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Abstract

Background

Personal continuity is a core value of general practice. It is increasingly threatened by societal and healthcare changes.

Aim

To 1) investigate the association between personal continuity and practice and patient characteristics; and 2) incorporate general practitioners (GPs)' views to enrich and validate our quantitative findings.

Design and Setting

A mixed methods study based on observational, routinely collected healthcare data of 269,478 patients from 48 Dutch general practices (2013-2018) and interviews with selected GPs.

Methods

First, we related four different personal continuity outcome measures to eight practice and twelve patient characteristics by multilevel linear regression analyses. Second, we performed a thematic analysis of semi-structured interviews with ten GPs to include their views on factors attributing to personal (dis)continuity. These GPs worked at the ten practices with the largest difference between calculated and model-estimated personal continuity.

Results

We found that an increased number of usual GPs and contacts by locum GPs were dose-dependently associated with lower personal continuity (highest vs. lowest quartile -0.094 and -0.095, P<0.001), whereas days since enlistment was dose-dependently associated with higher personal continuity (highest vs. lowest quartile +0.017, P<0.001). Older age, number of chronic conditions and contacts were also associated with higher personal continuity. The in-depth interviews identified three key themes affecting personal continuity: team composition, practice organisation and personal views.

Conclusion

Personal continuity is associated with practice and patient characteristics. The dose-dependent associations suggest a causal relationship and, complemented by GPs' views, may provide practical targets to improve personal continuity directly.

Keywords

Personal continuity, continuity of care, general practice, primary healthcare, mixed methods

How this fits in

Personal continuity, a core value of general practice, is threatened by societal and healthcare changes. To identify practice and patient characteristics associated with personal continuity, this study used both observational routinely collected care data and semi-structured interviews with GPs. The dose-dependently associated characteristics (i.e. number of usual GPs and days since enlistment), combined with GPs' views, may provide practical targets for future interventions to improve personal continuity in general practice.

Introduction

Personal continuity is considered one of the core values of general practice (1-5). Personal continuity implies familiarity and mutual confidence between patient and doctor that can and usually do arise from repeated contacts over time (6). Reported benefits include a better patient-doctor relationship (7, 8), better preventive care (9), fewer emergency department visits (10), greater patient and doctor satisfaction (8, 11, 12), fewer hospital admissions (13), reduced health care costs (14), better medication compliance and prescription (9, 15-19) and reduced mortality rates (20, 21). Adverse effects of personal continuity include frustrated or difficult patient-doctor relationships and delayed diagnosis or referrals (22).

Sandvik *et al.* (2021) found an association between length of relationship between patient and usual general practitioner (GP) and lower use of out-of-hours services, fewer acute hospitalizations, and lower mortality (23). These associations were dose-dependent and probably causative, suggesting that any improvement of personal continuity may influence these outcomes and benefit the patient (23).

However, societal and healthcare changes potentially reduce personal continuity. For example, GPs increasingly work part time and in larger practices (1, 2, 5, 24). Both patients and doctors are increasingly mobile (1). The prevalence of complex, chronic diseases increases (1). Finally, the rise of the consumer movement enables patients to have fast access to any doctor (2). Together, these changes result in fragmented care from different providers, organisations and disciplines. In addition, high workload levels and workforce shortages could limit GPs' ability to realise personal continuity (25). Consequently, in recent years, personal continuity has declined in general practice (26).

In order to optimise personal continuity, it is important to identify practice and patient characteristics that are associated with discontinuity (27). Patient characteristics could help to determine patients who are prone to discontinuity, whereas associated practice characteristics may enable us to identify organisational factors that promote or obstruct personal continuity (27). For example, previous research from Canada, Norway and United Kingdom showed that older patients were more likely to see their usual doctor (27-29). If practices offered patients a convenient appointment system, patients

were more likely to have a contact with their preferred GP (26). Other factors that may influence personal continuity include age, sex, ethnicity, income, education and patient preferences (30). In addition, practices with larger list sizes (over 6000-6500 patients) had lower personal continuity than smaller practices (27, 31). One study shows that personal continuity was inversely associated with number of GP leave days and being a training practice (32). In contrast, rurality and percentage of scheduled appointments with an assigned healthcare provider were positively associated with personal continuity.

However, to our knowledge, only one study exists on the association between personal continuity and *both* practice and patient characteristics in general practice (27). Therefore, we incorporated *both* practice and patient characteristics *and* established outcome measures, which we complemented with GPs' views. Our aims were to 1) investigate the association between personal continuity and practice and patient characteristics; and 2) incorporate GPs' views to enrich and validate our quantitative findings.

