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Predictors and population health outcomes of persistent high GP turnover in English general practices: a retrospective observational study

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ABSTRACT

Objective English primary care faces significant challenges, including 'persistent high turnover' of general practitioners (GPs) in some partnerships. It is unknown whether there are specific predictors of persistent high turnover and whether it is associated with poorer population health outcomes.

Design A retrospective observational study.

Methods We linked workforce data on individual GPs to practice-level data from Hospital Episode Statistics and the GP Patient Survey (2007–2019). We classified practices as experiencing persistent high turnover if more than 10% of GPs changed in at least 3 consecutive years. We used multivariable logistic or linear regression models for panel data with random effects to identify practice characteristics that predicted persistent high turnover and associations of practice outcomes (higher emergency hospital use and patient experience of continuity of care, access to care and overall patient satisfaction) with persistent high turnover.

Results Each year, 6% of English practices experienced persistent high turnover, with a maximum of 9% (688/7619) in 2014. Larger practices, in more deprived areas and with a higher morbidity burden were more likely to experience persistent high turnover. Persistent high turnover was associated with 1.8 (95% CI 1.5 to 2.1) more emergency hospital attendances per 100 patients, 0.1 (95% CI 0.1 to 0.2) more admissions per 100 patients, 5.2% (95% CI –5.6% to –4.9%) fewer people seeing their preferred doctor, 10.6% (95% CI –11.4% to –9.8%) fewer people reporting obtaining an appointment on the same day and 1.3% (95% CI –1.6% to –1.1%) lower overall satisfaction with the practice.

Conclusions Persistent high turnover is independently linked to indicators of poorer service and health outcomes. Although causality needs to be further investigated, strategies and policies may be needed to both reduce high turnover and support practices facing challenges with high GP turnover when it occurs.

INTRODUCTION

General practitioners (GPs) have a key role in the healthcare system in England, providing comprehensive population healthcare and acting as gatekeepers to specialist care.¹ Nevertheless, in the last

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Increases in general practitioner (GP) turnover, especially 'persistent high GP turnover', are contributing to the crisis in English primary care. It is not known whether there are certain practice characteristics associated with 'persistent high turnover' and whether persistent high turnover is in turn associated with worse performance on commonly used indicators of service and health outcomes.

few years, English primary care has faced major challenges with the number of GPs per patient reducing^{2,3} and an increasing number of GPs considering early retirement.^{3,4} Other GPs state intentions to reduce working hours, due to excessive workload, dissatisfaction with physical working conditions,³ low morale, or reduced job satisfaction^{5–7} and high burnout rate.^{8,9}

In 2015, the UK government promised 5000 new GPs by 2020¹⁰ but failed to deliver on that promise.¹¹ The contributing factors to the steady decrease in the number of GPs can be found in the insufficient number of newly trained GPs joining the workforce, lack of overseas recruitment and more GPs retiring early.³ The decreasing number of general practices is also partly due to the inability to recruit staff and lack of resources allocated to the service as the population grows, patient consultations increase and people are living longer with complex health needs.¹²

WHAT THIS STUDY ADDS

⇒ Practices with persistent high turnover tend to be larger, located in more deprived areas and with a higher morbidity burden across serious chronic conditions. The distribution of these practices also varies across regions, with the highest levels of persistent high turnover being in NHS Cumbria and North East, South Central and West Midlands. Persistent high turnover was associated with higher emergency hospital attendance and admission rates, in addition to a lower proportion of patients obtaining an appointment on the same day or being satisfied overall with their practice.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Persistent high turnover is an important parameter when considering quality of care and access provided by general practices. Although further research is needed to establish causality, persistent high turnover appears to be contributing directly or indirectly to avoidable health system costs. Strategies and policies are needed to support practices facing challenges with high GP turnover.

GP turnover, which can be defined as the proportion of GPs leaving a practice,¹³ is a major issue for the healthcare system. GP turnover has increased in the last decade, and it is unevenly distributed across England,¹³ with practices in more deprived areas likely to experience higher levels of turnover.¹³ In these deprived areas, average GP consultation rates are higher, and GPs need to deal with increasingly complex problems in less time, with no additional resources.^{14–16}

There is limited information available on the reasons GPs leave their practices.¹⁷ Therefore, it is unknown whether a GP leaving a practice is retiring, moving to a different practice or leaving the profession. For this reason, it is difficult to discern whether GP turnover may be a temporary situation for the practice or when the practice is facing enduring problems with retention. Previous work has highlighted that some practices experience high GP turnover for long periods of time,¹³ defined as ‘persistent high turnover’. This phenomenon may indicate recurring problems with recruitment and retention¹⁸ and may have an impact on safety of patients, quality, access and continuity of care.

Very little is known about high GP turnover¹³ and its association with practice-level outcomes. A 2015 US study found that primary care provider turnover was associated with worse patient experiences of care but did not have a major effect on ambulatory care quality.¹⁹ However, high turnover could inevitably lead to poorer continuity of care, when the latter has been associated with higher risks of hospitalisation^{20 21}

and mortality,²¹ higher costs of care,²² higher emergency care use²³ and lower patient satisfaction.²⁴ High turnover may also affect the ability to deliver primary care services,²⁵ so it may affect outcomes directly as well as indirectly (through poorer continuity of care).

Continuity of care matters to patients, as shown by the fact that more than half of GP patients taking part in a national survey expressed willingness to wait longer to see their preferred GP.²⁶ Continuity of care has also been associated with lower hospital admissions for conditions that are primarily managed in primary care.²³

It is currently unknown whether certain practice characteristics are associated with persistent high turnover and whether practices facing persistent high turnover are associated with worse performance on commonly used indicators of service and health outcomes. This study aims to address that gap by examining if practice list size, deprivation and other characteristics are associated with persistent high turnover in English primary care, and whether practices with persistent turnover are associated with higher hospital activity, lower continuity of care, poorer access and lower satisfaction.

METHODS

The study follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Data sources and study design

The study used a retrospective observational design (2007–2019 and 2009–2017), combining data from four resources¹³: GP workforce,²⁷ GPs-by-general practice,²⁸ Hospital Episode Statistics^{29 30} and the GP Patient Survey (GPPS).³¹ Details are provided in the online supplemental material text 1.

Variables

We defined GP turnover as the proportion of GPs who leave a practice during a year. We defined ‘persistent high GP turnover’ as more than 10% of GPs leaving a practice in each of at least 3 consecutive years.¹³

For outcomes, we included emergency attendances at all type 1 and 2 emergency departments in England, where there is a consultant-led 24-hour service or a consultant-led single specialty with full resuscitation facilities and designated accommodation for the reception of accident and emergency (A&E) patients.³⁰ Emergency admission included all non-elective admissions to hospitals. Both types of measures are reported as the number of A&E attendances or admissions per 100 registered patients.

Three outcomes were derived from the GPPS because they were considered the most relevant: the proportion of patients who were able to see their preferred GPs ‘always or almost always’ or ‘a lot of times’ among those patients who answered they had a preferred GP, the proportion of patients who were

able to obtain an appointment with a GP or a nurse on the same day, and the proportion of patients who reported being 'very satisfied or fairly satisfied' or gave a 'very good' or 'fairly good' score with the overall experience with the practice.

Statistical analyses

Practices with fewer than 750 registered patients, or with no GPs left at the end of the year in question, or active for less than 3 years were excluded from the analyses (1455 in total or 1.5%). Two sets of analyses were conducted. The first aimed to identify risk factors associated with persistent high turnover. The second aimed to investigate the association between persistent high turnover and practice-level outcomes.

Multivariable logistic regression panel data model with random effects was used to quantify the association between risk factors and persistent high turnover. The outcome persistent high turnover was modelled as a binary outcome, according to whether a practice experienced or not persistent high turnover (classified as 1 and 0, respectively). Multivariable linear regression panel data models with random effects were used to investigate the association between persistent high turnover and the various outcomes. Additionally, the Hausman test and the Breusch-Pagan Lagrange multiplier were used to assess whether random effects were justified for these models.

All models were adjusted for practice area deprivation captured by the 2015 Index of Multiple Deprivation (IMD) in quintiles³²; size of the practice population in quintiles; NHS regions; rurality, defined according to the 2011 rural-urban classification³³; and the aggregate prevalence of seven serious chronic conditions extracted from the Quality and Outcomes Framework (QOF).^{34 35} These conditions were coronary heart disease, stroke/transient ischaemic attack, hypertension, diabetes, heart failure and chronic kidney disease. When examining associations between turnover and outcomes, we included interactions between persistent high turnover and either IMD, practice population, NHS regions or rurality. Postestimation average marginal effects were calculated to obtain the predictive probability for the interactions of interest. Due to the small proportion of missing values in the analyses (which varied between 0.2% and 4.5%), complete case analyses were conducted.

When exploring the association between persistent high turnover and outcomes, the following sensitivity analyses were performed: analysing turnover, modelled as continuous or binary (GP turnover above 10%); restricting the analyses to 2015–2017 and including full time equivalent(FTE) per patient ratio in the analyses (also when persistent high turnover was the outcome); restricting the analyses of the GPPS to 2011–2017 since the question relative to the ability to get an appointment on the same day or overall

experience of the patients with the practice changed slightly after 2010.

All analyses were performed in Stata V.16.

Stakeholder involvement

The main stakeholders in this study were GPs. In view of this, GPs were involved in two ways, as part of the research team and during separate stakeholder involvement meetings. The purpose of the stakeholder involvement meetings with GPs was to gain their feedback on the study findings. This involved two discussion groups with a total of four GPs. They welcomed the findings of the study and recognised the need for research in this area. They highlighted a number of issues they faced, including issues with occupational health, which can be poor for GPs, workload pressure, limited opportunities and contribution to decision making and the management of their practice, particularly salaried GPs, with lack of funding and investment from the government.

RESULTS

Descriptive statistics

The average number of practices included was 7526 per year, and on average, 373.5 (6%) of them had experienced persistent high turnover. In particular, the proportion of practices with persistent high turnover increased during the study window from 2.7% (211/7946) in 2009 to 6.3% (417/6585) in 2019 and with a minimum in 2009 and a peak in 2014 equal to 9% (688/7619). The distribution of the number of practices included and those with persistent high turnover is provided in [table 1](#) and online supplemental figure 1. There was regional variability in the proportion of affected practices ([figure 1](#)).

Table 1 Number of practices and number of practices with 'persistent high turnover' by year

Year	Practices (n)	Practices with persistent high turnover (%)
2007	7798	–
2008	7858	–
2009	7946	211 (2.66)
2010	8038	276 (3.43)
2011	7986	372 (4.66)
2012	7907	428 (5.41)
2013	7795	559 (7.17)
2014	7619	688 (9.03)
2015	7390	586 (7.93)
2016	7207	495 (6.87)
2017	6956	411 (5.91)
2018	6751	413 (6.12)
2019	6585	417 (6.33)

