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The impact of primary care networks on emergency hospitalisations in the English NHS: An interrupted time series analysis

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A R T I C L E I N F O

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A B S T R A C T

Recent years have seen an emergence of collaborative primary care models in the English National Health Service and other international health systems. Primary Care Networks (PCNs) were introduced in England in July 2019, marking the first time collaboration between general practices was incentivised through a nationwide policy. While participation was not mandatory, nearly all general practices joined a PCN, largely due to strong financial incentives. Our study aim was to estimate the impact of PCNs on emergency hospitalisations using an interrupted time series design. Quarterly data between October 2016 and March 2023 from the North West London Whole Systems Integrated Care dataset was used to construct two primary outcomes: all-cause and ambulatory care sensitive conditions (ACSC) emergency hospitalisations, as well as Accident and Emergency attendances, considered as a secondary outcome. Furthermore, we analysed whether the impact of PCNs varied based on practice characteristics. A reduction in all-cause and ACSC hospitalisations was observed following the PCNs' introduction, until the start of the COVID-19 pandemic. The analysis also revealed a smaller reduction in ACSC hospitalisations among practices with more deprived patient populations and larger populations of patients with long-term conditions. While PCNs' implementation appears to have led to a reduction in emergency hospitalisations in North West London, this effect was only observed in the very short term as it stopped with the COVID-19 pandemic. Future studies should examine the effect across England and evaluate their continued impact.

1. Background

In January 2019, Primary Care Networks (PCNs) were announced by the Department of Health and Social Care in England as part of its *NHS Long Term Plan* [1]. The Plan's aim was to promote long-term sustainability of high-quality health, with PCNs being one proposed mechanism to achieve this. PCNs are collaborative general practice groups often formed by neighbouring general practices to serve around 30,000 to 50, 000 people, meeting local population health needs as they arise [1]. However, practices can choose to join a PCN with practices regardless of geographical location. While not mandating practices to join, the new policy introduced strong incentives for forming PCNs, including a £2.4 billion investment in primary care by 2023/24 (on average £1.5 million per PCN), a single fund for distributing network resources, and a 'shared savings' scheme [1,2]. In return, participating practices were required to deliver seven predefined national service specifications, such as those supporting early cancer diagnosis and structured medication reviews [3]. By July 2019, almost 99 % of general practices joined a PCN [4,5]. While an estimated 55 % to 81 % of practices participated in some form of a collaborative model prior to 2019 [6–8], the introduction of PCNs marks the first nationwide policy promoting general practice collaboration in the English National Health Service (NHS) [3].

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Despite their central place in recent NHS policy discourse, limited evidence exists on PCNs' success in addressing quality of care [11,12]. This lack of evidence also extends to pre-2019 large-scale general practice models [12,13], and reflects the general paucity of research on primary care patient safety, compared to the extensive literature within the secondary care sector [14–22]. One possible reason for this gap is the rapid reorganisation of English primary care, in response to rising demand and shrinking budgets [23].

However, the trend towards care integration is not unique to the English NHS. Several other European countries, including Finland and Italy, have experimented with collaborative primary care models [24–26]. Similarly, provider integrated delivery network, such as Kaiser Permanente, exist in the United States [27]. Early evidence points towards integrated care systems in the US experiencing improvement on indicators of access and satisfaction with care [27–29], and performing better than the English NHS, [30] indicating that integrated and collaborative care models may lead to improvements in quality of care [24,25,31].

This study aims to address the literature gap on the impact of primary care collaboration in the English NHS by evaluating the effect of PCNs on emergency hospitalisation outcomes. Emergency hospitalisations were selected as outcomes due to their attributable high health burden, costs to the healthcare system and subsequent diversion of funds from other areas, including primary care. In the NHS, the cost of emergency hospital admissions reached £17 billion in 2016/17 [32], accounting for a significant portion of the total NHS England funding allocation for 2016/17 of £107 billion [33]. Older people and those with multimorbidity are particularly at risk [32], a concern given the increasingly ageing and multimorbid population. Many emergency admissions can be prevented through adequate primary care for ambulatory care sensitive conditions (ACSCs), such as asthma and diabetes [34]. While dependent on many factors including patient engagement, emergency admissions can provide insight into the quality of primary care [35], which is important given the central role of PCNs in meeting their community's health needs and diverting care away from hospitals.