Methods

Study design

We used a mixed methods approach to study the association between personal continuity and practice and patient characteristics. First, we analysed observational, routinely collected health data from 48 general practices associated with the Academic Network of General Practice at Amsterdam University Medical Center, location VU University Medical Center (ANH VUmc, Amsterdam, the Netherlands). Second, we conducted ten semi-structured telephone interviews with ten GPs from different practices using a purposive sampling strategy.

Quantitative methods

Data collection, access and cleaning methods

In total, the 48 practices included in this study provided care for 269,478 patients in a six year observation period (2013-2018). All non-institutionalised citizens are enlisted in one general practice (33). These practices provide care during office hours (33). We subsequently selected patients with at least one contact at their general practice. In order to gather meaningful data and be able to calculate personal continuity, we reached consensus within our research group to select patients who 1) were enlisted at least one year; and 2) had at least five contacts with their practice, including at least two with a GP between 2013-2018 (Figure 1). MW, BL and OM had access to the anonymised analytical dataset.

Continuity measures (dependent variable)

To calculate personal continuity between GP and patient, we included telephone calls, home visits, e-mails and face-to-face consultations that were registered in the electronic medical record by a GP. For each patient, we used the included GP-contacts to calculate four established continuity outcome measures: Usual Provider of Care (UPC), the Herfindahl–Hirschman Index (HI) the Continuity Of Care Index, also known as the Bice-Boxerman Index (BBI), and the Modified Modified Continuity Index (MMCI) (34-37). All continuity outcome measures have ranges between 0 (minimal, i.e. all contacts different GPs) and 1 (maximal, i.e. all contacts same GP). We determined the practice continuity by

aggregating continuity outcomes of its individual patients (5). In the main text, we show the results of the continuity outcome measure with the highest explained variance (MMCI). For calculations, see Table S1.

Determinants

Practice characteristics

Based on suggestions from the literature and availability in the data, the ANH VUmc collected practice and patient characteristics for each practice. We included the number and working hours of the usual GPs, number of usual GPs working longer than five years at practice, number of locum GPs and percentage of contacts by locum GPs (between 2013-2018) (2, 29, 35, 38). Usual GP is defined as a partner or salaried GP who usually works at this practice (27). Other practice characteristics included list size (2, 27), training practice (39) and number of other employees (30).

Patient characteristics

For each individual patient, we included sociodemographic variables sex, age, and an estimate of income and migration background (30). The estimates were provided by ANH VUmc data managers, based on the patients' 4-digit zip code data (01-01-2016) and data from the National Statistical Office (Statistics Netherlands) (40). The local median income (low, average or high), corrected for differences between family compositions, was provided by the National Statistical Office. Similarly, migration background was based on the local percentage of population who or whose parents were born in Africa, South America, Asia (excluding Indonesia and Japan) or Turkey.

We also included information on the patient's medical history, i.e. chronic diseases, and in particular coronary heart, oncologic and psychiatric diseases (30, 41-43). These diagnoses were registered by Dutch GPs using the International Classification of Primary Care version 1 (ICPC-1 NL) and defined by the Netherlands Institute for Health Services Research (44, 45) (details in Table S2A and S2B). Additionally, we calculated the number of days since enlistment in the practice, the number of contacts, and percentage of telephone calls and home visits (30).

Quantitative analysis

We conducted all statistical analyses on the final dataset with IBM SPSS version 26 (46). We summarised data with mean and standard deviation (SD) or median with ranges for normally distributed and non-normally distributed continuous characteristics, respectively. We described categorical patient characteristics with the mean and SD percentage per practice.

To determine the association between personal continuity and the characteristics, we built linear mixed models with fixed effects for patients and practice characteristics and random intercepts for patients nested within practices. First, we used a backward selection procedure, to identify the statistically significant patient characteristics by removing those characteristics with the highest P-value one-by-one until all remaining had $P \leq 0.001$. Second, we used the same procedure to identify the remaining associated practice characteristics. We categorised continuous practice characteristics into quartiles because plots showed that the linearity assumption was not met.

We estimated models for each of the continuity measures separately, to determine the best fit. The quality of the models was measured by the amount of explained variance of the models with both practice and patient characteristics. To determine the additional value of the practice characteristics, we also calculated the explained variance of the model with patient characteristics only. Additionally, we conducted likelihood ratio tests to confirm the best version of the model for each of the continuity outcomes. The model for the continuity outcome with the highest explained variance was considered the best fit and displayed in the results (other outcomes Table S3 (descriptive statistics), S4 (final models) and S5 (R^2)). Lastly, the internal validity of the final model was investigated by a bootstrapping validation procedure, creating 1000 random samples from the study population (Table S5).