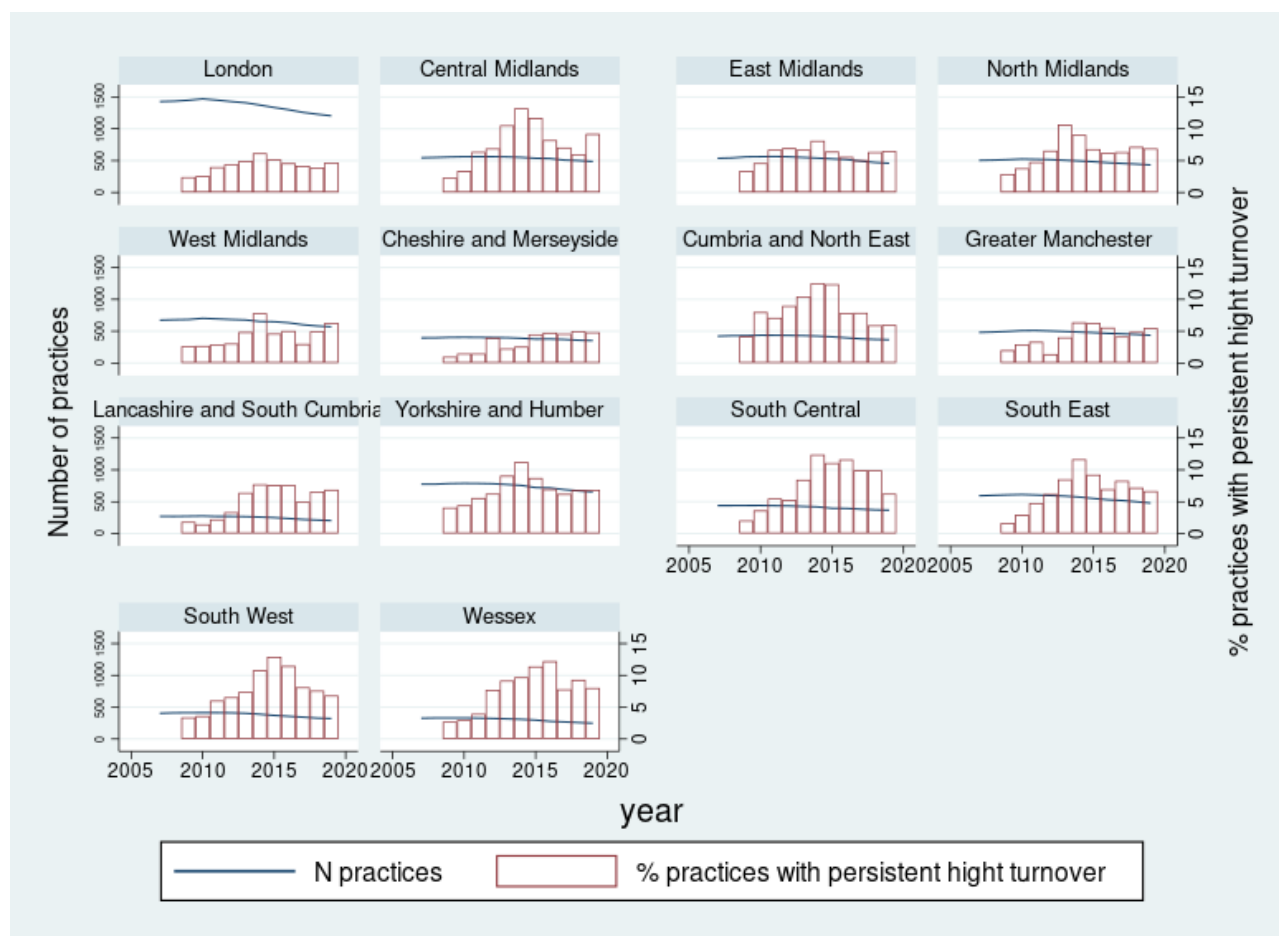


Figure 1 Distribution of number of practices and proportion of practices with 'persistent high turnover' by NHS regions.

Risk factors associated with persistent high turnover

Characteristics associated with persistent high turnover were: higher practice location deprivation (OR of highest deprivation quintile vs lowest 1.21, 95% CI 1.01 to 1.46), larger list size (OR of highest list size quintile vs third quintile 2.69, 95% CI 2.35 to 3.08), urbanity (rurality OR 0.79, 95% CI 0.66 to 0.93) and larger QOF morbidity burden across serious conditions (OR per one unit increase of 1.03, 95% CI 1.02 to 1.04). A change in QOF morbidity burden from the 25th percentile to the 75th percentile would correspond to increased odds of persistent high turnover of 1.27 or an increase in the probability of persistent high turnover from 3.8% to 6.1%. We also observed regional variation, after controlling for other covariates, with the highest adjusted rates observed in NHS Cumbria and North East (OR 1.73, 95% CI 1.32 to 2.27) and the lowest in NHS Cheshire and Merseyside (OR 0.54, 95% CI 0.39 to 0.75), compared with London (see [table 2](#) and online supplemental table 1).

Persistent high turnover and emergency attendances or admissions

During the study window, the mean number of hospital emergency attendances or admissions was 24.62 (SD 10.34) and 9.28 (SD 2.58) per 100 registered patients,

respectively. Emergency visits increased steadily from 17.44 in 2009 to 26.57 in 2017, as did admissions from 9.02 to 9.85 over the same time period (online supplemental table 2).

Persistent high turnover was associated with an increase of 1.80 (95% CI 1.55 to 2.05) hospital attendances per 100 registered patients, controlling for other covariates. Variables associated with increased emergency attendances included deprivation and the QOF morbidity burden across serious conditions ([table 3](#)). There was regional variation in the impact of persistent high turnover on the outcome, as expected. This implied that in some regions (NHS Cumbria and North East, NHS East Midlands, NHS South East and NHS Wessex), the difference in emergency attendances between practice with and without persistent high turnover was greater than that in other regions (online supplemental figure 2).

Persistent high turnover was significantly associated with 0.1 more emergency admissions per 100 patients (0.11, 95% CI 0.06 to 0.16), after controlling for other covariates. Other variables associated with an increase of emergency admissions were higher practice area deprivation, urbanity, larger practice list size and QOF burden of serious conditions ([table 3](#)). Again, there was

Table 2 Multivariable analysis of risk factors associated with 'persistent high turnover'

	OR	P value
IMD 1	Reference	
IMD 2	1.12 (0.95 to 1.32)	0.178
IMD 3	1.11 (0.94 to 1.32)	0.203
IMD 4	1.17 (0.99 to 1.40)	0.069
IMD 5	1.21 (1.01 to 1.46)	0.039
List size 1 (mean, sd) (2528, 592)	0.15 (0.12 to 0.18)	<0.001
List size 2 (4493, 565)	0.42 (0.36 to 0.50)	<0.001
List size 3 (6532, 649)	Reference	
List size 4 (9119, 866)	1.71 (1.5 to 1.94)	<0.001
List size 5 (14 291, 4362)	2.69 (2.35 to 3.08)	<0.001
NHS London	Reference	
NHS Central Midlands	1.38 (1.08 to 1.76)	0.009
NHS East Midlands	1.12 (0.87 to 1.45)	0.364
NHS North Midlands	1.19 (0.92 to 1.55)	0.185
NHS West Midlands	0.89 (0.69 to 1.15)	0.386
NHS Cheshire and Merseyside	0.54 (0.39 to 0.75)	<0.001
NHS Cumbria and North East	1.73 (1.32 to 2.27)	<0.001
NHS Greater Manchester	1.00 (0.75 to 1.32)	0.983
NHS Lancashire and South Cumbria	0.87 (0.61 to 1.24)	0.439
NHS Yorkshire and Humber	1.30 (1.03 to 1.63)	0.026
NHS South Central	1.51 (1.16 to 1.96)	0.002
NHS South East	1.21 (0.94 to 1.54)	0.133
NHS South West	1.37 (1.04 to 1.80)	0.024
NHS Wessex	1.23 (0.92 to 1.65)	0.163
QOF prevalence of serious conditions	1.03 (1.02 to 1.04)	<0.001
Rurality	0.79 (0.66 to 0.93)	0.006

IMD, Index of Multiple Deprivation; QOF, quality and outcomes framework.

regional variability, with the majority of NHS regions significantly associated with higher emergency admission compared with London, except for NHS Central Midlands and East Midlands, and NHS South Central. Examining the persistent high turnover with practice location deprivation interaction, we found that there were small differences in the outcome for practices located in the most deprived areas, which increased for the more affluent areas (online supplemental figure 3).

Persistent high turnover and continuity of care, patient satisfaction and access

The mean proportion of patients who were able to see their preferred doctor was 65.1% (SD 17.2%) during the study window, decreasing from 72.5% in 2009 to 56.1% in 2017; whereas the mean proportion of patients who were able to obtain an appointment on the same day was 45.9% (SD 23%) during the study window, decreasing from 80.3% in 2009 to 32.3% in 2017, and the mean proportion of patients who were satisfied with the practice overall was 86.3% (SD 9%)

and remained stable during the study window (online supplemental tables 3–5).

Persistent high turnover was significantly associated with a 5.25 decrease in the proportion of patients seeing their preferred doctor (–5.25, 95% CI –5.64 to –4.86). Higher practice area deprivation, large practice size, urbanity and greater QOF morbidity burden of serious conditions were also associated with a decrease in the proportion of patients seeing their preferred doctor. There was also regional variability in the distribution of the proportion of patients seeing their preferred GPs (table 3), but also in the association between persistent high turnover and the proportion of patients seeing their preferred doctor. The size of the association of interest also varied across practice location deprivation strata (online supplemental figures 4 and 5).

Persistent high turnover was significantly associated with a 10.61 decrease in the proportion of patients getting an appointment on the same day (–10.61, 95% CI –11.40 to –9.81). Large practices and those with a greater QOF morbidity burden of serious conditions were also associated with a decrease in the proportion patients getting an appointment on the same day (table 3). Interaction terms indicated that the size of the association was smaller for larger practices and those located in deprived areas (online supplemental figures 6 and 7).

Persistent high turnover was also associated with a small decrease in patient satisfaction (–1.34, 95% CI –1.56 to –1.12). Other variables associated with a decrease in patients' overall satisfaction were practice area deprivation list size, QOF morbidity burden of conditions, large practice size, and practices in London or in urban areas (table 3). Interaction terms indicated variation in the association of interest, by practice location deprivation and list size (online supplemental figures 8 and 9).

All the sensitivity analyses were broadly consistent with the main results (see table 4 and online supplemental tables 6–13).

DISCUSSION

Main findings

A small but significant number of general practices in England experience high GP turnover for at least 3 consecutive years, a phenomenon here defined as persistent high turnover. Findings revealed that practice area deprivation, larger practices, a greater burden of serious health conditions and urban area are associated with persistent high turnover. Regional variability in persistent high turnover was also observed. Furthermore, our results showed that practices having issues with GP turnover for a longer period of time were associated with higher emergency attendances and admissions. Patients from those practices were less likely to see their preferred doctor, to obtain an appointment with a healthcare professional on the same day of

Table 3 Multivariable analysis of the association between 'persistent high turnover' and outcomes (emergency attendances, emergency admissions, proportion of patients seeing their preferred doctor, proportion of patients getting an appointment on the same day or proportion of patients overall satisfied with the practice)