2. Conceptual framework

We use the organisational learning theory by Argyris and Schön to hypothesise the relationship between PCNs and emergency hospitalisation [36,37]. Under single-loop learning, general practices rectify errors retrospectively following a performance evaluation. Conversely, double-loop learning promotes the anticipation and correction of errors, through revising operational strategies and policies (Fig. 1) [36]. In small-scale general practice organisations, the pressures may prevent GPs from investing time in double-loop learning [23]. However, practices operating under PCNs may be better positioned to relieve those pressures and enable double-loop learning, due to specific operational changes introduced in the 2019 *NHS Long Term Plan*.

First, PCNs promote better communication between constituent practices and alignment of key operational approaches [38]. potentially resulting in quality improvements. Second, PCNs may choose to integrate their functions and systems – a common feature of collaborative models [8]. Furthermore, the policy underpinning PCNs' creation encourages hiring of shared healthcare staff (e.g. pharmacists and physiotherapists) through the Additional Roles Reimbursement Scheme (ARRS) [3]. As a result, patients' access to care may become timelier and more targeted, providing relief for GPs and potentially improving care quality. Finally, the 2019 *NHS Long Term Plan* committed to additional training and development for the new multidisciplinary teams [1], which could improve quality of care.

3. Methods

We used a Poisson regression with an interrupted time series (ITS) design to estimate the effect of the PCNs' introduction [39], assuming a Poisson distribution of studied outcomes. The analysis was conducted among general practices in North West London (NWL) using quarterly data during Q3 2016/17 to Q4 2022/23 (October 2016 to March 2023). All referenced time periods refer to quarters of the financial year (FY) (e.g. Q3 2016/17 – October 2016 to December 2016).

3.1. Data sources

The study used the NWL Whole Systems Integrated Care (WSIC) dataset to estimate the effect of PCNs on emergency hospitalisations [40]. WSIC contains patient-level data from over 350 practices within the NWL Integrated Care System (ICS). We linked the practice's collaboration status prior to the introduction of PCNs from an organisational model catalogue described elsewhere [6], and updated this information using the NHS Extended access to general practice dataset and practice group websites [41]. NHS Digital and Office for Health Improvement and Disparities datasets were linked to introduce additional covariates in the analysis [42,43].

3.2. Outcome variables

We analysed the impact of PCNs' introduction on two primary outcome variables: all-cause emergency hospitalisations and ACSC hospitalisations, which were used to model the rate of hospitalisations in the Poisson regression. They were selected to examine whether findings differ based on the consideration of those hospitalisations deemed avoidable, as in the case of ACSC conditions [44], where the need for emergency hospitalisations may reflect inadequate primary care quality [34,45]. The selection of ACSC-related emergency hospitalisations is further justified as patients with long-term ACSC conditions may be

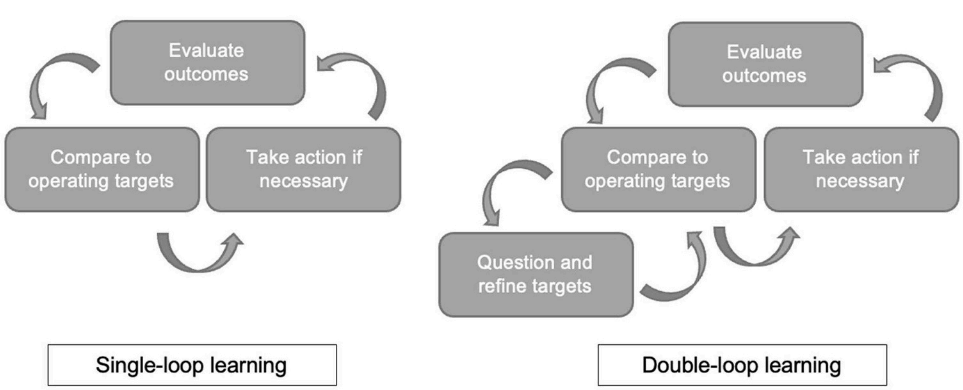

Fig. 1. Single- and double-loop learning in organisations.
Source: Illustration based on the single- and double-loop learning theory by Argyris & Schön [37].

more likely to benefit from PCNs, especially through the delivery of national service specifications and the hiring of additional healthcare professionals. WSIC admitted patient care data was used to identify the first hospital episode for every inpatient spell coded as an emergency. All primary diagnoses were considered for all-cause hospitalisations, whereas ACSC hospitalisations were identified by screening primary diagnoses for ACSC International Classification of Diseases 10 (ICD-10) codes, following the NHS Outcomes Framework methodology [46]. All non-ordinary admissions and transfers from other hospitals were excluded.