Qualitative methods

We selected a purposeful sample of GPs from different practices to participate in the semi-structured interviews to gain maximum insights to enrich and validate our quantitative findings. First, for each patient, we computed the model-based MMCI, which was calculated using the fixed effect of the patient and practice characteristics identified by the multilevel analysis. Next, for each practice, we

calculated the difference between the mean calculated and the mean model-based MMCI over all patients within that practice. We selected the five practices with the highest positive and the five practices with the highest negative differences. One GP per practice was invited by PS to participate and received written information concerning the study. After the GP agreed to participate, the interviewer MW scheduled an interview. At the start of the interview, the interviewer obtained oral informed consent. After a reminder, the response rate was 100% and all interviews were included in the analysis.

One author (MW) conducted all semi-structured telephone interviews, for which MW, OM and PS created a topic list. This list included a brief summary of the quantitative data. A topic list revision was considered after the analysis of the first three interviews, however, no revisions were needed. The interviewer avoided closed questions and encouraged participants to talk freely about their visions regarding factors that influence continuity of care in their practice during the observation period.

The interviews were conducted between February 22, 2021 and March 17, 2021 and took on average 17 (range 13-31) minutes. All interviews were audio recorded and transcribed verbatim. None of the participating GPs provided comments on their interview transcript. Afterwards, the interview data were coded and contact details of the GPs were deleted.

Qualitative analysis

MW and AK used thematic analysis according to Braun and Clarke to identify, analyse and report patterns within the data (47). Thematic analysis allows for minimal organisation and detailed description of the data and may provide additional interpretation of various aspects of the research topic (47). To identify overarching key themes, we compared and discussed the derived patterns until consensus was reached.

Results

Quantitative results

Descriptive analysis

The final dataset included 185,215 patients who had 4,530,304 contacts with their practice, of which 2,734,776 contacts with a GP between 2013-2018 (Figure 1). The mean list size was 4027 patients per practice. The mean age of the patients was 40 years and 43.3% of patients were male (Table 1). The mean MMCI was lower in large practices.

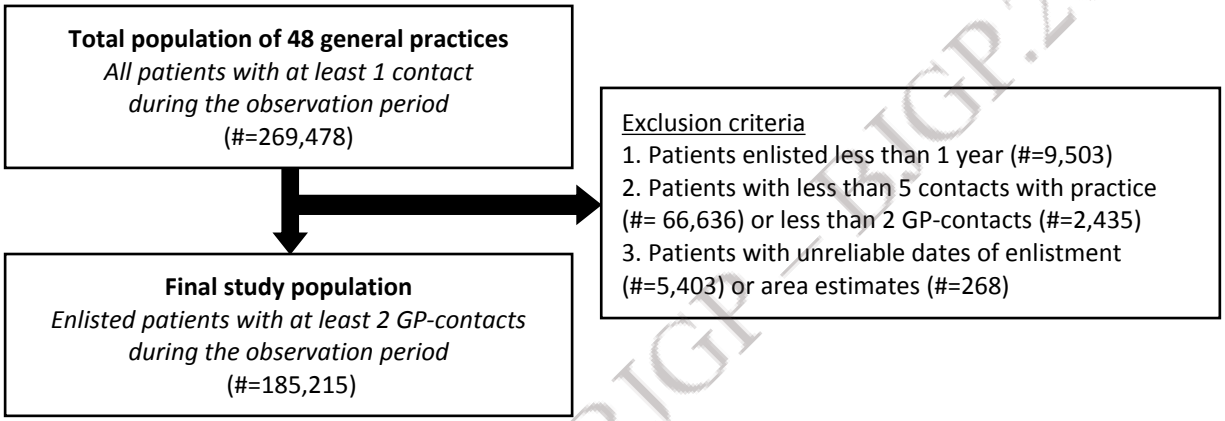

Figure 1. Selection of the final study population.; # = number of patients; GP = general practitioner; GP-contacts = contacts with GP.