	Emergency attendances			Emergency admissions			Frequency seeing preferred doctor			Same-day appointment			Overall satisfaction		
	Coefficient	P value		Coefficient	P value		Coefficient	P value		Coefficient	P value		Coefficient	P value	
Persistent high turnover	1.80 (1.55 to 2.05)	<0.001		0.11 (0.06 to 0.16)	<0.001		-5.25 (-5.64 to -4.86)	<0.001		-10.61 (-11.40 to -9.81)	<0.001		-1.34 (-1.56 to -1.12)	<0.001	
IMD 1	Reference			Reference			Reference			Reference			Reference		
IMD 2	0.92 (0.48 to 1.36)	<0.001		0.30 (0.20 to 0.40)	<0.001		-0.14 (-0.89 to 0.61)	0.718		0.59 (-0.18 to 1.35)	0.133		-0.68 (-1.08 to -0.28)	0.001	
IMD 3	2.36 (1.90 to 2.81)	<0.001		0.65 (0.55 to 0.76)	<0.001		-1.78 (-2.57 to -1.00)	<0.001		0.85 (0.07 to 1.63)	0.033		-1.95 (-2.36 to -1.53)	<0.001	
IMD 4	4.86 (4.39 to 5.33)	<0.001		1.06 (0.95 to 1.17)	<0.001		-3.81 (-4.61 to -3.00)	<0.001		-0.01 (-0.82 to 0.79)	0.973		-2.97 (-3.39 to -2.55)	<0.001	
IMD 5	7.94 (7.45 to 8.44)	<0.001		1.71 (1.60 to 1.83)	<0.001		-6.12 (-6.97 to -5.27)	<0.001		-0.16 (-0.99 to 0.68)	0.712		-4.35 (-4.79 to -3.9)	<0.001	
List size 1	0.17 (-0.17 to 0.52)	0.32		0.16 (0.08 to 0.23)	<0.001		10.71 (10.14 to 11.29)	<0.001		1.96 (1.24 to 2.68)	<0.001		0.22 (-0.09 to 0.53)	0.160	
List size 2	0.27 (-0.02 to 0.56)	0.06		0.06 (0.01 to 0.12)	0.033		4.74 (4.27 to 5.20)	<0.001		-0.35 (-1.04 to 0.33)	0.311		0.26 (0.01 to 0.52)	0.044	
List size 3	Reference			Reference			Reference			Reference			Reference		
List size 4	-0.35 (-0.64 to -0.06)	0.02		-0.05 (-0.11 to 0.01)	0.113		-4.25 (-4.71 to -3.78)	<0.001		0.37 (-0.31 to 1.06)	0.287		-0.2 (-0.46 to 0.05)	0.119	
List size 5	0.35 (0.00 to 0.70)	0.05		0.11 (0.03 to 0.18)	0.004		-9.14 (-9.71 to -8.57)	<0.001		-2.16 (-2.9 to -1.43)	<0.001		-0.83 (-1.14 to -0.52)	<0.001	
London	Reference			Reference			Reference			Reference			Reference		
Central Midlands	-4.92 (-5.62 to -4.21)	<0.001		0.96 (0.80 to 1.13)	<0.001		6.77 (5.53 to 8.00)	<0.001		10.70 (9.59 to 11.81)	<0.001		3.63 (2.99 to 4.27)	<0.001	
East Midlands	-4.32 (-5.03 to -3.61)	<0.001		0.64 (0.47 to 0.81)	<0.001		10.49 (9.24 to 11.75)	<0.001		10.91 (9.77 to 12.04)	<0.001		4.96 (4.32 to 5.61)	<0.001	
North Midlands	-4.26 (-4.99 to -3.53)	<0.001		1.49 (1.32 to 1.67)	<0.001		10.98 (9.70 to 12.26)	<0.001		10.18 (9.02 to 11.35)	<0.001		6.21 (5.55 to 6.87)	<0.001	
West Midlands	0.40 (-0.26 to 1.06)	0.231		1.30 (1.15 to 1.46)	<0.001		7.51 (6.35 to 8.67)	<0.001		7.46 (6.41 to 8.52)	<0.001		3.78 (3.19 to 4.38)	<0.001	
Cheshire and Merseyside	-1.14 (-1.94 to -0.34)	0.005		3.20 (3.00 to 3.39)	<0.001		10.76 (9.35 to 12.16)	<0.001		12.54 (11.25 to 13.82)	<0.001		7.98 (7.25 to 8.71)	<0.001	
Cumbria and North East	-3.74 (-4.53 to -2.95)	<0.001		2.56 (2.38 to 2.75)	<0.001		14.53 (13.14 to 15.92)	<0.001		7.52 (6.25 to 8.79)	<0.001		8.84 (8.12 to 9.56)	<0.001	
Greater Manchester	3.07 (2.34 to 3.80)	<0.001		2.33 (2.16 to 2.51)	<0.001		8.73 (7.44 to 10.01)	<0.001		3.29 (2.14 to 4.45)	<0.001		5.83 (5.16 to 6.49)	<0.001	
Lancashire and South Cumbria	-6.17 (-7.11 to -5.24)	<0.001		2.17 (1.95 to 2.40)	<0.001		12.88 (11.22 to 14.54)	<0.001		8.47 (6.98 to 9.96)	<0.001		6.53 (5.68 to 7.38)	<0.001	
Yorkshire and Humber	0.84 (0.20 to 1.47)	0.010		1.73 (1.58 to 1.88)	<0.001		9.75 (8.63 to 10.87)	<0.001		9.22 (8.20 to 10.24)	<0.001		6.08 (5.51 to 6.66)	<0.001	
South Central	-6.29 (-7.06 to -5.51)	<0.001		0.48 (0.30 to 0.67)	<0.001		11.07 (9.71 to 12.44)	<0.001		6.47 (5.23 to 7.7)	<0.001		5.92 (5.22 to 6.63)	<0.001	
South East	-2.40 (-3.09 to -1.71)	<0.001		1.09 (0.93 to 1.26)	<0.001		10.46 (9.25 to 11.67)	<0.001		10.42 (9.33 to 11.52)	<0.001		4.42 (3.79 to 5.04)	<0.001	
South West	-5.33 (-6.13 to -4.53)	<0.001		1.05 (0.86 to 1.24)	<0.001		15.20 (13.80 to 16.60)	<0.001		14.30 (13.02 to 15.58)	<0.001		8.49 (7.76 to 9.21)	<0.001	
Wessex	-7.28 (-8.15 to -6.42)	<0.001		1.51 (1.31 to 1.72)	<0.001		15.79 (14.27 to 17.30)	<0.001		8.78 (7.40 to 10.16)	<0.001		7.69 (6.91 to 8.48)	<0.001	
QOF prevalence of serious conditions (%)	0.15 (0.15 to 0.18)	<0.001		0.09 (0.09 to 0.10)	<0.001		-0.41 (-0.43 to -0.38)	<0.001		-0.40 (-0.43 to -0.37)	<0.001		-0.03 (-0.05 to -0.02)	<0.001	
Rurality	-3.78 (-4.25 to -3.30)	<0.001		-0.72 (-0.83 to -0.61)	<0.001		4.81 (3.98 to 5.64)	<0.001		1.61 (0.84 to 2.38)	0.394		2.91 (2.48 to 3.34)	<0.001	

Note: mean and SD for each list size. List size 1: 2528 (592); list size 2: 4493 (565); list size 3: 6532 (649); list size 4: 9119 (866); list size 5: 14 291 (4362). The variable region represents the 14 NHS regions in England. IMD, Index of Multiple Deprivation; QOF, quality and outcomes framework.

Table 4 Sensitivity analysis of the multivariable analyses of the association between 'persistent high turnover' or high turnover and different outcomes

	Persistent high turnover		High turnover	
	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value
Emergency attendances*	1.80 (1.55 to 2.05)	<0.001	0.50 (0.39 to 0.62)	<0.001
Emergency admissions*	0.11 (0.06 to 0.16)	<0.001	0.05 (0.03 to 0.07)	<0.001
Proportion of patients seeing their preferred doctor*	-5.25 (-5.64 to -4.86)	<0.001	-0.75 (-0.93 to -0.57)	<0.001
Proportion of patients getting an appointment on the same day*	-10.61 (-11.40 to -9.82)	<0.001	-2.75 (-3.12 to -2.37)	<0.001
Proportion of patients overall satisfied with the practice*	-1.34 (-1.56 to -1.12)	<0.001	0.03 (-0.07 to 0.14)	0.507
*Fully adjusted models including persistent high turnover or turnover and IMD, listsizes, NHS regions, QOF prevalence of serious conditions and rurality				
*Fully adjusted models.				

contacting the practice and were less satisfied with the overall service of the practice. Available data provide limited information about the reasons why GPs leave their practice; therefore, it is unknown whether a GP is retiring, moving to a different workplace or leaving the profession. To have a more accurate understanding of the impact of GP turnover, it is important to focus on those practices that have recurrent problems with retention of staff.

Strengths and limitations

The study has several strengths. It uses national data from England, which has allowed GPs' actual turnover to be quantified rather than 'intention to leave' the practice. Second, it covers a long time window, which has enabled examination of whether a practice experiences turnover issues during consecutive years. Third, the method used to calculate GP turnover uses the exact dates when a GP joins and leaves a practice, and is more accurate than using aggregate data.^{13 18}

Limitations of the study need to be acknowledged as well. The datasets used do not include information on the reasons the GPs leave the practice; therefore, we were unable to know whether the GPs moved to another practice, left the profession or retired.²⁸ We were not able to distinguish between salaried and partner GPs; therefore the results are combined for these two categories. It is worth noting that salaried GPs do not have the same legal responsibilities or financial investments as GP partners, giving them more flexibility.^{12 36} It was not possible to adjust for GP workload in the analyses because NHS Digital revised the methodology to calculate GPs' FTE per patient ratio after 2015. This variable was included in the sensitivity analysis restricted to 2015–2019 or 2015–2017. We had access to only limited demographic information from the datasets, and therefore, we could not take these into account in the analyses. The time window analysed ends in 2020 and does not take into account all the stress and pressure GPs have faced during the COVID-19 pandemic. It is likely that GP turnover during and following the pandemic response was modified by multiple factors including temporary return to work by recently retired GPs,³⁷

increased opportunities for GPs to work remotely³⁸ and continuing increased need for healthcare from GPs.⁷ Further analyses will be needed to understand how these and other changes may affect GP turnover. Finally, this was an observational study, and despite the fact that we could test for an association between potential risk factors and persistent high GP turnover or between persistent high GP turnover and poor outcomes, we cannot exclude these associations are due to unknown confounders.

Comparison with existing literature

Our study has explored the prevalence of persistent high GP turnover, the practice characteristics associated with it, or its association with patterns of healthcare delivery or patient experience health outcomes. The existing literature has explored changes in healthcare used linked to GP turnover,³⁹ the unequal distribution of the GP workforce according to area deprivation or continuity of care in community setting and its association with hospital activity²³ and GP patients' satisfaction.²⁴ Our findings are in line with Sabety *et al*, who found that GP turnover was associated with lower use of primary care and increased use of specialty, urgent and emergency care.³⁹ Our findings are also similar to those of Asaria *et al*, who found that the GP workforce is smaller in more deprived areas⁴⁰ and similar to those studies which found that continuity of care is associated with higher hospital admissions and lower patients satisfaction.^{23 24} An analysis by the Health Foundation has found that patients living in more deprived areas report a poorer overall experience with their GP practice and that practices in these areas receive the lowest overall satisfaction scores compared with more affluent areas.²⁶ These findings are broadly confirmed in our analyses where practices with persistent high turnover and located in more deprived areas were associated with lower ability to access to practice and lower overall satisfaction with the practice. Our results, however, are in contrast to Anderson *et al*, who systematically reviewed GPs' intentions to quit their patient care and found that neither small or large practices were associated with GPs' intentions to quit their job.⁴¹ However, these

studies explored GPs' intentions to leave the job rather than actual movement of GPs.

Interpretation of findings

Our findings have revealed that characteristics associated with practices experiencing high GP turnover for sustained periods of time include high practice area deprivation, large practice size, high morbidity burden of serious conditions and urban area. The association between persistent high turnover and deprivation may be explained by the burden and challenges GPs face in deprived areas in managing patients with more complex health needs with no additional resources, and the unequal distribution of the GP workforce in deprived areas. A recent study exploring how socioeconomic deprivation impacts GP work found that in highly deprived areas, GP work typically extends beyond the management of the illness but that they are not resourced to perform those additional tasks.⁴² For example, they need to manage the increased burden of multimorbidity at an earlier age and balancing increased medical complexity with social complexity compared with more affluent areas.⁴² The Health Foundation has shown that, after adjustments to take account of increased workload in more deprived areas, these practices receive around 7% less funding per need-adjusted registered patient than those serving less deprived populations.²⁶

The association between practices with persistent high GP turnover and higher emergency attendances and admissions might be explained by the impact of GP turnover on continuity of care, as avoidable emergency attendances have been linked to poor quality of primary care.⁴³ Regional variations were found when we explored risk factors for persistent high turnover and for the relationship between these practices and hospital activity or GP patients' satisfaction. These differences might be due to different levels of social deprivation, unequal distribution of the GP workforce and different pressures on the healthcare system.

High GP turnover, especially when it persists for consecutive years, is a concern for the healthcare system. While we cannot estimate the financial cost attributable to each GP practice with persistent high turnover, we can estimate the associated cost of persistent high turnover for emergency hospital care (A&E and non-elective admissions). If the associations found in these studies are causal, they would suggest considerable costs to the healthcare system from the effects of turnover. For example, the costs generated by an average practice with problems with persistent high turnover and high emergency admissions/attendances is an additional £73 200 per annum (£2.9 million per annum to the healthcare system).⁴⁴ We would expect persistent high turnover to be associated with levels of use of other health and social care services as well as impact of unmet health and social

care needs which would likely increase future financial costs to the healthcare system.