Accident and Emergency (A&E) department attendances were considered as a secondary outcome due to the introduction of the Same Day Emergency Care (SDEC) pathway as part of the 2019 *NHS Long Term Plan*. The pathway included the Same Day Emergency Care (SDEC) pathway, which aims to avoid the overnight hospitalisation of patients who can receive required care on the same day [1]. It is important to determine whether improvements in emergency hospitalisation rates could be attributed to increased A&E visits resulting from the SDEC initiative. Within the WSIC A&E data, we identified all first A&E attendances regardless of diagnosis and aggregated them at the practice level.

3.3. Covariates

Practices' binary collaboration status prior to the PCNs' introduction was constructed from an organisational model catalogue compiled for a pre-existing study [6], complemented with the NHS England data on extended access and information from practice group websites [41]. Additional covariates, divided into predisposing, enabling and need based on the Andersen model of health services utilisation [47], were linked from NHS Digital and the Office for Health Improvement and Disparities [42,43]. Predisposing covariates included the proportion of registered patients over the age of 65 and the general practice Index of Multiple Deprivation (IMD) scores (based on registered patients' postcodes). The enabling covariate was the practice list size, while the proportion of registered patients with long-term conditions was designated as a need covariate. Finally, to enable its inclusion in the differential effect analysis, a variable of PCN size was derived for each participating practice using the list sizes of all practices belonging to a specific PCN as of July 2019.

3.4. Statistical methods

We used an ITS approach to estimate the impact of PCNs' introduction on the outcomes of interest. ITS analysis identifies the pre-intervention trend, extrapolated to create the counterfactual, and the post-intervention immediate change, which can be disaggregated into level and slope changes [48]. In the case of PCNs, all practices formed the newly established networks at the same known point in time (July 2019), meeting the requirement for clearly differentiated pre- and post-intervention periods for this approach [39].

Data on all three outcomes was available in 26 sequential quarters, including 11 preceding (Q3 2016/17 to Q1 2019/20) and three following the introduction of PCNs (Q2 2019/20 to Q4 2019/20), eight quarters of the COVID-19 pandemic (Q1 2020/21 to Q4 2021/22) and four quarters after the removal of the pandemic restrictions (Q1 2022/23 to Q4 2022/23). The number of all-cause and ACSC emergency hospitalisations were used as primary outcome variables, with the log of the number of registered patients used as the offset to model rates of hospitalisations. All results were expressed as incidence rate ratios (IRR). Based on the conceptual model, PCNs' introduction is expected to reduce all-cause and ACSC emergency hospitalisation rates. However, any observed reduction may be partly influenced by the concurrent introduction of SDEC pathway resulting in an increase in A&E attendances. Thus, this study also examines whether the introduction of PCNs had an effect on the number of A&E attendance rates.

In the primary analysis, a single-group ITS analysis was run by estimating a Poisson regression model to evaluate the impact of the PCNs introduction on the rates of hospitalisation outcomes [49]. The quarterly counts of all-cause emergency hospitalisations, ACSC hospitalisations and A&E department attendances were included as dependent variables in the Poisson model. A dummy variable taking the value of 0 in the pre-PCN periods, and 1 after the PCNs' introduction was included to determine their impact on outcomes of interest. A separate count variable indicating the number of quarters from the start of the study was included to estimate the underlying outcome trends. Given the short time (three quarters) during which PCNs were in operation before the advent of the COVID-19, we did not seek to separately estimate the level and trend changes resulting from PCNs' introduction, instead estimating their combined impact [39]. Seasonality was adjusted for using quarterly indicator variables [50]. The model was tested for residual autocorrelation using the Cumby-Huizinga test [51]. and adjusted by specifying an appropriate lag. Confidence intervals and standard errors were calculated using bootstrapping with 1000 repetitions., and analysis was performed using Stata version 15.1 [52].