	Small practice, <2500 listed patients (n=12)	Intermediate practice, 2500-4000 listed patients (n=21)	Large practice, >4000 listed patients (n=15)	All practices (n=48)
Continuity indices per practice	**Median (min-max)**	**Median (min-max)**	**Median (min-max)**	**Median (min-max)**
MMCI	0.78 (0.68-0.87)	0.78 (0.63-0.90)	0.74 (0.57-0.79)	0.76 (0.57-0.90)
Practice characteristics	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
List size	2,287.0 (204.9)	3,141.0 (347.0)	6,661.1 (1,752.5)	4,027.5 (2,077.3)
Usual GP characteristics				
Number of usual GPs	3.1 (1.1)	3.5 (1.3)	7.1 (1.8)	4.5 (2.3)
Number of working days/yr	176.2 (63.3)	183.4 (47.9)	191.9 (30.0)	184.3 (48.0)
Number of GP >5 yrs at practice	1.6 (1.0)	1.8 (0.6)	4.2 (2.0)	2.5 (1.7)
Locum GP characteristics				
Number of locum GPs	6.8 (5.4)	5.7 (5.5)	5.7 (4.6)	6.0 (5.2)
% of contacts by locum GPs	11.5 (8.0)	11.0 (9.0)	16.6 (14.9)	12.8 (11.0)
Number of employees[a]	27.3 (13.7)	24.9 (16.5)	45.2 (11.9)	31.9 (17.0)
Training practice %[b]	33.3	66.7	86.7	64.6
Patient characteristics[c]	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Male %	44.1 (4.2)	42.7 (3.6)	42.7 (3.6)	43.3 (3.3)
Age[d]				
0-18 years %	18.1 (2.8)	18.5 (5.3)	22.5 (7.4)	19.7 (5.8)
18-65 years %	60.6 (5.2)	66.9 (6.1)	64.1 (5.7)	64.5 (6.1)
65+ years %	21.3 (5.9)	14.6 (5.3)	13.4 (6.9)	15.9 (6.6)
Medical history[e]				
>2 Chronic diseases %	35.6 (8.0)	30.4 (7.5)	30.2 (5.7)	31.6 (7.4)
Oncologic disease %	11.5 (2.7)	8.8 (3.3)	8.0 (2.9)	9.2 (3.3)
Coronary heart disease %	5.3 (2.1)	4.4 (1.6)	4.4 (1.8)	4.6 (1.8)
Psychiatric disease %	15.0 (3.2)	16.0 (3.2)	15.5 (3.0)	15.6 (3.1)
Income (area)[f]				
Low %	22.0 (16.7)	29.9 (19.1)	40.0 (32.1)	31.1 (24.4)
Average %	55.3 (14.7)	50.8 (26.0)	37.8 (30.8)	47.9 (25.9)
High %	22.7 (17.2)	19.3 (26.9)	22.2 (53.5)	21.0 (25.7)
Migration background (area)[f]				
<10 %	39.3 (20.3)	29.9 (17.8)	13.7 (18.5)	27.6 (21.0)
10-30 %	39.9 (14.2)	46.2 (21.7)	34.7 (30.8)	41.5 (23.6)
30-70 %	16.8 (13.7)	24.0 (28.6)	51.6 (38.4)	30.9 (32.2)
Years since enlistment[g]	12.7 (2.3)	11.1 (2.6)	9.8 (1.8)	11.1 (2.5)
GP-contacts per patient				

Number of contacts	12.8 (2.7)	15.3 (1.9)	15.2 (2.2)	14.7 (2.6)
Type of GP-contacts per practice				
Telephone calls %	16.4 (5.1)	20.5 (6.3)	19.9 (3.6)	19.2 (5.5)
Home visits %	2.2 (0.7)	1.8 (1.0)	2.0 (1.5)	1.9 (1.0)
Face-to-face %	80.7 (4.9)	76.5 (6.5)	77.5 (4.3)	78.0 (5.6)
E-mail %	0.8 (1.5)	1.1 (1.5)	0.6 (1.0)	0.7 (1.3)

Table 1: Characteristics of the 48 general practices and their patients in 2013-2018. a: excluding GPs; b: trainee GP at practice; c: determined on patient level, aggregated on practice level; d: on 01-01-2016; e: percentage of patients who have been diagnosed with chronic conditions (<1); cancer; coronary heart disease; chronic psychiatric disorder; f: estimated income and migration background based on national data on 01-01-2016 (local income, corrected for differences between family compositions; local migration background, i.e.local percentage of population who or whose parents were born in Africa, South America, Asia; g: on 31-12-2018. GP = general practitioner. MMCI = Modified Modified Continuity Index.

Multivariate mixed-model analysis

Of the four continuity measures, MMCI had the best fit, i.e. the highest explained variance in the final model with both practice and patient characteristics (R^2 24.2% and Table S5).

We found an inverse, dose-dependent association between personal continuity and number of usual GPs, i.e. the more usual GPs work at the practice, the more discontinuity ((Table 2). Percentage of contacts by locum GPs had a similar association with personal continuity. List size, number of working days of the usual GP, number of usual GPs longer than 5 years at practice, number of other employees, and being a training practice were not associated with personal continuity.