Practices with persistent high GP turnover need to be better supported by local and national authorities; policies and strategies to maximise retention of GPs should facilitate sustainable GP workload and contractual requirements, as well as the need for personal and professional support, targeting areas which influence job satisfaction and work-life balance.⁴⁵ This may require attention to the funding formulae, which determine the distribution of funding for practices, as these currently do not fully take account of the demands associated with practising in a deprived area.⁴⁶

CONCLUSIONS

Practices with persistent high turnover of GPs are independently linked with poorer outcomes such as higher numbers of emergency hospital attendances and admissions compared with practices without persistent high turnover. Persistent high turnover has an impact on quality of healthcare and contributes to avoidable health system costs. One of the factors associated with a practice experiencing high turnover over a number of years is deprivation of the area where the practice is located, highlighting the need for more support for these practices. There is a need for more in-depth studies to explore the contexts and reasons of GPs leaving their practices. Strategies and policies are needed to support practices facing challenges with GP turnover.

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Predictors and population health outcomes of persistent high GP turnover in English general practices: a retrospective observational study

Supplementary Material

We used a retrospective observational design using the GP workforce dataset; GP-by-practice data; Hospital Episodes Statistics (HES) data and General Practitioner Patient' Survey (GPPS) data between 2007-2019 and 2009-2017 in England. Practice characteristics and GPs' turnover were obtained from the GP workforce dataset linked to the GP-by-practice data (*GP membership-epracmem*) by practice code and each year. "HES and the GPPS were used to identify population health outcomes. It is noteworthy, information from these datasets was available only at aggregate level."

Text 1. Data sources

GP workforce dataset

NHS Digital regularly publishes workforce datasets which include information on individual GPs and practice level characteristics since 1995. These datasets are publicly available on the NHS Digital website.¹ This study used the annual datasets (September releases) between 2007 and 2020 and the files containing practice-level data containing all the information relative to a practice.²

Membership of practices

The GPs-by-general practice data (*GP membership-epracmem*), available from the NHS Prescription Data Service (NHS RxS) and published by the NHS Organisation Data Service (ODS) contains information on dates when a GP joins and leaves a GP practice which enables the calculation of GP turnover across a specified time window. These datasets include information only on those GPs who have been allocated an individual prescribing number i.e. GP partners and salaried GPs. These data are published free of charge and capture information on GP membership to each practice from 1974 and are updated weekly on the NHS Technology Reference data Update Distribution (TRUD)³ website. Data on GP membership of practices were extracted on the second week of November 2020. The GP workforce dataset and GPs-by-practice data were linked following the same process as in Parisi et al., (2021).

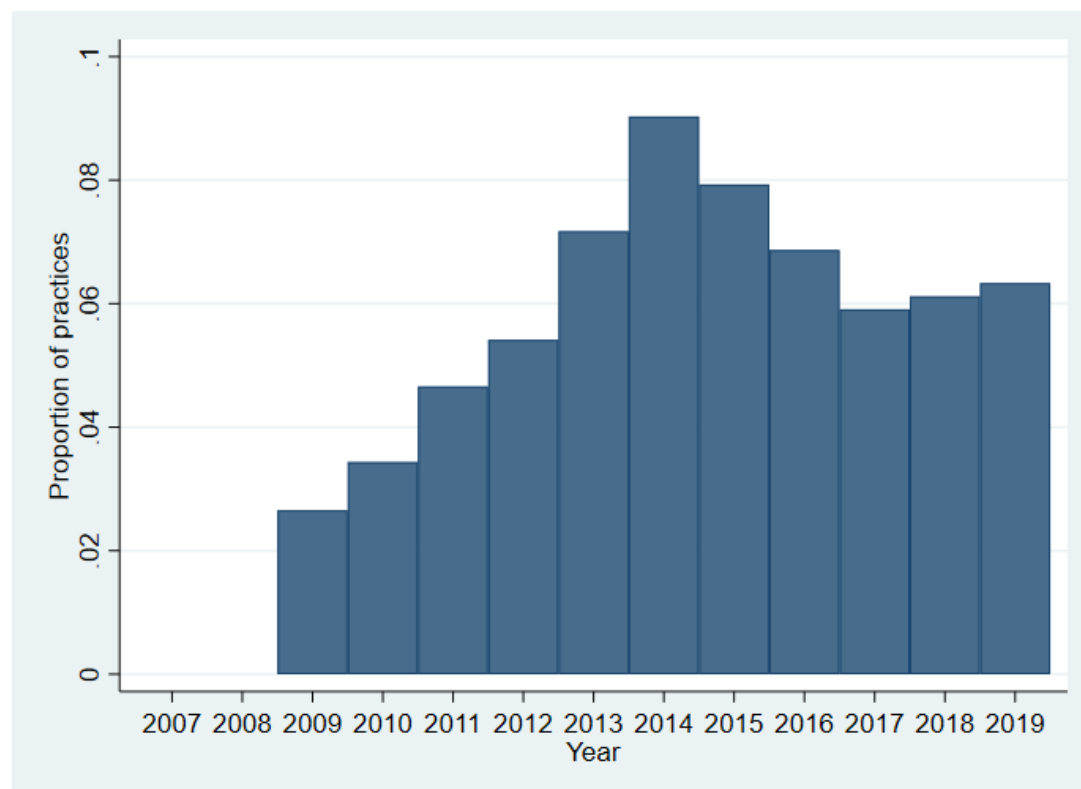
HES dataset

HES is an administrative record level dataset containing all publicly funded NHS hospital activity in England.⁴ The data was primarily collected for commissioning purposes, where hospitals are reimbursed for the activity they provide. Data was extracted from the Accident and Emergency and the Admitted Patient Care (APC) data series between 2009/10 -2017/18 financial years, for HES APC data provider spells were constructed from the patient-episode level data. We obtain the number of non-elective admissions (where the HES APC variable "ADMIMETH" began with the value 2) and A&E attendances for patients registered at each GP practice in England. We had access to an already processed dataset where data were aggregated (specifically, A&E emergency attendances or admissions per 100 registered patients). During the study window 99.5% of practices were merged to HES data."

GPPS dataset

The GPPS is a biannual postal survey conducted on behalf of NHS England, which collects patients' views and experiences of the services provided by their practice.⁵ We used the surveys published between 2009 and 2017.

Supplementary Figure 1: Proportion of practices with persistent high turnover by year



Statistical analyses

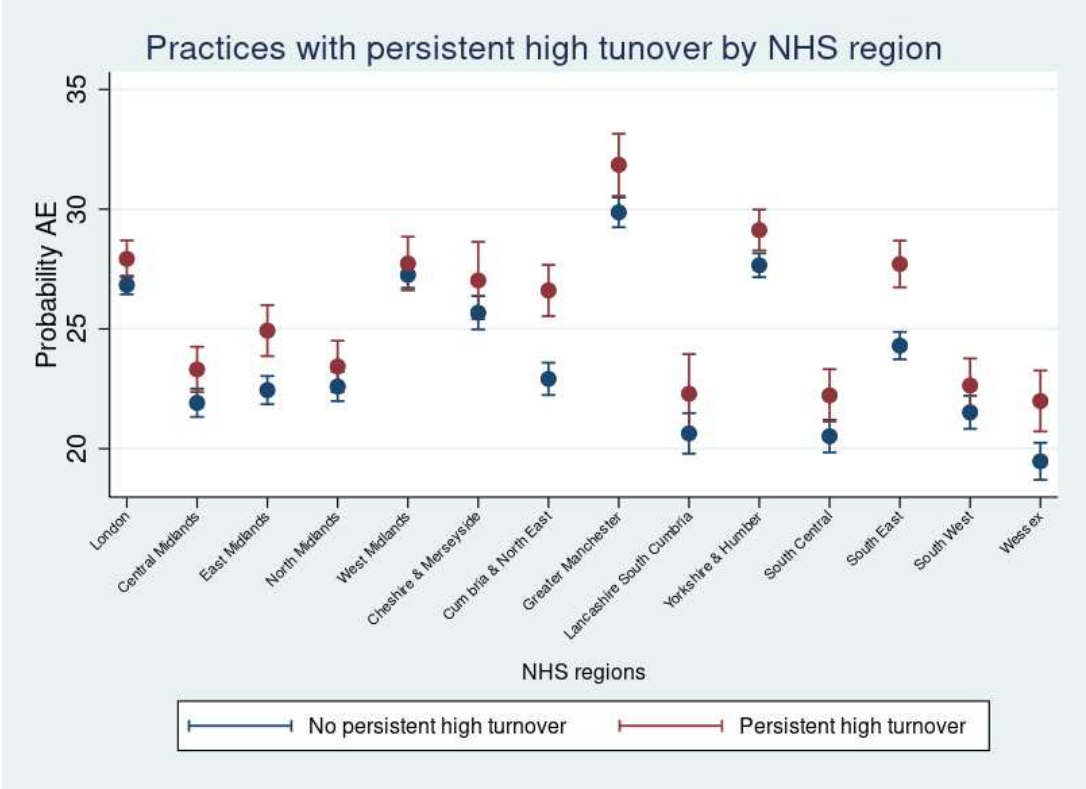
Supplementary Table 1. Unadjusted analysis of risk factors for persistent high turnover.

	OR (95% CI)	p-value
IMD 1	Reference	
IMD 2	1.04 (0.88 to 1.23)	0.661
IMD 3	1.03 (0.87 to 1.22)	0.720
IMD 4	0.97 (0.82 to 1.16)	0.764
IMD 5	0.85 (0.71 to 1.01)	0.063
Listsize 1, (mean; sd) (2528; 592)	0.14 (0.12 to 0.18)	<0.001
Listsize 2 (4493; 565)	0.42 (0.36 to 0.49)	<0.001
Listsize 3 (6532; 649)	Reference	
Listsize 4 (9119; 866)	1.73 (1.53 to 1.96)	<0.001
Listsize 5 (14291; 4362)	2.75 (2.41 to 3.13)	<0.001
NHS London	Reference	
NHS Central Midlands	2.28 (1.79 to 2.9)	<0.001
NHS East Midlands	1.7 (1.32 to 2.18)	<0.001
NHS North Midlands	1.8 (1.4 to 2.32)	<0.001
NHS West Midlands	1.03 (0.81 to 1.32)	0.795
NHS Cheshire and Merseyside	0.72 (0.52 to 0.99)	0.043
NHS Cumbria and North East	2.57 (1.98 to 3.33)	<0.001
NHS Greater Manchester	1.06 (0.8 to 1.39)	0.699
NHS Lancashire and South Cumbria	1.21 (0.85 to 1.71)	0.286
NHS Yorkshire and Humber	1.9 (1.52 to 2.37)	<0.001
NHS South Central	2.25 (1.73 to 2.93)	<0.001
NHS South East	1.78 (1.4 to 2.27)	<0.001
NHS South West	2.3 (1.76 to 3.01)	<0.001
NHS Wessex	2.24 (1.67 to 3.01)	<0.001
QoF preval serious conditions	1.03 (1.03 to 1.04)	<0.001
Rurality	0.87 (0.74 to 1.02)	0.082

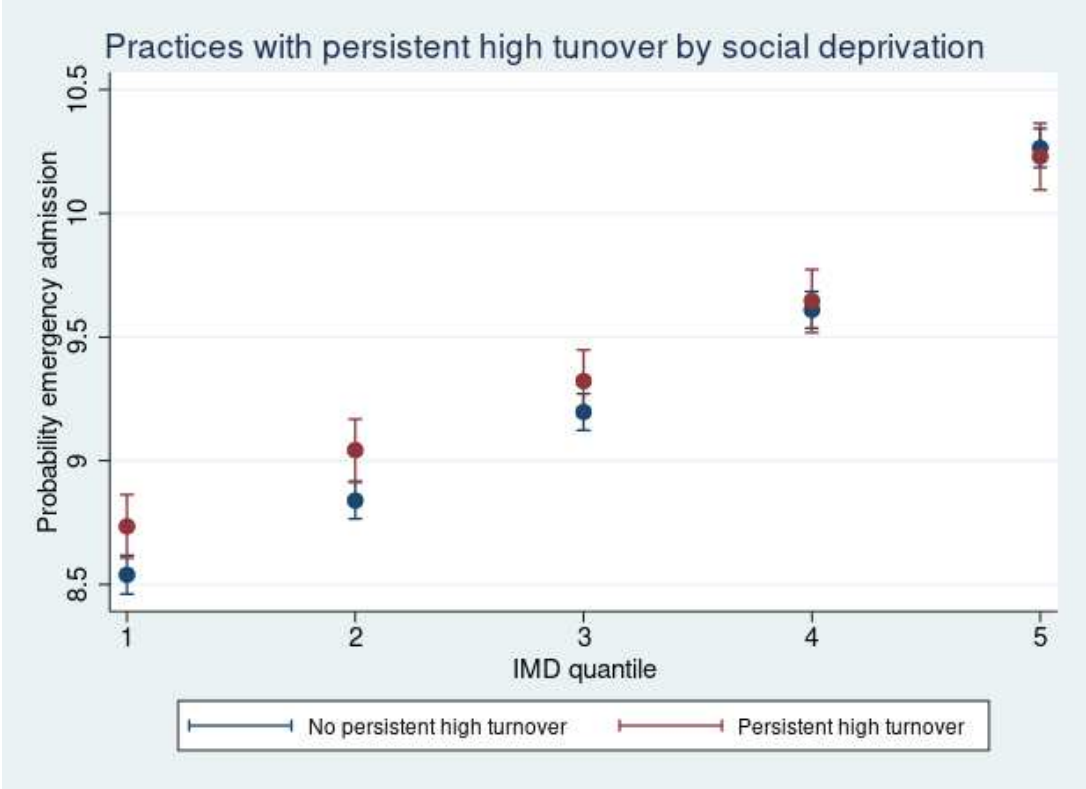
Supplementary Table 2. Distribution of emergency attendance and admissions per practice.