Six subsequent model iterations were considered to understand the possibility of a differential effect of PCNs' based on individual practice characteristics and the size of the PCN the practice belongs to [53]. Each model included one covariate considered in the differential analysis (prior collaboration, practice size, IMD score, and proportion of patients over 65 and with long-term conditions, PCN size). Practices already engaging in collaboration may have been quicker to implement PCNs, especially if they already collaborated with their peer practices. Similarly, larger practices could benefit from economies of scale allowing them to more quickly adapt to new ways of working. Meanwhile, practices with more deprived or complex patient populations likely experience additional pressures, possibly negatively affecting their ability to implement new initiatives. Finally, the diverging size of PCNs may have had an impact on the degree of success practices within them had in providing effective care for their local populations.

In all models, COVID-19-affected periods (the pandemic – Q1 2020/21 to Q4 2020/21, and the post-pandemic period – Q1 2022/23 to Q4 2022/23) were modelled as separate regression segments, due to significant changes in service delivery during the pandemic [54]. Emergency COVID-19 hospitalisations were excluded from the primary analysis, as their inclusion would result in higher hospitalisation rates during the pandemic period. Meanwhile, non-COVID-19 emergency hospitalisations, especially those for ACSC, are difficult to avoid once an exacerbation of the patient's condition has taken place, and therefore less likely to be affected by patients avoiding hospital settings during the pandemic.

3.5. Sensitivity analyses

Several sensitivity analyses were performed. The primary model does not account for time-varying confounding variables, because the ITS design captures differences arising from slowly changing practice-level confounders in the underlying trend [39]. Alternative specifications, adjusting for practice characteristics and including general practice fixed effects, were estimated as part of the sensitivity analysis.

Another sensitivity analysis involved modelling the anticipatory period (January 2019 to July 2019 as a separate regression segment, because the announcement of PCNs' introduction may have incentivised some practices to begin collaborating in anticipation of the July 2019 deadline. We also ran a controlled ITS (CITS) model, where practices participating in a collaborative model prior to 2019 formed a control group [55]. This was to account for potential differences in the PCNs' impact on practices joining a collaborative model for the first time. We also conducted a separate analysis by only including the subset of practices which did not collaborate in any form prior to July 2019.

Finally, we ran sensitivity analyses to account for the COVID-19 pandemic. This included estimating two separate models – one including COVID-19 emergency hospitalisations in the all-cause emergency hospitalisations outcome derivation, and one excluding the time periods following the start of the COVID-19 pandemic from the analysis.

4. Results

4.1. Descriptive statistics

The analysis included 312 general practices, 259 of which had been collaborating prior to the PCNs' introduction and 53 which had not. All practices operated for the entire study period, resulting in a balanced panel. 737,286 all-cause and 43,094 ACSC emergency hospitalisations, and 4926,773 A&E attendances, were identified among participating practices between October 2016 and March 2023. As shown in Table 1, a statistically significant difference was observed in the rates of both primary outcomes between pre- and post-intervention periods: 14.43 vs 13.06 for all-cause and 0.85 vs 0.74 for ACSC hospitalisations. Table 1 also shows that most practice characteristics were statistically different in the pre- and post-intervention periods. Descriptive statistics of variables split by the practices' pre-PCN collaboration status can be found in Table S1 in the Supplementary Information. Additionally, proportion of ACSC emergency hospitalisations attributable to different conditions can be found in Table S2 in the Supplementary Information.

4.2. Primary analysis

As shown in Table 2, a statistically significant reduction of 4.7 % for all-cause and 8.6 % for ACSC hospitalisations (IRR = 0.95, 95 % CI 0.92 to 0.98; IRR = 0.91, 95 % CI 0.86 to 0.97) was observed following PCNs' introduction. After the onset of the COVID-19 pandemic in April 2020, for which both the level and slope change were estimated, both all-cause and ACSC hospitalisations experienced a statistically significant immediate reduction, followed by a subsequent trend increase. In the post-pandemic segment (Q1 2022/23 to Q4 2022/23), both outcomes once again saw a statistically significant reduction. The results are displayed visually in Fig. 2. In the post-PCN periods, no statistically significant change in A&E attendances was observed.

We considered the differential impact of PCNs' introduction based on six general practice and PCN characteristics: pre-PCN collaboration status, list size, IMD score, proportions of patients with long-term conditions and those over the age of 65, and PCN size. Practices with higher patient deprivation and more patients with long-term conditions were found to have comparatively higher ACSC hospitalisations in the post-PCN period. The full results of these additional analyses can be found in the Table S3 in the Supplementary Information.