On a patient level, we found that female sex is associated with higher personal continuity. Compared to younger adults (18-65 years), patients with older age (>65 years) had higher personal continuity. In contrast, children (<18 years) had lower personal continuity. Number of chronic diseases, psychiatric disease, and oncologic disease were associated with higher personal continuity, whereas coronary heart disease was associated with lower personal continuity. We found a dose-dependent association between higher personal continuity and days since enlistment. Number of contacts, in particular percentage of telephone calls and home visits, were associated with higher personal continuity. Area estimated income and migration background were not associated with personal continuity.

The confidence intervals of the 1000 bootstrap samples were narrow and the results were thus similar to those presented for the final MMCI model (Table S6).

Practice characteristic	MMCI			
	B	95% CI		Sig.
Usual GP characteristics				
Number of usual GPs				<0.001
Q1 (2-3)	ref			
Q2 (4-5)	-0.056	-0.091	-0.021	
Q3 (6-7)	-0.062	-0.100	-0.024	
Q4 (8-10)	-0.094	-0.135	-0.053	
Locum GP characteristics				
% of contacts by locum GPs				<0.001
Q1 (0-4.2)	ref			
Q2 (4.2-11.6)	-0.033	-0.071	0.006	
Q3 (12.7-18.6)	-0.075	-0.116	-0.034	
Q4 (18.8-60.6)	-0.092	-0.131	-0.052	

Patient characteristic	MMCI			
	B	95% CI		Sig.
Sex				0.001
Female	ref			
Male	-0.003	-0.004	-0.001	
Age [a]				<0.001
0-18 years	-0.042	-0.044	-0.040	
18-65 years	ref			
65+ years	0.027	0.024	0.030	
Medical history[b]				
Number of chronic diseases	0.005	0.004	0.005	<0.001
Psychiatric disease				<0.001
No	ref			
Yes	0.023	0.021	0.026	
Oncologic disease				<0.001
No	ref			

Yes	0.007	0.004	0.011	
Coronary heart disease				<0.001
No	ref			
Yes	-0.008	-0.013	-0.004	
Days since enlistment[c]				<0.001
Q1 (0-1415)	ref			
Q2 (1416-3197)	0.008	0.006	0.011	
Q3 (3198-6052)	0.013	0.010	0.015	
Q4 (5053-10592)	0.017	0.014	0.019	
Contacts				
Number of contacts	0.004	0.004	0.004	<0.001
% telephone calls	0.116	0.111	0.121	<0.001
% home visits	0.061	0.050	0.072	<0.001

Table 2. Practice and patient characteristics associated with MMCI. *P≤0.001. 1, R2=24.2%. a: on 01-01-2016; b: patients who have been diagnosed with chronic diseases; c: on 31-12-2018. Q1=0-25%, Q2=25-50%, Q3=50-75%, Q4=75-100%; GP=general practitioner; MMCI = Modified Modified Continuity Index; ref=reference group.*

Interviews

Three overarching key themes that were reported to affect personal continuity in these practices: team composition, practice organisation and personal views (Figure 2). Among the GPs that participated in the semi-structured interviews, 80% worked at a training practice (Table S3).

