and unmeasured variables were not explored.

Implications

Implementation of evidence-based PC teams is critical for ensuring the efficient delivery of quality PC. Key aspects of PC team structure include DUP type, provider interdependence and patient medical complexity. Our study suggests that quality of care is associated with patient complexity, but not with UPC type (physician, NP or PA) or provider interdependence. When considering PC team design for medically complex patients, additional study is warranted on outcomes that would be beneficial for complex older patients, such as treatment burden and other patient-reported measures.

CONCLUSIONS

In this study, we simultaneously evaluated the impact of three key team structural features on diabetes-specific outcomes—PC provider interdependence, UPC type and patient complexity. Our findings suggest that PC teams with multiple providers can have a range of provider interdependence and usual provider types without sacrificing the quality of diabetes care. These findings may suggest that patient-centred prioritisation of health goals for complex patients are occurring, by all UPC types, and within multiple provider teams.

However, additional research is needed to understand the impact of these factors on a wider range of outcomes that may be more pertinent to PC and complex patients with multiple chronic conditions.

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Contributors CE is the author responsible for the overall content as the guarantor. CE conceived of the idea for this work, the conceptual model and drafted the manuscript. PAM, VAS, SD, JBA, AV, GLJ collaborated on the design, conduct, interpretation and manuscript preparation. CE, HB and JC worked on data including variable formation and analysis and provided comments on manuscript drafts. CE is the guarantor.

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Data availability statement Data are available upon reasonable request. We will make de-identified limited access datasets available. A researcher wishing to use the dataset will be required to obtain approval from Duke in accordance with institutional policies. Agreements will clearly specify the intended analyses as well as assurances that Duke and HIPAA regulations will be followed. Appropriate contracts and/or agreements will require compliance approval from both institutions. If approval is granted, the dataset will be supplied as outlined in the agreements. The dataset will be available for use once the date of acceptance of the publication that reports the main findings is known. In all cases, we stipulate appropriate (and inappropriate, when necessary) use of research, training and intervention materials.

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