Table 2
Primary analysis results: Single-group interrupted time series.

Outcome	IRR	95 % CI
All-cause emergency hospitalisations, per 1000 registered patients		
Intercept	0.01***	0.01, 0.01
Pre-PCNs trend	0.99**	0.99, 1.00
Post-PCNs	0.95***	0.92, 0.98
COVID-19 pandemic		
Level	0.63***	0.60, 0.66
Trend	1.07***	1.06, 1.08
Post-COVID-19		
Level	0.87***	0.85, 0.89
Trend	0.96***	0.95, 0.96
ACSC hospitalisations, per 1000 registered patients		
Intercept	0.00	0.00, 0.00
Pre-PCNs trend	0.99**	0.98, 1.00
Post-PCNs	0.91***	0.86, 0.97
COVID-19 pandemic		
Level	0.55***	0.51, 0.59
Trend	1.10***	1.08, 1.12
Post-COVID-19 change		
Level	0.85***	0.80, 0.92
Trend	0.92***	0.89, 0.94
A&E attendances, per 1000 registered patients		
Intercept	0.09***	0.09, 0.09
Pre-PCNs trend	1.00*	1.00, 1.00
Post-PCNs	0.99	0.97, 1.02
COVID-19 pandemic change		
Level	0.57***	0.56, 0.58
Trend	1.10***	1.09, 1.10
Post-COVID-19 change		
Level	0.77***	0.74, 0.80
Trend	0.94***	0.93, 0.95
Number of observations	8112	
Number of groups	312	

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; PCN, primary care network.
Note: The analysis was adjusted for seasonality by including quarterly indicator variables.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3. Sensitivity analyses

The results are robust to the inclusion of practice covariates and practice fixed effects in the analysis. Modelling the anticipatory period as a separate regression segment shows a statistically significant increase in emergency hospitalisations after the 2019 *NHS Long-Term Plan* announcement, followed by a decrease in all-cause and ACSC hospitalisations after the PCNs' introduction in July 2019. Furthermore, while the results of a sensitivity analysis including COVID-19 hospitalisations in the derivation of the outcome variable are consistent with those of the

Table 1
Descriptive statistics of key variables by time period.

Variables (practice-level)	Pre-PCN introduction (n = 3432)			Post-PCN introduction (n = 936)			t-test p-value (difference in means)
	Mean	SD	IQR	Mean	SD	IQR	
Number of all-cause emergency hospitalisations	97.89	70.54	46.00; 133.00	93.21	73.22	39.00; 123.00	0.081
Number of ACSC hospitalisations	5.80	5.36	2.00; 8.00	5.29	5.53	1.00; 7.00	0.011
Number of A&E attendances	627.19	343.80	369.00; 824.50	649.95	392.72	368.50; 842.50	0.107
All-cause emergency hospitalisations, per 1000 registered patients	14.43	6.99	8.06; 19.90	13.06	7.28	6.61; 19.04	<0.001
ACSC hospitalisations, per 1000 registered patients	0.85	0.66	0.32; 1.26	0.74	0.68	0.19; 1.14	<0.001
A&E attendances, per 1000 registered patients	93.76	26.49	75.70; 111.04	90.32	28.22	68.81; 107.73	0.001
List size, 000s	6.81	3.49	4.09; 8.62	7.25	3.79	4.37; 8.95	0.002
Patients over 65,%	11.47	3.97	8.86; 13.97	11.60	3.96	9.00; 14.07	0.371
Patients with long-term conditions,%	45.21	7.72	40.62; 50.19	42.70	7.10	38.03; 47.29	<0.001
IMD score	23.23	7.82	17.15; 27.51	21.80	6.69	16.70; 26.23	<0.001

Abbreviations: PCN, primary care network; ACSC, ambulatory care sensitive condition; A&E, accident and emergency; IMD, Index of Multiple Deprivation ; SD, standard deviation; IQR, interquartile range.
Note: n denotes the number of quarterly observations. The pre-PCN introduction period includes 11 quarters preceding the PCN introduction (Q3 2016/17 to Q1 2019/20). The post-PCN time period includes the three quarters immediately after PCN introduction (Q2 2019/20 to Q4 2019/20).