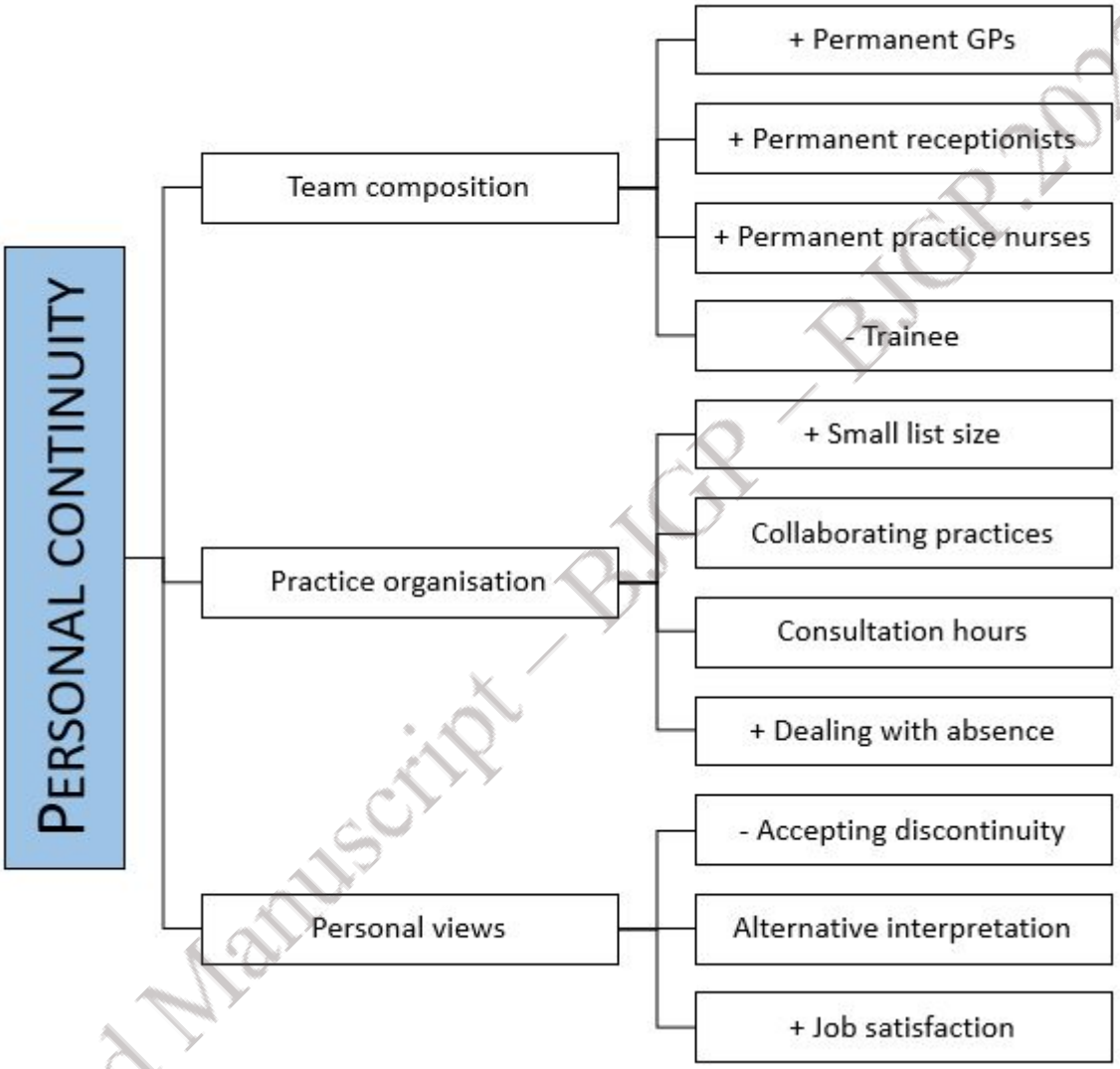

Figure 2. Key themes influencing levels of personal continuity according to the general practitioners (GPs).

Team composition

All GPs considered the employment of a familiar team important in maintaining personal continuity.

GP 1: *"I'm sure we agree that part time employment is incompatible with personal continuity, simply because something might happen on the day you're not in."*

Some GPs said that they experienced difficulty in finding permanent colleagues, i.e. who were available multiple days a week for months or years. According to those GPs, patient's experience of personal continuity was also dependent on the familiar presence of other team members, including receptionists.

GP 2: *"When a patient calls, the telephone is answered by a familiar receptionist. My receptionists have been working with me for 40 years, so they know the patients for a long time. Because of our positive atmosphere, staff stays with us for decades."*

According to a GP, the presence of GP trainees would threaten personal continuity.

GP 1: *"Every year, we have a different trainee (…), who has to see complex patients as well."*

GPs expressed mixed views on the influence of practice nurses on personal continuity. They claimed that the presence of practice nurses was greatly appreciated because they provided continuity by coordinating care for patients with chronic diseases (33). Nevertheless, some GPs said that it can be difficult to keep an eye on certain vulnerable patients.

GP 3: *"During the study period, the number of practice nurses has increased. They have taken on a lot of interactions with the patients. Some of the care practice nurses provide occurs in addition to care provided by GPs, but a proportion of it substitutes for – and comes at the expense of – patients' contacts with me or my [GP] colleagues."*

<u>*Practice organisation*</u>

According to the GPs, practices with a small number of listed patients are expected to provide more personal continuity. However, those small practices had to hire locum GP more often when the usual GP was unavailable.

GP 3: *"Fifteen years ago, we would record a taped message instructing the patients to call another practice whilst we were unavailable, for example during the holidays. This barrier was too high to overcome, so patients would wait. When the GP returned, their appointments would be jam-packed for three weeks. (…) Therefore, we hire locum GPs, many. We consider that phenomenal customer service, however, it does dilute personal continuity (…)"*

Some large practices organised themselves into multiple smaller practices. This way, they could cover each other's shifts if the usual GP was absent. The planning of consultation hours was considered essential in the availability of the usual GPs and, therefore, personal continuity.

