Family Practice, 2022, 381–388
https://doi.org/10.1093/fampra/cmab120
Advance Access publication 25 October 2021

OXFORD

Health Service Research

Effects of GP characteristics on unplanned hospital admissions and patient safety. A 9-year follow-up of all Norwegian out-of-hours contacts

Ellen Rabben Svedahl[1,*], Kristine Pape[1], Bjarne Austad[1], Gunnhild Åberge Vie[1], Kjartan Sarheim Anthun[1,2], Fredrik Carlsen[3], Johan Håkon Bjørngaard[1,4]

[1]Department of Public Health and Nursing, Norwegian University of Science and Technology, Trondheim, Norway, [2]Department of Health Research, SINTEF Digital, Trondheim, Norway, [3]Department of Economics, Norwegian University of Science and Technology, Trondheim, Norway, [4]Faculty of Nursing and Health Sciences, Nord University, Levanger, Norway

*Corresponding author: Department of Public Health and Nursing, Norwegian University of Science and Technology, PO Box 8905, 7491 Trondheim, Norway. Email: ellen.r.svedahl@ntnu.no

Abstract

Background: There are substantial differences in hospital referrals between general practitioners (GPs); however, there is little research on the consequences for patient safety and further healthcare use.

Objective: To investigate associations between out-of-hours GP characteristics, unplanned hospital admissions, and patient safety.

Methods: This cohort study included all Norwegian out-of-hours services contacts from 2008 to 2016, linked to registry data on patient characteristics, healthcare use and death, and GP age, sex, specialist status, out-of-hours service experience, and prior admission proportion. We estimated the impact from GP characteristics on (i) immediate unplanned hospital admissions for "all conditions," (ii) immediate unplanned hospital admissions for "critical conditions," (iii) 30-day unplanned hospital admissions, (iv) 30-day hospital costs, and (v) 30-day risk of death. To limit confounding, we matched patients in groups by age, time, and location, with an assumption of random assignment of GPs to patients with this design.

Results: Patients under the care of older and male GPs had fewer immediate unplanned hospital admissions, but the effects on cumulative 30-day unplanned hospital admissions and costs were small. The GPs' prior admission proportion was strongly associated with both immediate and 30-day unplanned hospital admissions. Higher prior admission proportion was also associated with admitting more patients with critical conditions. There was little evidence of any associations between GP characteristics and 30-day risk of death.

Conclusions: GPs' prior admission proportion was strongly associated with unplanned hospital admissions. We found little effects on 30-day mortality, but more restrictive referral practices may threaten patient safety through missing out on critical cases.

Key Messages

- GP characteristics were associated with substantial differences in referrals.
- Older, male, and specialist GPs were associated with lower odds for referrals.
- The GP's referral history was the most important determinant for further referrals.
- Reducing referrals may threaten patient safety through missing critical cases.
- The differences in referrals had minor effects on 30-day mortality.

Lay Summary

Referral for specialized health services is a key part of the general practitioner (GP) role. Differences in referrals between primary care physicians have been widely studied, as they represent a target for reducing the use of specialized health services. However, the potential consequences beyond the actual referral have received little attention. Studying associations between physician characteristics and clinical decisions are difficult because physicians often systematically see different patient populations with different morbidity. Previous findings showing large differences in clinical decisions regarding referrals and hospital admissions may suffer from confounding. With our carefully matched study design, we could assume that the assignment of physicians to patients was random. We found substantial differences in referrals associated with GP characteristics. Seeing older and male GPs and specialists in family medicine were associated with fewer immediate unplanned hospital admissions but did not substantially influence unplanned hospital costs within 30 days. However, GPs with a history of admitting many of their recent patients had a substantial higher tendency to admit their future patients and represented a higher use of health services and costs. These GPs also referred more critically ill patients, an essential aspect of patient safety. The differences in referrals had minor impact on the patients' 30-day risk of death.