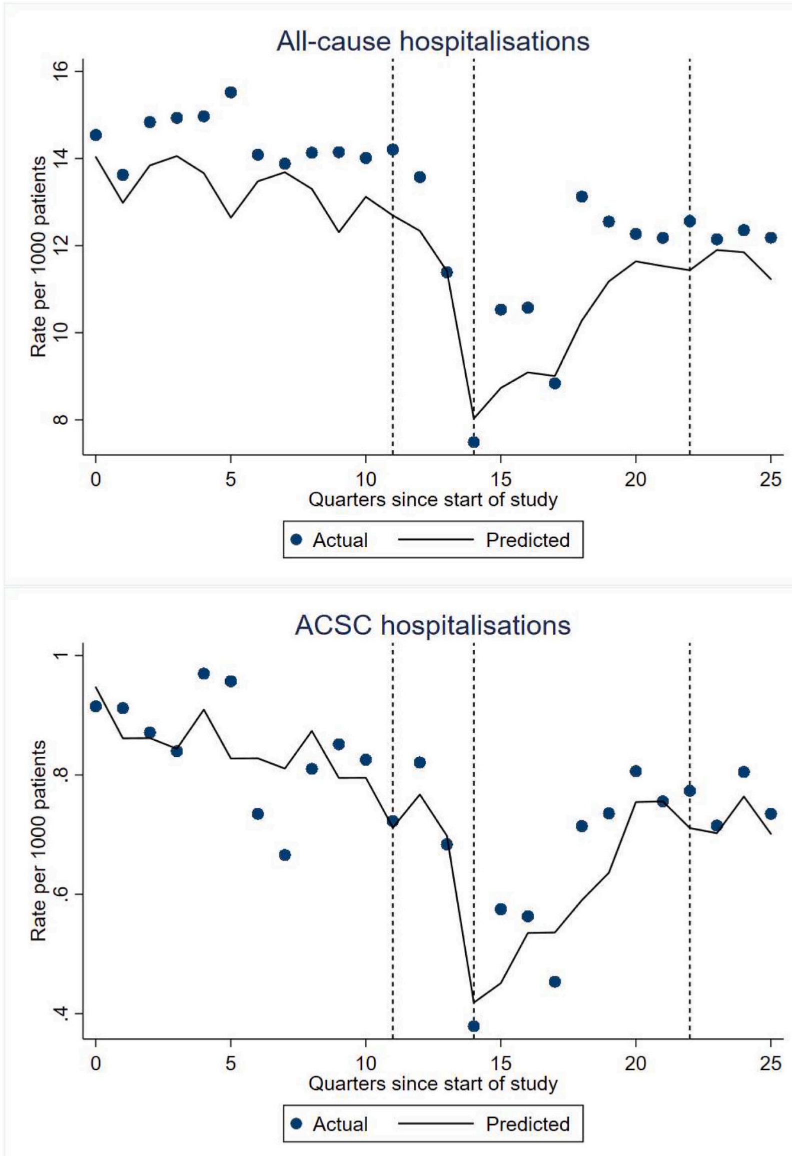

Fig. 2. Effect of primary care networks on all-cause and ACSC emergency hospitalisations.
Note: Vertical lines represent PCN implementation (2019q2), start of the COVID-19 pandemic (2020q1) and the removal of pandemic restrictions (2022q1). Actual and Predicted refer to the average values of the dependent variables – all-cause and ambulatory care sensitive conditions (ACSC) hospitalisations.

base case model, the results of the analysis excluding COVID-19-affected time periods altogether resulted in a loss of statistical significance for the reduction in all-cause emergency hospitalisations in the post-PCN period. This is likely due to fewer data points in the overall analysis. However, the magnitude of the effect remained broadly consistent with the primary analysis.

The CITS performed as part of the sensitivity analysis found a statistically significant difference in the effect between practices collaborating prior to the introduction of PCNs and those starting to collaborate in 2019, with the latter experiencing a larger reduction in both all-cause and ACSC hospitalisations (IRR = 0.92, 95 % CI 0.88 to 0.97; IRR = 0.85, 95 % CI 0.73 to 0.99). This was further supported by the additional sensitivity analysis including only practices not collaborating prior to 2019, which found a larger statistically significant reduction in both all-cause and ACSC hospitalisation compared to the base case analysis. The results of all sensitivity analyses are presented in Tables S4-S10 in the Supplementary Information.