			Emergency attendances			Emergency admissions	
Year	Practices (=n)	Practices in the analysis (=n)	Practices with missing outcome, n (%)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
2009	7749	7709	40 (0.52)	17.44 (12.97)	18.10 (3.81-26.62)	9.02 (2.65)	8.72 (7.36-10.37)
2010	7841	7732	109 (1.39)	22.98 (11.43)	22.89 (16.17-30.15)	9.10 (2.60)	8.77 (7.43-10.48)
2011	7895	7785	110 (1.39)	25.16 (10.41)	24.22 (18.58-31.05)	9.03 (2.70)	8.75 (7.35-10.37)
2012	7907	7885	22 (0.28)	25.52 (9.28)	24.80 (19.24-31.13)	9.06 (2.44)	8.83 (7.47-10.44)
2013	7795	7778	17 (0.22)	25.60 (8.90)	24.74 (19.41-30.80)	9.15 (2.46)	8.91 (7.54-10.54)
2014	7619	7612	7 (0.09)	25.75 (8.79)	24.76 (19.59-31.05)	9.33 (2.55)	9.15 (7.68-10.79)
2015	7371	7368	3 (0.04)	26.32 (9.02)	25.40 (20.08-31.72)	9.50 (2.47)	9.34 (7.88-10.97)
2016	7175	7170	5 (0.07)	26.62 (8.91)	25.69 (20.46-31.83)	9.54 (2.59)	9.37 (7.86-11.03)
2017	6925	6919	6 (0.09)	26.57 (8.95)	25.56 (20.54-31.63)	9.85 (2.67)	9.65 (8.16-11.31)
2009-2017				24.62 (10.34)	24.28 (18.45-30.80)	9.28 (2.58)	9.03 (7.61-10.71)

Supplementary Figure 2: Predicted probabilities from the multivariable analysis of the association between persistent high turnover and emergency attendances with an interaction between persistent high turnover and NHS region.



Supplementary Figure 3: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and emergency admissions with an interaction between persistent high turnover and social deprivation (IMD).



Supplementary Table 3. Distribution of the outcome “Frequency of seeing preferred GPs ‘always or almost always’ or ‘a lot of times’”.

Year	Practices, n	Missing outcome (%)	Practices included, n	Mean (SD)	Median (IQR)
2009	7749	268 (3.46)	7481	72.51 (14.81)	73.8 (62.92 to 83.54)
2010	7841	148 (1.89)	7693	72.81 (14.39)	74.08 (63.38 to 83.48)
2011	7895	151 (1.91)	7744	71.36 (15.2)	72.83 (61.25 to 82.67)
2012	7907	361 (4.57)	7546	65.99 (15.85)	67.09 (55.44 to 77.9)
2013	7795	346 (4.44)	7449	63.63 (16.63)	64.64 (52.03 to 76.25)
2014	7619	342 (4.49)	7277	61.64 (17.12)	62.14 (49.75 to 74.52)
2015	7371	344 (4.67)	7027	60.36 (16.94)	61.23 (48.61 to 72.94)
2016	7175	323 (4.5)	6852	58.93 (17.1)	59.49 (46.94 to 71.39)
2017	6925	315 (4.55)	6610	56.09 (18.03)	56.21 (43.14 to 69.39)
				65.08 (17.24)	66.41 (53.28 to 78.07)

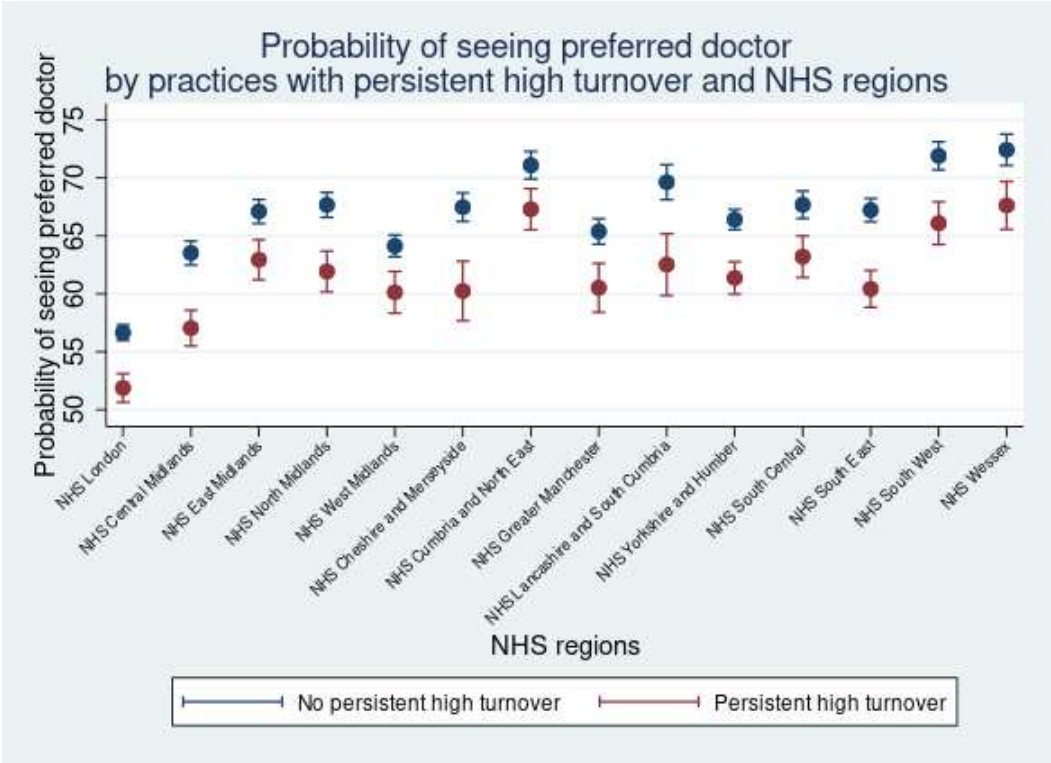
Supplementary Table 4. Distribution of the outcome “proportion of patients able to obtain an appointment on the same day”.

Year	Practices, n	Missing outcome (%)	Practices included, n	Mean (SD)	Median (IQR)
2009	7749	9 (11.61)	7740	80.33 (11.55)	81.93 (73.33 to 89.02)
2010	7841	12 (15.3)	7829	80.26 (11.38)	81.4 (73.04 to 88.8)
2011	7895	3 (3.8)	7892	35.56 (14.26)	33.35 (24.78 to 44.92)
2012	7907	5 (6.32)	7902	35.6 (14.17)	33.49 (24.94 to 44.93)
2013	7795	4 (5.13)	7791	35.88 (14.38)	33.77 (25.09 to 45.27)
2014	7619	4 (5.25)	7615	36.38 (14.67)	34.24 (25.54 to 45.82)
2015	7371	1 (1.36)	7370	36.7 (14.54)	34.98 (25.75 to 45.77)
2016	7175	4 (5.58)	7171	37.35 (14.48)	35.54 (26.54 to 46.94)
2017	6925	4 (5.78)	6921	32.3 (13.92)	30.15 (21.95 to 41.53)
				45.88 (23.25)	39.74 (27.51 to 62.13)

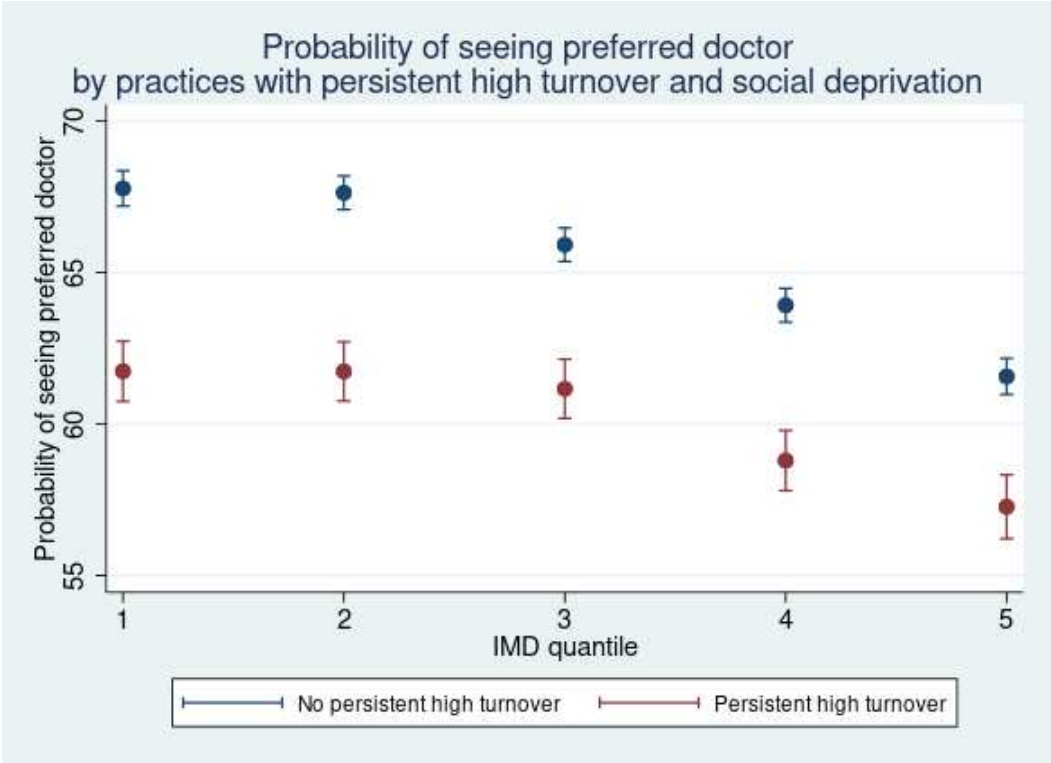
Supplementary Table 5. Distribution of the outcome “proportion of patients’ overall satisfaction with the practice”.