Key words: after-hours care, general practitioners, health services research, patient admission, patient safety, referral and consultation

Background

In most healthcare systems, the overall general policy is to reduce unnecessary and unplanned hospital admissions as they are demanding for the health services, costly for society, and may increase the risk of overtreatment and complications for the patients. Gatekeeping in primary care is shown effective to control the use of specialized health services.[1] Thus, evidence suggesting large differences in referral practices between primary care physicians highlight a target for quality improvement and reduction of unnecessary admissions.[2–7] However, this evidence may suffer from potential unmeasured confounding from different patient populations between the physicians because important patient characteristics may not be readily available in such studies.[8] Hence, what appears as differences in physicians' referral patterns may instead reflect differences in their patients' healthcare needs. In health systems where regular general practitioners (GPs) mainly serve a selected patient population, strong associations between GP characteristics and patient characteristics may be observed, without this reflecting real differences in referral threshold. However, the out-of-hours setting, where the patients to a lesser degree choose their GP, may be better suited for studying such associations. Out-of-hours medical services provide urgent primary medical care outside office hours and hold an essential gatekeeping role for unplanned hospital admissions.[9,10] GPs are the backbone in the out-of-hours services in many countries.[11] Increasing pressure on primary care is now challenging the contribution from experienced GPs and may also lead to a shift in the characteristics in the GPs staffing both normal hours and out-of-hours primary care.[12,13] Knowledge about the potential effects of GP characteristics on referral differences is therefore valuable. Further, there is a lack of research on the consequences of such differences for patient safety and healthcare use.

The aim of this study was to investigate the impact of GP characteristics on unplanned hospital admissions. To handle confounding from different patient populations, we studied patient contacts in the out-of-hours setting, and further matched patients in comparable groups. In addition to looking at the differences in immediate unplanned hospital admissions for all conditions, we included outcomes reflecting patient safety; immediate admissions for critical conditions, 30-day hospital use and costs, and 30-day risk of death.

Materials and methods

Study setting

The Norwegian out-of-hours services is a statutory municipal service, organized as a GP cooperative which is the most dominant model in Europe.[11] Other physicians also staff the out-of-hours services, but GPs contribute with about half of the contacts.[14] Most acute illness outside office hours are handled in the out-of-hours service as a primary care emergency unit, and patients are assigned to the physician on-call in their area. See Supplementary Material for details of the study setting.

Study population

This study is based on complete national data on patient contacts with primary care physicians from the Control and Payment of Health Reimbursement Register (KUHR).[15] The study population comprises all patients contacting the Norwegian out-of-hours services in the period 2008–2016, assessed by physicians also

working as regular GPs during office hours. We included out-of-hours services contacts between 16:00 and 08:00 on weekdays and whole Saturday, Sunday, and public holidays. We used a unique identification number to link patient data to somatic hospital visits in the Norwegian Patient Registry,[16] demographical information including municipality code, immigration, and education status from Statistics Norway,[17] and date of death from the Norwegian Cause of Death Registry.[18] Unplanned admissions to psychiatric care were not included in this study. GP characteristics available from the Norwegian General Practitioner Register were linked to each patient contact by a unique physician ID.[19] See Supplementary Material for details of the study population and data sources.

Study design

We designed our study so we could arguably assume that the patients' measured and unmeasured pretreatment conditions, were balanced between the compared patient groups and independent of the characteristics of the GP(s) on-call. This implied a matching procedure, defined by combining information on patients: (i) being in same 10-year age groups, (ii) visiting the same out-of-hours service, (iii) on the same weekday in the same month and year, and (iv) in the same 8-h time unit during the day (Fig. 1). By matching patients and analyzing only within-group variability, we effectively controlled for all confounding that was constant within each patient-matched group. As an example, we compared patients in a given 10-year age group visiting a particular out-of-hours service on a Tuesday evening in January 2015 with patients in the same 10-year age group visiting the same service one of the three other Tuesday evenings in January 2015. For about 70% of patients, only one GP was available on-call (in the current 8-h time unit and age group). To avoid the effect of possible patient selection in situations where two or more GPs were on-call at the same time, we used the weighted average of GP characteristics within each 8-h time unit in each service.

We excluded out-of-hours claims where the patient's regular GP was present at the out-of-hours service, as these contacts could easily be made based on an agreement between the patient and the GP. See Supplementary Material for details of the study design.

Outcome variables

The study had the following outcomes:

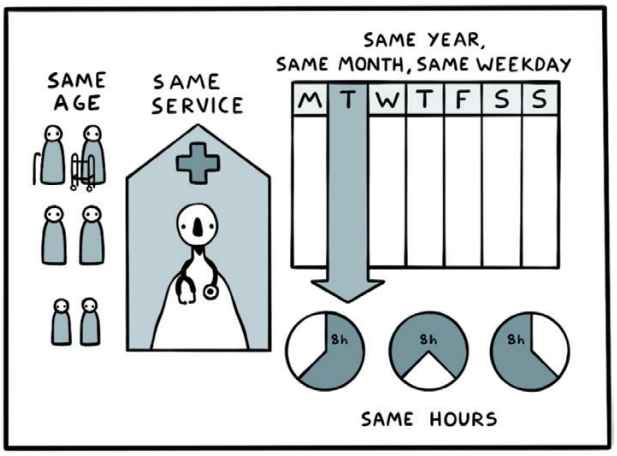

Fig. 1. Study design. Comparable groups were made by matching patients in the same 10-year age group, visiting the same out-of-hours service, the same weekdays in the same month and year, and the same 8-h time unit.