5. Discussion

Our findings suggest that the introduction of PCNs led to a decrease in both all-cause and ACSC emergency hospitalisations during the three post-intervention quarters before the COVID-19 pandemic. This is supported by key assumptions of the ITS method being met, including the intervention occurring at a specific point in time, no concurrent interventions affecting the outcomes of interest, sufficient and consistently measured outcome data points in the pre- and post-intervention time periods, and appropriately accounting for autocorrelation. Meanwhile, A&E attendances did not experience significant change, suggesting that the decrease in hospitalisations was likely not due to a corresponding increase in A&E attendances. This supports the hypothesised relationship between general practice collaboration and care quality, and suggests that key PCN characteristics, including sharing of best practices, key function integration, and hiring of new staff, may have had success in promoting double-loop learning. Considering emergency hospitalisations have the potential to incur high costs to the healthcare system, any reduction resulting from PCNs successful implementation may be clinically and economically significant. In the case of our study, the identified short-term effect of PCNs on reducing emergency hospitalisation rates could be a sign of their future potential in this aspect, although more research is needed to determine this with certainty.

The differential impact analysis found that practices with a more deprived population experienced a smaller reduction in ACSC hospitalisations. This could be due to such practices experiencing additional difficulties, including challenges to patient access, thereby affecting their ability to effectively engage with PCNs. Existing research supports this argument, as evidenced by a negative association between social deprivation and quality of care [56,57]. A similar, but weakly significant, relationship was observed between practices with larger populations of patients with long-term conditions and ACSC hospitalisations. Additionally, the CITS and analysis including only previously non-collaborating practices indicate that practices collaborating for the first time following PCNs' introduction experienced a larger reduction in both all-cause and ACSC emergency hospitalisations. This could indicate that formal policies incentivising primary care collaboration are more successful in improving quality of care compared to voluntary collaborative models. Lastly, the sensitivity analysis including the anticipatory period identified a post-PCN implementation decrease in all-cause and ACSC hospitalisations, supporting the base case results.

These findings contribute to the limited literature on the impact of PCNs on patient safety and care quality [12]. The scarcity of evidence is unsurprising given their recent introduction and the COVID-19 pandemic which shifted health system priorities. However, a recent report highlighted the key role PCNs played in adapting care delivery during the pandemic, including the successful rollout of the NHS COVID-19 vaccination campaign [58]. This could explain why other areas of primary care may have suffered, leading to an increase in non-COVID-19 hospitalisations during the pandemic, as identified in our analysis. Similarly, existing literature noted an increase in emergency admissions during the pandemic in the United Kingdom, following a brief reduction at the start [59].

This highlights the unstable environment in which PCNs emerged, with only three quarters of our study period unaffected by COVID-19. During these early days, implementation challenges were likely still preventing PCNs from reaching their full potential. Key changes, such as recruiting staff and changing the ways of working, can take significant time to implement. It is therefore possible that there are additional factors contributing to the observed improvement in hospitalisation rates. However, the anticipatory period between the *NHS Long Term Plan* announcement in January 2019 and the July 2019 PCN deadline, considered in the sensitivity analysis, likely meant that general practices were able to anticipate and mitigate some of the challenges in their implementation, thereby enabling the newly designed PCNs to realise the improvements in care quality more quickly.

Previous research suggests that PCNs made good progress towards other goals, including the recruitment of additional healthcare professionals through the ARRS [58]. While PCN staffing levels data was not available for the entire post-PCNs study period, and thereby not included in the analysis, this highlights an early implementation success of one of the key features of the newly established networks, as highlighted in the conceptual framework. An early evaluation also suggests the newly formed networks successfully established the provision of national service specifications – centrally determined service requirements which all PCNs must deliver on as part of their contract with the NHS [9]. This further reinforces the argument that there is scope for PCNs to improve care quality. However, several challenges remain. GPs highlight concerns including increased administrative burden, worsening continuity of care, and lack of facilities and training [11]. Additionally, there have been issues with engagement with this new operational structure outside of the higher-level management teams [60]. These challenges are critically important to the further development and refinement of PCNs.