Year	Practices, n	Missing outcome (%)	Practices included, n	Mean (SD)	Median (IQR)
2009	7749	28 (0.36)	7721	89.31 (7.38)	91.01 (85.85 to 94.56)
2010	7841	94 (1.2)	7747	82.68 (11.07)	85.16 (76.69 to 90.86)
2011	7895	45 (0.57)	7850	88.67 (6.92)	90.14 (85.21 to 93.64)
2012	7907	12 (0.15)	7895	88.08 (7.66)	89.59 (84.15 to 93.65)
2013	7795	14 (0.18)	7781	86.64 (8.43)	88.26 (82.08 to 92.93)
2014	7619	6 (0.08)	7613	85.82 (8.81)	87.48 (80.92 to 92.34)
2015	7371	0 (0)	7371	84.96 (9.54)	86.69 (79.81 to 91.97)
2016	7175	2 (0.03)	7173	85.33 (9.18)	87.12 (80.42 to 92.17)
2017	6925	2 (0.03)	6923	85.13 (9.55)	86.91 (79.74 to 92.4)
				86.33 (9.01)	88.26 (81.66 to 92.91)

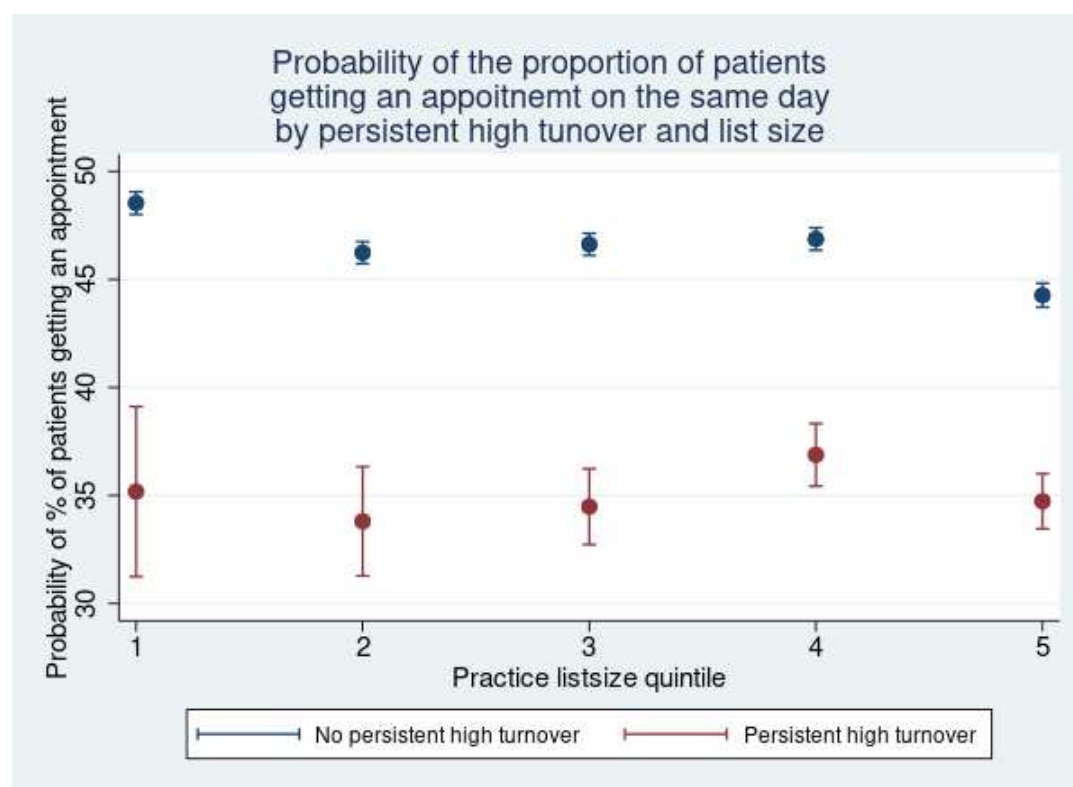
Supplementary Figure 4: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients seeing their preferred doctor with an interaction between persistent high turnover and NHS region.



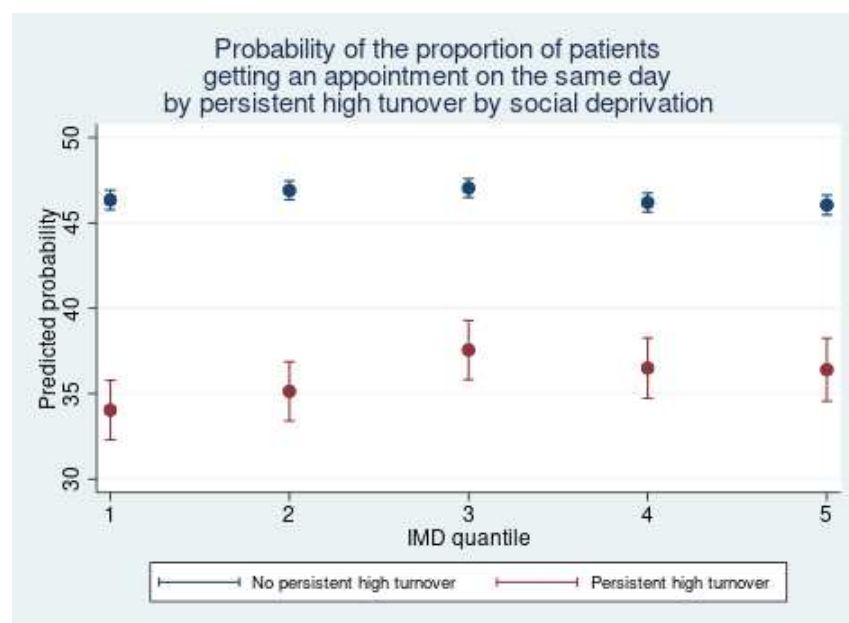
Supplementary Figure 5: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients seeing their preferred doctor with an interaction between persistent high turnover and social deprivation (IMD).



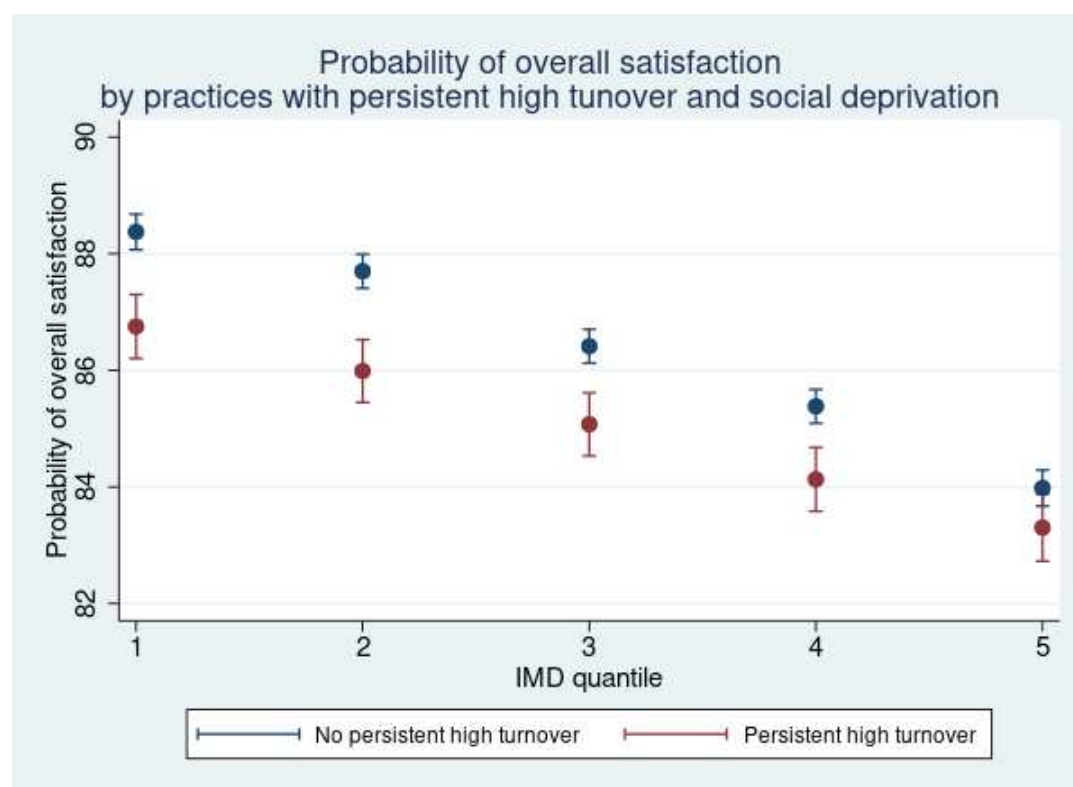
Supplementary Figure 6: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients getting an appointment on the same day with an interaction between persistent high turnover and listsize.



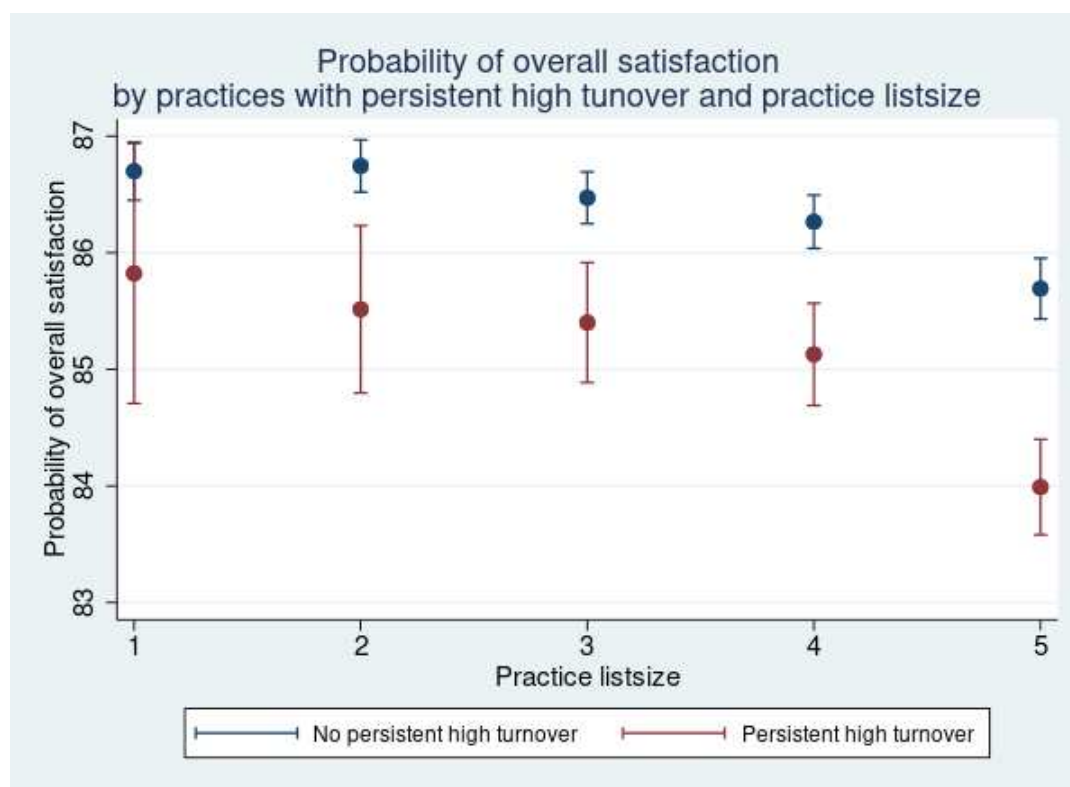
Supplementary Figure 7: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients getting an appointment on the same day with an interaction between persistent high turnover and social deprivation (IMD).



Supplementary Figure 8: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients overall satisfied with the practice with an interaction between persistent high turnover and social deprivation.



Supplementary Figure 9: Predicted probabilities from the multivariable analysis of the association of persistent high turnover and proportion of patients overall satisfied with the practice with an interaction between persistent high turnover and listsize.



Supplementary Table 6. Sensitivity analysis of the multivariable analysis of risk factors associated with persistent high turnover, restricting the analysis to 2015-2019 and including FTE per patients ratio in the model.