1) Immediate unplanned hospital admissions, defined as urgent hospital contact registered within 10 h:
   a. Admissions for all conditions vs not admitted.
   b. Admissions for critical conditions vs not. Critical conditions were measured as contacts resulting in a severe discharge diagnosis, such as myocardial infarction, stroke, pulmonary embolism, severe head injuries, fractures, and infections (see Supplementary Material for a complete list of ICD-10 codes).
2) Thirty-day unplanned hospital use presented per 1,000 GP contacts:
   a. Cumulative incidence of unplanned hospital admissions.
   b. Cumulative costs from unplanned hospital stays starting within 30 days after the index contact. The costs were calculated from diagnosis-related group points.[20]
3) Thirty-day risk of death (only for the two oldest patient groups due to few deaths among the youngest).

Exposure variables

GP characteristics at the time of each contact included the GPs' sex, age, and speciality status. Further, we measured the GPs' previous working experience from out-of-hours services (defined as "low" if less than 200 out-of-hours contacts during the two preceding years) and the "prior admission proportion," calculated as the proportion of out-of-hours contacts during the preceding 4-month period resulting in immediate unplanned hospital admission, excluding the contact with the index patient. We divided the study population into four equal sized groups (quarters), based on the prior admission proportion of the GP(s) on-call. The top quarter was patients under the care of GPs with the highest hospital referral tendency, and the bottom quarter was under the care of GPs with the lowest. By comparing the top with the bottom quarters, we avoided comparisons with extreme deviations from normal practice.

Statistical analyses

Patient contacts were matched in groups as described above. All multivariable analyses were performed with a within-matched-group estimator. We performed separate analyses and present results for three age groups: 0–10 years, 11–69 years, and 70 years and older. Immediate unplanned hospital admissions and 30-day risk of death were analyzed with a within-matched-group estimator with conditional logistic regression (clogit command in Stata), while the 30-day unplanned hospital admissions and costs (for hospital stays starting 0–30 days after a contact) were estimated using a within-matched-group estimator with linear regression (xtreg, fe in Stata). In addition to the matching procedure, all estimates were adjusted for patient sex, age, and age squared. Precision was evaluated with robust 95% confidence intervals (CIs). The analyses were performed with Stata version 15.1.

Assumptions and additional analyses

Within each matched group, we assumed that the GP characteristics would not be associated with possible confounding characteristics of the patients. To justify this assumption, we performed balance tests calculating the associations between potentially confounding patient characteristics and the GP characteristics. The patient characteristics included age, sex, immigration status (yes/no), and education

(completed less than 13 years). Further, as a proxy for patient morbidity, we used the patients' health service contacts 30 days before each contact (i.e. GP visits, planned and unplanned hospital admissions, and outpatient visits), in addition to a Charlson Comorbidity Index score based on diagnoses from the most recent hospital visit the previous month.[21] Results are presented in Supplementary Table 1. In Supplementary Table 4, results for the main analysis are presented for each 10-year age group. We also analyzed all exposure variables adjusted for each other (Supplementary Fig. 1). Further, we compared the OR for immediate unplanned hospital admission for patients under the care of the active GPs and the other physicians (defined as non-GPs) staffing the out-of-hours services (Supplementary Table 3).

Results

We present descriptive results in Table 1. In the age group 0–10 years, 6.2% had an unplanned admission to hospital within 10 h of the index contact. For the age group 11–69 years and 70 and older, the corresponding numbers were 12.4% and 25.8%. For patients aged 11–69 years, 0.2% died within 30 days after the index contact. For patients aged 70 years and older, 4.6% died.

Immediate unplanned hospital admissions

All conditions

A 10-year increase in the GP age was associated with 5%–8% reduced odds of unplanned hospital admission (adjusted odds ratio [aOR] 0.92, 95% CI 0.90–0.93 in patients 0–10 years, aOR 0.95, 95% CI 0.94–0.96 in patients 11–69 years, and aOR 0.94, 95% CI 0.93–0.95 in patients 70 years and older) (Fig. 2). Contact with a male vs female GP gave 12% lower odds for hospital admission for patients aged 70 years and older and 24% lower odds for patients aged 0–10 years. GP specialists admitted fewer of their patients, and GPs with low out-of-hours experience admitted more. Contacts with GPs in the highest quarter in prior admission proportion compared with the lowest quarter were associated with a substantially higher admission aOR of 1.85 (95% CI 1.74–1.96) for patients aged 0–10 years, an aOR of 1.80 (95% CI 1.75–1.85) in patients aged 11–69 years, and an aOR of 1.73 (95% CI 1.66–1.82) for patients aged 70 years and older.