5.1. Strengths and limitations

To the best of our knowledge, this is the first study exploring the influence of PCNs on care quality by evaluating their impact on emergency hospitalisations. Our analysis presents a key contribution to the existing literature, with potential to inform future implementations of collaborative schemes in the primary care sector, while also being the first to explore the differential effects of the PCNs based on practice characteristics.

This study is subject to the following limitations. First, the lack of an extended study period unaffected by COVID-19 prevents extrapolation of the positive findings observed. This also prevented a further extension to the analysis to evaluate whether PCNs' implementation had a delayed effect on outcomes. This is an important limitation since large organisational changes like the incorporation of PCNs likely take time for practices to implement and operationalise. Similarly, placebo testing to further contextualise the short-term effect of PCNs on hospitalisations was not feasible due to data limitations. Second, certain factors which may influence the success of individual PCNs, such as staffing levels, were not accounted for in the analysis due to a lack of available data. Third, the final months of 2019/2020, particularly March 2020, have been modelled as the pre-pandemic period in the analysis, despite general practices already starting to change operations in response to the pandemic by mid-March 2020 [61].

Another limitation is the study focus on North West London, limiting the generalisability of findings due to the London having a larger proportion of younger people [62], higher ethnic diversity [63], more deprivation and higher education levels [64]. Potential geographical differences are likely further exacerbated due to PCNs being operationalised differently across the NHS, and in some cases relying on support from existing collaborations [9]. While designed to serve populations of 30,000 to 50,000 people, 7 % of PCNs serve smaller (<30, 000) and 35 % larger (>50,000) populations [10], leading to potential variability in performance [11]. Finally, due to data limitations it was not explored whether some practices chose to form PCNs within already established collaborative organisations, such as federations. Nevertheless, practices' prior collaboration status was considered through an analysis of differential impact by practice characteristics, and subsequent sensitivity analyses including the CITS and an analysis including only the subgroup of practices which did not collaborate prior to 2019.

5.2. Future research

PCNs continue to play a vital role in caring for their local populations within the newly established ICSs [11,65]. However, there has been insufficient research into their impact on quality of care, and expanding this evidence base is urgently needed. While our study aims to contribute to this goal, further evidence is needed on their impact at the national level, including consideration of possible spatial autocorrelation and divergence between different geographical regions. Additionally, if the lessons from PCNs' implementation are to be applied in international settings, further consideration of country-specific factors should be included in future research on the topic.

Future research should also consider the formation process of PCNs, which often relies on interpersonal relationship between GPs, but which also needs to consider local population needs [66]. Moreover, further exploration of the reasons behind the divergent findings of the differential impacts observed among practices with a larger proportion of patients with long-term conditions and higher deprivation, could shed light on whether PCNs are more effective at improving care for specific populations. Finally, it is important to evaluate the relationship between PCNs and collaborative models that precede them. Both the CITS analysis and the single-group analysis including only newly collaborating practices found that practices collaborating for the first time in July 2019 experienced a larger reduction in emergency hospitalisations following PCNs' implementation. Future research focused on identifying the drivers of this relationship could enhance understanding of pre-2019 models and their relation to PCNs.

6. Conclusion

Following the establishment of PCNs in July 2019, there has been a lack of evidence on their impact on care quality. Our analysis contributes to this evidence base by estimating the effect of PCNs on all-cause and ACSC emergency hospitalisations among practices in North West London. A statistically significant reduction in both all-cause and ACSC emergency hospitalisations was observed immediately after the PCNs' introduction. However, the COVID-19 pandemic significantly altered the NHS landscape, including the mechanisms of care delivered by PCNs, which prevented the identification of PCNs' longer-term effect on emergency hospitalisations.

Ethics

This study was undertaken within a research database that was given favourable ethics approval by the West Midlands Solihull Research Ethics Committee (reference 18/WM/0323; IRAS project ID 252449). All data used in this paper were fully anonymized before analysis.

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CRediT authorship contribution statement

Lana Kovacevic: Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Lindsay Forbes:** Writing – review & editing, Resources, Data curation. **Hutan Ashrafian:** Writing – review & editing, Supervision, Conceptualization. **Erik Mayer:** Writing – review & editing, Supervision, Resources. **Elias Mossialos:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **David Lugo-Palacios:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

Hutan Ashrafian is Chief Scientific Officer of Pre-emptive Medicine and Health Security at Flagship Pioneering.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2025.105524.

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