	OR (95% CIs)	p-value
FTE per pts ratio/1000	0.43 (0.31 to 0.61)	<0.001
IMD 1	Reference	
IMD 2	1.21 (0.93 to 1.56)	0.153
IMD 3	1.13 (0.87 to 1.47)	0.368
IMD 4	1.24 (0.95 to 1.63)	0.117
IMD 5	1.09 (0.81 to 1.45)	0.578
Listsize 1 (2528; 592)	0.07 (0.05 to 0.12)	<0.001
Listsize 2 (4493; 565)	0.32 (0.24 to 0.42)	<0.001
Listsize 3 (6532; 649)	Reference	
Listsize 4 (9119; 866)	1.72 (1.39 to 2.13)	<0.001
Listsize 5 (14291; 4362)	2.21 (1.78 to 2.75)	<0.001
NHS London	Reference	
NHS Central Midlands	2.03 (1.4 to 2.94)	<0.001
NHS East Midlands	1.27 (0.85 to 1.9)	0.243
NHS North Midlands	1.65 (1.1 to 2.49)	0.016
NHS West Midlands	1.4 (0.95 to 2.08)	0.091
NHS Cheshire and Merseyside	1.34 (0.83 to 2.16)	0.228
NHS Cumbria and North East	2.86 (1.87 to 4.38)	<0.001
NHS Greater Manchester	1.76 (1.16 to 2.68)	0.008
NHS Lancashire and South Cumbria	1.91 (1.12 to 3.25)	0.017
NHS Yorkshire and Humber	2.02 (1.41 to 2.88)	<0.001
NHS South Central	2.52 (1.69 to 3.75)	<0.001
NHS South East	1.75 (1.2 to 2.55)	0.004
NHS South West	2.97 (1.95 to 4.5)	<0.001
NHS Wessex	2.56 (1.65 to 3.97)	<0.001
QoF preval serious conditions	1 (0.99 to 1.01)	0.818
Rurality	0.89 (0.68 to 1.15)	0.369

Supplementary Table 7. Sensitivity analysis of the association between persistent high turnover and emergency attendances. Multivariable analysis including GP turnover modelled as continuous variable.

	Coefficient (95% CIs)	p-value
GP turnover %	0.01 (0 to 0.01)	<0.001
IMD 1	Reference	
IMD 2	0.93 (0.49 to 1.37)	<0.001
IMD 3	2.36 (1.91 to 2.82)	<0.001
IMD 4	4.86 (4.39 to 5.33)	<0.001
IMD 5	7.96 (7.47 to 8.45)	<0.001
Listsize 1 (2528; 592)	0.12 (-0.23 to 0.46)	0.504
Listsize 2 (4493; 565)	0.24 (-0.05 to 0.53)	0.105
Listsize 3 (6532; 649)	Reference	
Listsize 4 (9119; 866)	-0.31 (-0.6 to -0.02)	0.038
Listsize 5 (14291; 4362)	0.46 (0.11 to 0.81)	0.010
NHS London	Reference	
NHS Central Midlands	-4.92 (-5.62 to -4.22)	<0.001
NHS East Midlands	-4.35 (-5.06 to -3.64)	<0.001
NHS North Midlands	-4.28 (-5.01 to -3.55)	<0.001
NHS West Midlands	0.36 (-0.29 to 1.02)	0.278
NHS Cheshire and Merseyside	-1.21 (-2.01 to -0.4)	0.003
NHS Cumbria and North East	-3.75 (-4.54 to -2.96)	<0.001
NHS Greater Manchester	3.04 (2.31 to 3.77)	<0.001
NHS Lancashire and South Cumbria	-6.21 (-7.14 to -5.28)	<0.001
NHS Yorkshire and Humber	0.82 (0.18 to 1.45)	0.012
NHS South Central	-6.27 (-7.05 to -5.5)	<0.001
NHS South East	-2.41 (-3.1 to -1.72)	<0.001
NHS South West	-5.33 (-6.13 to -4.53)	<0.001
NHS Wessex	-7.29 (-8.15 to -6.43)	<0.001
QoF preval serious conditions %	0.17 (0.15 to 0.18)	<0.001
Rurality	-3.8 (-4.28 to -3.32)	<0.001

Supplementary Table 8. Sensitivity analysis of the association between persistent high turnover and emergency attendances restricting the analysis to 2015-2017 and including FTE per patients ratio.

	Coefficient (95% CIs)	p-value
Persistent high turnover	0.2 (-0.04 to 0.44)	0.106
FTE per pts ratio	-0.68 (-1.07 to -0.29)	0.001
IMD 1	Reference	
IMD 2	1.2 (0.72 to 1.68)	<0.001
IMD 3	3.11 (2.61 to 3.6)	<0.001
IMD 4	5.47 (4.96 to 5.98)	<0.001
IMD 5	8.59 (8.05 to 9.12)	<0.001
Listsize 1, mean; sd (2528; 592)	0.16 (-0.25 to 0.58)	0.447
Listsize 2 (4493; 565)	0.52 (0.19 to 0.84)	0.002
Listsize 3 (6532; 649)	Reference	
Listsize 4 (9119; 866)	-0.25 (-0.56 to 0.06)	0.113
Listsize 5 (14291; 4362)	-0.44 (-0.8 to -0.07)	0.02
NHS London	Reference	
NHS Central Midlands	-1.88 (-2.6 to -1.16)	<0.001
NHS East Midlands	-0.26 (-0.99 to 0.48)	0.490
NHS North Midlands	-2.69 (-3.45 to -1.93)	<0.001
NHS West Midlands	1.52 (0.83 to 2.2)	<0.001
NHS Cheshire and Merseyside	1.17 (0.34 to 2)	0.006
NHS Cumbria and North East	1.38 (0.56 to 2.2)	0.001
NHS Greater Manchester	5.19 (4.44 to 5.94)	<0.001
NHS Lancashire and South Cumbria	-2.71 (-3.69 to -1.73)	<0.001
NHS Yorkshire and Humber	2.53 (1.87 to 3.2)	<0.001
NHS South Central	-4.4 (-5.2 to -3.6)	<0.001
NHS South East	1.43 (0.72 to 2.15)	<0.001
NHS South West	-3.37 (-4.21 to -2.54)	<0.001
NHS Wessex	-3.29 (-4.19 to -2.4)	<0.001
QOF prevalence serious conditions %	-0.02 (-0.04 to 0)	0.045
Rurality	-3.39 (-3.88 to -2.89)	<0.001

Supplementary Table 9. Sensitivity analysis of the association between persistent high turnover and emergency admissions. Multivariable analysis including GP turnover modelled as continuous variable.

	Coef (95% CIs)	p-value
GP turnover %	0.001 (0 to 0.001)	0.004
IMD 1	Reference	
IMD 2	0.302 (0.203 to 0.402)	<0.001
IMD 3	0.654 (0.55 to 0.758)	<0.001
IMD 4	1.062 (0.955 to 1.169)	<0.001
IMD 5	1.715 (1.602 to 1.829)	<0.001
Listsize 1 mean; sd (2528; 592)	0.154 (0.08 to 0.227)	<0.001
Listsize 2 (4493; 565)	0.062 (0.003 to 0.122)	0.039
Listsize 3 (6532; 649)	Reference	
Listsize 4 (9119; 866)	-0.046 (-0.106 to 0.014)	0.132
Listsize 5 (14291; 4362)	0.115 (0.041 to 0.189)	0.002
NHS London	Reference	
NHS Central Midlands	0.961 (0.794 to 1.129)	<0.001
NHS East Midlands	0.64 (0.471 to 0.81)	<0.001
NHS North Midlands	1.492 (1.318 to 1.665)	<0.001
NHS West Midlands	1.3 (1.143 to 1.457)	<0.001
NHS Cheshire and Merseyside	3.19 (2.999 to 3.381)	<0.001
NHS Cumbria and North East	2.56 (2.373 to 2.748)	<0.001
NHS Greater Manchester	2.331 (2.157 to 2.504)	<0.001
NHS Lancashire and South Cumbria	2.171 (1.948 to 2.393)	<0.001
NHS Yorkshire and Humber	1.729 (1.578 to 1.88)	<0.001
NHS South Central	0.482 (0.297 to 0.667)	<0.001
NHS South East	1.091 (0.927 to 1.255)	<0.001
NHS South West	1.046 (0.856 to 1.237)	<0.001
NHS Wessex	1.513 (1.307 to 1.719)	<0.001
QoF preval serious conditions %	0.094 (0.091 to 0.098)	<0.001
Rurality	-0.724 (-0.836 to -0.612)	<0.001

Supplementary Table 10. Sensitivity analysis of the association between persistent high turnover and emergency admissions restricting the analysis to 2015-2017 and including FTE per patients ratio.

	Coefficient (95% CIs)	p-value
Persistent high turnover	0.12 (0.04 to 0.2)	0.004
FTE per pts ratio	0.05 (-0.07 to 0.17)	0.416
IMD 1	Reference	
IMD 2	0.36 (0.23 to 0.48)	<0.001
IMD 3	0.71 (0.58 to 0.84)	<0.001
IMD 4	1.13 (1 to 1.26)	<0.001
IMD 5	1.86 (1.73 to 2)	<0.001
Listsize 1	-0.2 (-0.31 to -0.08)	0.001
Listsize 2	-0.04 (-0.13 to 0.06)	0.447
Listsize 3	Reference	
Listsize 4	0.05 (-0.04 to 0.15)	0.259
Listsize 5	0.07 (-0.03 to 0.17)	0.187
NHS London	Reference	
NHS Central Midlands	1.15 (0.97 to 1.34)	<0.001
NHS East Midlands	0.81 (0.62 to 0.99)	<0.001
NHS North Midlands	1.33 (1.14 to 1.52)	<0.001
NHS West Midlands	1.41 (1.23 to 1.58)	<0.001
NHS Cheshire and Merseyside	3.04 (2.83 to 3.25)	<0.001
NHS Cumbria and North East	2.12 (1.91 to 2.33)	<0.001
NHS Greater Manchester	1.75 (1.56 to 1.94)	<0.001
NHS Lancashire and South Cumbria	1.69 (1.44 to 1.94)	<0.001
NHS Yorkshire and Humber	1.38 (1.22 to 1.55)	<0.001
NHS South Central	0.93 (0.73 to 1.14)	<0.001
NHS South East	1.19 (1.01 to 1.37)	<0.001
NHS South West	1.28 (1.07 to 1.49)	<0.001
NHS Wessex	1.51 (1.29 to 1.74)	<0.001
QoF preval serious conditions %	0.13 (0.12 to 0.13)	<0.001
Rurality	-0.85 (-0.98 to -0.72)	<0.001

Supplementary Table 11. Sensitivity analysis of the association between persistent high turnover and GPPS outcomes. Multivariable analysis including GP turnover modelled as continuous variable.

	Frequency seeing preferred doctor		Same day appointment		Overall satisfaction	
	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value
Turnov %	-0.003 (-0.007 to 0.002)	0.251	-0.037 (-0.046 to -0.029)	<0.001	-0.0003 (-0.0027 to 0.0021)	0.831
IMD 1	Reference		Reference			
IMD 2	-0.181 (-0.933 to 0.571)	0.636	0.541 (-0.225 to 1.307)	0.166	-0.6958 (-1.0897 to -0.3018)	0.001
IMD 3	-1.819 (-2.603 to -1.035)	<0.001	0.818 (0.038 to 1.598)	0.040	-1.9635 (-2.3717 to -1.5553)	<0.001
IMD 4	-3.832 (-4.639 to -3.026)	<0.001	-0.041 (-0.844 to 0.761)	0.919	-2.9873 (-3.4071 to -2.5675)	<0.001
IMD 5	-6.189 (-7.041 to -5.338)	<0.001	-0.213 (-1.047 to 0.621)	0.617	-4.3807 (-4.822 to -3.9395)	<0.001
Listsize 1	10.898 (10.322 to 11.473)	<0.001	2.303 (1.584 to 3.021)	<0.001	0.257 (-0.0486 to 0.5625)	0.099
Listsize 2	4.848 (4.384 to 5.313)	<0.001	-0.111 (-0.795 to 0.572)	0.750	0.2857 (0.0311 to 0.5403)	0.028
Listsize 3	Reference		Reference			
Listsize 4	-4.37 (-4.836 to -3.904)	<0.001	0.126 (-0.561 to 0.813)	0.720	-0.2322 (-0.4887 to 0.0243)	0.076
Listsize 5	-9.454 (-10.027 to -8.881)	<0.001	-2.699 (-3.431 to -1.967)	<0.001	-0.9035 (-1.2143 to -0.5928)	<0.001
NHS London	Reference		Reference			
NHS Central Midlands	6.709 (5.479 to 7.938)	<0.001	10.6 (9.486 to 11.714)	<0.001	3.6058 (2.9747 to 4.2368)	<0.001
NHS East Midlands	10.54 (9.29 to 11.789)	<0.001	10.941 (9.807 to 12.075)	<0.001	4.9656 (4.326 to 5.6052)	<0.001
NHS North Midlands	10.999 (9.721 to 12.278)	<0.001	10.145 (8.981 to 11.31)	<0.001	6.2033 (5.5491 to 6.8575)	<0.001
NHS West Midlands	7.595 (6.437 to 8.753)	<0.001	7.555 (6.499 to 8.611)	<0.001	3.8035 (3.2111 to 4.3959)	<0.001
NHS Cheshire and Merseyside	10.917 (9.511 to 12.323)	<0.001	12.749 (11.465 to 14.034)	<0.001	8.0122 (7.2904 to 8.7339)	<0.001
NHS Cumbria and North East	14.494 (13.108 to 15.88)	<0.001	7.343 (6.072 to 8.614)	<0.001	8.8155 (8.1061 to 9.5248)	<0.001
NHS Greater Manchester	8.786 (7.503 to 10.07)	<0.001	3.369 (2.211 to 4.528)	<0.001	5.8396 (5.1848 to 6.4945)	<0.001