Critical conditions

Contacts with GPs in the highest quarter in prior admission proportion compared with the lowest quarter were associated with higher odds also for admissions for critical conditions (aOR of 1.05, 95% CI 0.68–1.64 for patients aged 0–10 years, an aOR of 1.40, 95% CI 1.26–1.55 in patients aged 11–69 years, and an aOR of 1.16, 95% CI 1.03–1.29 for patients aged 70 years and older). Male GPs referred fewer patients aged 0–10 discharged with a critical condition (aOR 0.69, 95% CI 0.51–0.92).

Thirty-day unplanned hospital use

Higher GP age and seeing a male GP were associated with slightly fewer unplanned hospital admissions and lower costs 30 days after

Table 1. Out-of-hours contacts with GPs[a] in Norway 2008–2016: characteristics of patients and GPs weighted by the number of index contacts.

	Patients 0–10 years	Patients 11–69 years	Patients 70 years and older
Patient characteristics by number of index contacts			
All	871,947	2,553,888	509,798
Mean age, years (SD)	4 (2.8)	37 (16.3)	80 (6.9)
Male (%)	470,113 (54)	1,124,544 (44.0)	211,904 (41.6)
Low education[b] (%)	—	864,538 (37.5)	233,814 (46.1)
Immigration status[c] (%)	201,602 (23.1)	397,065 (15.6)	16,924 (3.3)
Unplanned hospital admission previous month (%)	23,482 (2.7)	133,622 (5.2)	63,960 (12.6)
Elective hospital admission previous month (%)	57,215 (6.6)	298,059 (11.7)	111,782 (21.9)
Outpatient clinic visits previous month (%)	64,480 (7.4)	320,522 (12.6)	114,415 (22.4)
Regular GP visits previous month (%)	81,592 (9.4)	228,862 (9.0)	56,239 (11.0)
Charlson Comorbidity Index[d], mean (SD)	0.01 (0.11)	0.05 (0.39)	0.24 (0.90)
Unplanned hospital admission next 10 h (%)	53,790 (6.2)	317,340 (12.4)	131,552 (25.8)
Unplanned hospital admission with urgent condition next 10 h (%)	785 (0.09)	17,334 (0.68)	16,630 (3.3)
Unplanned hospital admission with hip fracture (ICD-19 S72) next 10 h (%)	—	—	4,464 (0.9)
Unplanned hospital admission next 30 days (%)	94,490 (10.9)	510,744 (20)	197,649 (38.8)
Death within 30 days	—	5,292 (0.2)	23,509 (4.6)
GP characteristics weighted by index contacts			
Contacts with male physicians, *n* (%)	670,904 (76.9)	1,950,322 (76.4)	385,178 (75.6)
GP age, mean (SD)	43.6 (9.2)	43.7 (9.3)	43.7 (9.3)
Contacts with GP specialists, *n* (%)	4,240,124 (48.6)	1,234,398 (48.3)	239,740 (47)
Contacts with GPs with low OOH[e] experience, *n* (%)	93,549 (10.7)	283,273 (11.1)	61,311 (12.0)
Physician prior admission proportion[f] %, median (IQR[g])	10.8 (6.7–15.6)	12.1 (7.0–16.3)	11.9 (7.6–16.8)

[a]General practitioner.
[b]Completed less than 13 years in school.
[c]Immigrants and Norwegian-born to immigrant parents.
[d]Based on diagnoses from the last hospital visit previous month.
[e]Out-of-hours.
[f]The proportion of out-of-hours consultations resulting in unplanned hospital admissions the previous 4 months.
[g]Interquartile range.