GP 4: *"When I started working at our practice [in 2017], I immediately cancelled the daily walk-in hours. It was impossible for patients to schedule an appointment with their named GP. Patients did not know in advance which doctor was on call - they were unable to anticipate - so their consultation could be with a doctor they didn't know."*

The availability of the usual GPs was often restricted. One GP described the differences between time consuming face-to-face consultations and time efficient telephone consultations.

GP 5: *"We actually decided to increase the time allocated to face-to-face consultations. This way the consultation is less rushed, so I have time to talk about other things, for example, how their family is doing. To make this possible, we reduced the number of face-to-face consultations and, of course, increased the number of telephone consultations (…). For me, this change has been a great improvement. My patients appreciate this too."*

Another GP argued that the need of personal continuity was restricted to a selection of patients, who should be prioritised in practice organisation.

GP 1: *"Young people often do not need to have a named GP, it does not matter to them as much. However, we actively allocate a named GP to people over 65 years, in order to improve the patient-doctor relationship, to anticipate on the comorbidity that is expected within 10-15 years. Unless it is an emergency, of course".*

<u>*Personal views*</u>

As illustrated by the previous quotes, the interviewed GP expressed their views on personal continuity directly or indirectly. Two GPs claimed that personal discontinuity is inevitable. Some GPs suggested alternative interpretations of personal continuity.

GP 3: *"(…) Do you define continuity as 'having a single healthcare provider, possibly with limited availability' or 'having ample access to any [general practice] healthcare provider'? We offer the latter, not just for 46 weeks a year, but 53 weeks a year. You could say that our practice is never closed."*

GP 1: *"Perhaps we should define personal continuity as 'I see one of these two doctors' rather than 'I always see this specific GP'."*

Despite the practical challenges, the general view on personal continuity was optimistic.

GP 2: *"In my opinion, the familiarity between patients and [general practice] healthcare providers results in a very pleasant work environment."*

Discussion

Summary

We found that personal continuity was lower in a dose-dependent way when the number of usual GPs or percentage of contacts by locum GPs increased (highest vs. lowest quartile -0.094 and -0.095, P≤0.001). Being a training practice and list size were not associated with personal continuity. On a patient level, personal continuity dose-dependently increased when the patient was enlisted longer (highest vs. lowest quartile +0.017, P≤0.001). Personal continuity in our Dutch general practices was high, which is similar to other studies in the period 2013-2018 (MMCI median 0.76, range 0.57-0.90) (32).

Qualitative interviews with GPs revealed three key themes affecting personal continuity: team composition, practice organisation and personal views. According to the GPs, a feasible way to increase personal continuity was working in small, stable, familiar teams including two usual GPs who share workload and cover each other's absences. Increasing the number of efficient telephone calls as opposed to time consuming face-to-face consultations, is in line with the quantitative finding that personal continuity was higher when the percentage of telephone consultations increases. Some GPs actively allocated older patients in anticipation of expected morbidities, which could explain the quantitative association between personal continuity and age. Being a GP training practice would reduce personal continuity according to the GPs, because the employment of trainees at a particular practice is temporary. However, we found no evidence to support this in our data.

Strengths and limitations

The major strength of this study was the mixed methods design. The combined results provided complementary insights into the characteristics associated with personal continuity. This study was based on a longitudinal real-life routinely collected care data from 48 general practices covering all GP-contacts in 6 years. Our main outcome was based on contacts, registered by a particular GP working at a particular practice. In addition to practice characteristics, we included patient characteristics, which Dutch GPs are expected to record routinely (55). Furthermore, because no international

consensus exists on the best measure to calculate personal continuity in general practice, we included four different measures. Another strength of this study was the in-depth thematic analysis of GP interviews. Although the participating GPs received initial results of their practices, they were encouraged to share their views openly to avoid solely data driven responses. We found no differences in GP responses between the included practices based on our sampling strategy.

A limitation of this study is that all practices were located in urban areas (the cities of Amsterdam and Haarlem). Therefore, we were unable to study the association between rurality and personal continuity as shown in previous studies (32, 37). However, these practices varied in list sizes, patient populations and practice organisation, and had similar MMCI levels compared to other studies (32). Our results are thus generalizable for Dutch general practices, in particular in urban areas. Furthermore, we only had access to local estimations of migration background and income per patient, which may not correspond with the individual patient's characteristics. This may have resulted in an underestimation of these associations with personal continuity. Finally, we focussed on personal continuity between GP and patient. According to the interviewed GPs, contacts with other health care providers (i.e. GP trainees, practice nurses) may contribute to perceived personal (team) continuity as well. We did not investigate other types of continuity directly, i.e. management and information (1).