NHS Lancashire and South Cumbria	12.955 (11.297 to 14.613)	<0.001	8.531 (7.04 to 10.023)	<0.001	6.5394 (5.6996 to 7.3792)	<0.001
NHS Yorkshire and Humber	9.755 (8.637 to 10.872)	<0.001	9.185 (8.164 to 10.207)	<0.001	6.0773 (5.5062 to 6.6485)	<0.001
NHS South Central	11.003 (9.644 to 12.362)	<0.001	6.319 (5.086 to 7.552)	<0.001	5.8909 (5.1929 to 6.5888)	<0.001
NHS South East	10.44 (9.231 to 11.648)	<0.001	10.349 (9.251 to 11.447)	<0.001	4.4022 (3.7823 to 5.022)	<0.001
NHS South West	15.171 (13.771 to 16.572)	<0.001	14.165 (12.885 to 15.444)	<0.001	8.4707 (7.7513 to 9.19)	<0.001
NHS Wessex	15.777 (14.265 to 17.289)	<0.001	8.705 (7.326 to 10.083)	<0.001	7.6787 (6.9009 to 8.4565)	<0.001
QoF preval serious conditions %	-0.417 (-0.443 to -0.39)	<0.001	-0.407 (-0.439 to -0.374)	<0.001	-0.0339 (-0.048 to -0.0198)	<0.001
Rurality	4.881 (4.049 to 5.712)	<0.001	1.715 (0.943 to 2.487)	<0.001	2.9275 (2.4998 to 3.3551)	<0.001

Supplementary Table 12. Sensitivity analysis of the association between persistent high turnover and GPPS outcomes. Multivariable analysis restricting the analysis to 2011-2017.

	Frequency seeing preferred doctor		Same day appointment		Overall satisfaction	
	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value
Persistent high turnover	-2.03 (-2.43 to -1.62)	<0.001	0.55 (0.25 to 0.86)	<0.001	-2.03 (-2.43 to -1.62)	<0.001
IMD 1	Reference		Reference		Reference	
IMD 2	-0.59 (-1.4 to 0.23)	0.159	0.69 (-0.05 to 1.43)	0.067	-0.59 (-1.4 to 0.23)	0.159
IMD 3	-2.22 (-3.07 to -1.37)	<0.001	1.41 (0.64 to 2.19)	<0.001	-2.22 (-3.07 to -1.37)	<0.001
IMD 4	-4.49 (-5.36 to -3.62)	<0.001	0.67 (-0.12 to 1.47)	0.098	-4.49 (-5.36 to -3.62)	<0.001
IMD 5	-6.95 (-7.86 to -6.03)	<0.001	1.71 (0.87 to 2.55)	<0.001	-6.95 (-7.86 to -6.03)	<0.001
Listsize 1	10.73 (10.08 to 11.37)	<0.001	-0.67 (-1.2 to -0.14)	0.013	10.73 (10.08 to 11.37)	<0.001
Listsize 2	4.75 (4.22 to 5.28)	<0.001	-0.65 (-1.08 to -0.22)	0.003	4.75 (4.22 to 5.28)	<0.001
Listsize 3	Reference		Reference		Reference	
Listsize 4	-4.11 (-4.63 to -3.59)	<0.001	0.01 (-0.42 to 0.44)	0.961	-4.11 (-4.63 to -3.59)	<0.001
Listsize 5	-8.24 (-8.87 to -7.61)	<0.001	-0.06 (-0.59 to 0.48)	0.833	-8.24 (-8.87 to -7.61)	<0.001
NHS London	Reference		Reference		Reference	
NHS Central Midlands	5.33 (4.04 to 6.61)	<0.001	9.23 (8.01 to 10.46)	<0.001	5.33 (4.04 to 6.61)	<0.001
NHS East Midlands	9.11 (7.81 to 10.42)	<0.001	8.17 (6.93 to 9.42)	<0.001	9.11 (7.81 to 10.42)	<0.001
NHS North Midlands	9.43 (8.09 to 10.77)	<0.001	6.58 (5.31 to 7.85)	<0.001	9.43 (8.09 to 10.77)	<0.001
NHS West Midlands	6.52 (5.31 to 7.74)	<0.001	4.6 (3.45 to 5.75)	<0.001	6.52 (5.31 to 7.74)	<0.001
NHS Cheshire and Merseyside	9.18 (7.7 to 10.65)	<0.001	9.69 (8.29 to 11.1)	<0.001	9.18 (7.7 to 10.65)	<0.001
NHS Cumbria and North East	12.61 (11.15 to 14.07)	<0.001	1.73 (0.35 to 3.12)	0.014	12.61 (11.15 to 14.07)	<0.001
NHS Greater Manchester	8.03 (6.68 to 9.37)	<0.001	1.32 (0.04 to 2.59)	0.043	8.03 (6.68 to 9.37)	<0.001
NHS Lancashire and South Cumbria	11.25 (9.52 to 12.99)	<0.001	4.57 (2.94 to 6.21)	<0.001	11.25 (9.52 to 12.99)	<0.001
NHS Yorkshire and Humber	8.39 (7.22 to 9.57)	<0.001	6.22 (5.11 to 7.33)	<0.001	8.39 (7.22 to 9.57)	<0.001
NHS South Central	10.23 (8.81 to 11.64)	<0.001	4.11 (2.75 to 5.47)	<0.001	10.23 (8.81 to 11.64)	<0.001
NHS South East	9.33 (8.06 to 10.59)	<0.001	8.22 (7.01 to 9.43)	<0.001	9.33 (8.06 to 10.59)	<0.001
NHS South West	13.74 (12.28 to 15.2)	<0.001	10.51 (9.11 to 11.91)	<0.001	13.74 (12.28 to 15.2)	<0.001
NHS Wessex	14.52 (12.94 to 16.1)	<0.001	4.52 (3.01 to 6.03)	<0.001	14.52 (12.94 to 16.1)	<0.001

QoF preval serious conditions %	-0.26 (-0.3 to -0.23)	<0.001	-0.06 (-0.08 to -0.03)	<0.001	-0.26 (-0.3 to -0.23)	<0.001
Rurality	4.62 (3.75 to 5.5)	<0.001	0.29 (-0.53 to 1.12)	0.483	4.62 (3.75 to 5.5)	<0.001

Supplementary Table 13. Sensitivity analysis of the association between persistent high turnover and GPPS outcomes. Multivariable analysis restricting the analysis to 2015-2017 and including FTE per patients ratio in the model.

	Frequency seeing preferred doctor		Same day appointment		Overall satisfaction	
	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value
Persistent high turnover	-1.58 (-2.28 to -0.87)	<0.001	0.96 (0.37 to 1.55)	0.001	-0.5 (-0.89 to -0.11)	0.012
FTE per pts ratio	2.43 (1.35 to 3.5)	<0.001	1.96 (1.06 to 2.86)	<0.001	3.75 (3.18 to 4.32)	<0.001
IMD 1	Reference		Reference		Reference	
IMD 2	-1.48 (-2.49 to -0.48)	0.004	0.74 (-0.17 to 1.65)	0.113	-1.04 (-1.59 to -0.5)	<0.001
IMD 3	-3.37 (-4.4 to -2.34)	<0.001	1.89 (0.96 to 2.83)	<0.001	-2.8 (-3.36 to -2.24)	<0.001
IMD 4	-5.73 (-6.79 to -4.67)	<0.001	1.39 (0.43 to 2.35)	0.005	-3.81 (-4.38 to -3.24)	<0.001
IMD 5	-8.06 (-9.17 to -6.95)	<0.001	2.34 (1.34 to 3.34)	<0.001	-5.87 (-6.46 to -5.27)	<0.001
Listsize 1	10.52 (9.5 to 11.55)	<0.001	-2.13 (-2.99 to -1.27)	<0.001	0.88 (0.36 to 1.41)	0.001
Listsize 2	5.14 (4.33 to 5.95)	<0.001	-0.93 (-1.64 to -0.22)	0.010	0.56 (0.12 to 1)	0.013
Listsize 3	Reference		Reference		Reference	
Listsize 4	-4.55 (-5.33 to -3.77)	<0.001	0.51 (-0.18 to 1.19)	0.146	-0.3 (-0.73 to 0.13)	0.172
Listsize 5	-6.86 (-7.71 to -6)	<0.001	0.03 (-0.73 to 0.79)	0.944	-0.53 (-1 to -0.06)	0.027
NHS London	Reference		Reference		Reference	
NHS Central Midlands	2.16 (0.69 to 3.63)	0.004	9.84 (8.51 to 11.18)	<0.001	2.42 (1.63 to 3.21)	<0.001
NHS East Midlands	5.83 (4.32 to 7.34)	<0.001	8.74 (7.37 to 10.1)	<0.001	3.31 (2.5 to 4.12)	<0.001
NHS North Midlands	5.95 (4.4 to 7.5)	<0.001	6.99 (5.58 to 8.39)	<0.001	5.38 (4.54 to 6.21)	<0.001
NHS West Midlands	3.42 (1.99 to 4.84)	<0.001	5.28 (4 to 6.55)	<0.001	2.95 (2.19 to 3.71)	<0.001
NHS Cheshire and Merseyside	5.36 (3.65 to 7.07)	<0.001	10.42 (8.88 to 11.97)	<0.001	6.46 (5.55 to 7.38)	<0.001
NHS Cumbria and North East	8.02 (6.32 to 9.72)	<0.001	2.08 (0.55 to 3.6)	0.008	7.09 (6.18 to 7.99)	<0.001
NHS Greater Manchester	5.66 (4.1 to 7.22)	<0.001	1.8 (0.41 to 3.19)	0.011	5.44 (4.61 to 6.27)	<0.001
NHS Lancashire and South Cumbria	6.41 (4.35 to 8.46)	<0.001	4.54 (2.73 to 6.35)	<0.001	5.44 (4.36 to 6.52)	<0.001
NHS Yorkshire and Humber	4.79 (3.41 to 6.18)	<0.001	6.86 (5.62 to 8.1)	<0.001	4.88 (4.15 to 5.62)	<0.001
NHS South Central	8.68 (7.05 to 10.3)	<0.001	4.05 (2.56 to 5.54)	<0.001	4.9 (4.02 to 5.79)	<0.001
NHS South East	6.91 (5.44 to 8.38)	<0.001	8.19 (6.86 to 9.52)	<0.001	3.39 (2.6 to 4.18)	<0.001
NHS South West	10.64 (8.93 to 12.34)	<0.001	10.06 (8.51 to 11.61)	<0.001	7.42 (6.5 to 8.34)	<0.001

NHS Wessex	10.84 (9.02 to 12.66)	<0.001	3.91 (2.25 to 5.58)	<0.001	5.63 (4.64 to 6.62)	<0.001
QoF preval serious conditions %	-0.03 (-0.07 to 0.02)	0.252	-0.01 (-0.05 to 0.02)	0.464	0.04 (0.01 to 0.06)	0.002
Rurality	4.61 (3.59 to 5.63)	<0.001	-0.22 -1.14 0.7	0.644	2.64 2.09 3.19	<0.001

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