Comparison with existing literature

To our knowledge, no research has been published that used mixed methods to study the association between practice and patient characteristics and the selected personal continuity measures. Guthrie (2002) and Palmer *et al.* (2018), who studied both patient and practice characteristics, found an inverse association between large list size and personal continuity (27, 30). We found no association between list size and personal continuity. However, number of GPs, which was associated with personal continuity, could be an indicator for list size. In contrast with our study, Guthrie and Palmer used a questionnaire to determine personal continuity (26). Guthrie also found that young males have lower odds of personal continuity than their female peers (OR=0.86). A reversed association was observed with increased age, which Guthrie considered a "life cycle effect" (26). This could explain why we found

that female sex was associated with personal continuity (mean age 40), whereas Coma *et al.* (2021) found that males had higher personal continuity (mean age 51) (32).

Similar to our study, Coma *et al.* (2021) studied various aggregated personal continuity measures on a practice level. They found a similar MMCI (0.73) with higher explained R^2 (56%), compared to our study (0.76 and 24.2%, respectively). However, the majority of this R^2 was attributed to the single variable *Percentage of appointments booked with an assigned GP* (39% in variable only model), which we did not include. Therefore, we expected our R^2 to be lower. This study also found an inverse association between percentage of migration from a low income country and MMCI (-0.14; $P<0.05$). We found no association between area estimates of migration background and personal continuity ($P\leq0.001$).

Based on patient's views described in a previous study, we expected coronary heart disease to be associated with higher levels of personal continuity (43). However, in contrast to other chronic diseases, we found an inverse association. This could be explained by the increased employment of practice nurses, who provide care for patients with certain chronic diseases, including cardiovascular risk management (32). Additionally, patients with cardiovascular diseases may require urgent consultations more often, which may therefore involve a non-usual GP (32, 33).

Finally, Walker *et al.* (2018) and Coma *et al.* (2021) found that personal continuity in training practices was lower than independently practicing physicians, which is not in line with our findings (32, 39). Forman *et al.* (2019) suggested that the awareness of GPs of the tension between providing continuity and educating young GPs may have resulted in team-based strategies to maintain continuity despite the presence of a trainee (48). The GPs who participated in our study described this tension, so perhaps they already implemented those strategies. This could explain why we found no statistically significant association between being a training practice and personal continuity.

Implications for Research and/or practice

Practice level personal continuity is still high (MMCI=0.76). In our data, we found that MMCI was a better fit than the three other commonly used continuity measures (BBI, HI and UPC). Complemented by GP's views, suggestions to improve personal continuity include working in small teams with 2-3

usual GPs, and pro-active allocation of older patients with chronic diseases. In addition, patients and their families should be encouraged to schedule appointments with their usual GP, to increase familiarity and mutual confidence. These changes may benefit the patient and health care providers directly, because any improvement of personal continuity is associated with a lower use of out-of-hours services, fewer acute hospitalisations, and lower mortality (23). Future research should evaluate the effect of the aforementioned suggestions (i.e. working in small, familiar teams and informing patients) as interventions. Additionally, why MMCI was the best fit remains unknown, but will be part of future research.

Differences in personal continuity between practices are partially explained by the included practice and patient characteristics. A large proportion of the explained variance is still unknown, although it may partially be explained by our qualitative findings. For example, we did not include the patient's preference, which may be dependent on confidence in GP, complexity of symptoms, or the convenience of the practice's appointment system. Therefore, future studies should incorporate patient's views, i.e. by using a patient reported outcome measure, and compare those outcomes to the four continuity measures used in this study (49).

Additional information

Supplementary data

Table S2A. ICPC included in study

Table S2B. ICPC definitions

Table S3: Characteristics of all practices and patients (2013-2018)

Table S4. Practice and patient characteristics associated with UPC, BBI and HI

Table S5. R2 final models MMCI, UPC, BBI and HI

Table S6. Bootstrapping results final model MMCI

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Ethical approval

The medical ethics committee of VU University Medical Center confirmed that the Medical Research Involving Human Subjects Act (WMO) does not apply to this study (no. VUmc2015-260 and no. 2020.0700). The ANH VUmc database contains of pseudonymised data from all patients of the participating general practices, excluding those patients who objected to this. Interviewed GPs provided an oral informed consent before the audio-taped interview. Their participation was voluntary, confidential and participants could withdraw from the interview at any time without any explanation.

Competing interests

The authors declare that they have no competing interests.

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