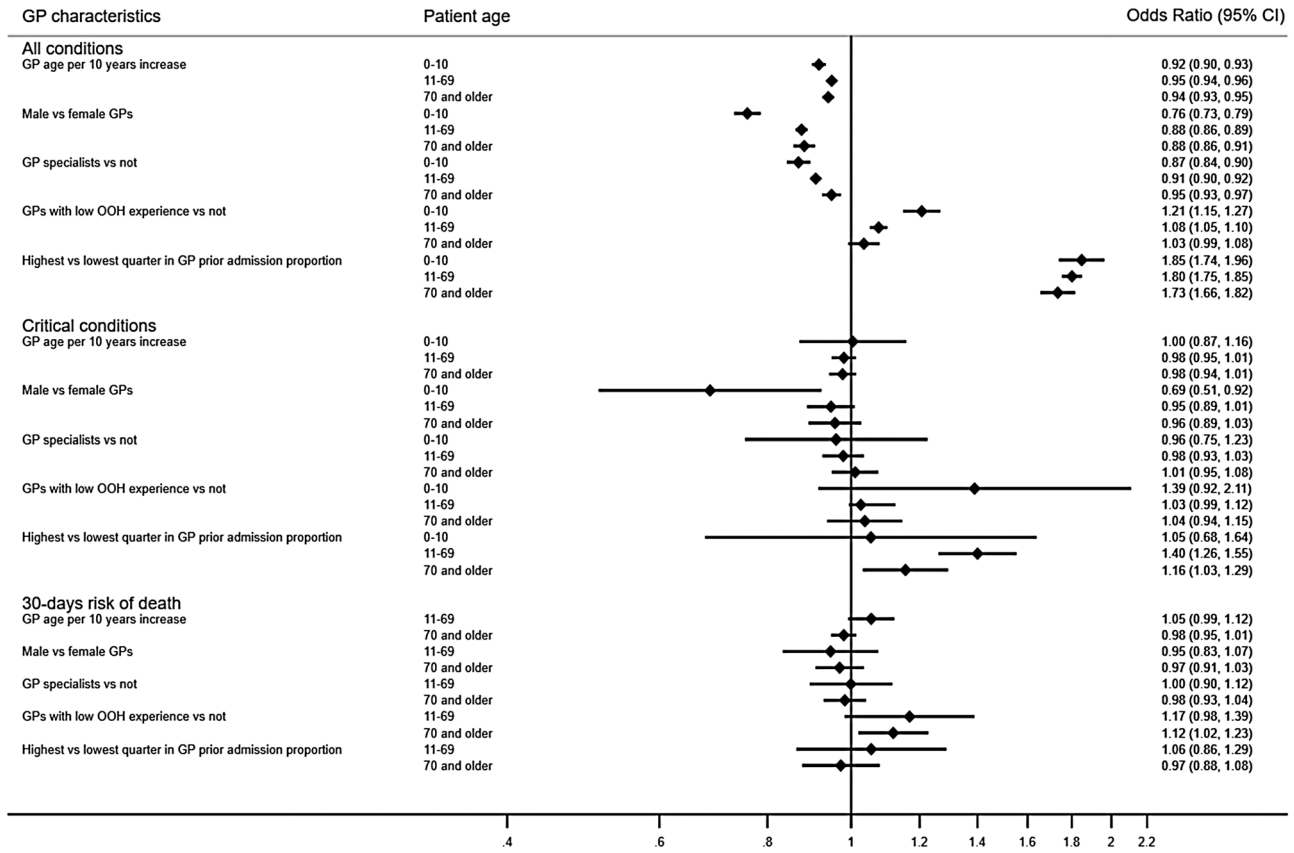

Fig. 2. All Norwegian out-of-hours contacts 2008–2016. Odds ratios for unplanned hospital admission for all conditions, critical conditions, and 30-day risk of death after the index contact. The associations were computed by comparing patients in the same 10-year age groups visiting the same out-of-hours services on the same weekdays, during the same year, month, and 8-h time unit, and were adjusted for patient sex, age, and age squared.

the index contact (Table 2). GPs' speciality status and out-of-hours experience did not substantially influence 30-day unplanned hospital admissions or costs. Contacts with GPs in the highest quarter in prior admission proportion compared with the lowest quarter were estimated to result in more unplanned hospital admissions in the 30 days following the index contact (adjusted difference per 1,000 GP contacts of 35 [95% CI 31–39] in patients 0–10 years, and 80 [95% CI 71–90] more in patients 70 years and older) and also higher 30-day unplanned hospital costs (adjusted difference per 1,000 GP contacts of 54,301€, 95% CI 36,557–72,045€ for patients aged 0–10 years, 127,344€, 95% CI 99,685–155,002€ in patients aged 11–69 years, and 412,353€, 95% CI 285,561–539,145€ for patients aged 70 years and older).

Thirty-day risk of death

There was little evidence of any associations between GP characteristics and 30-day risk of death after the index contact, however we observed 12%–17% increased odds of death associated with GPs with low out-of-hours experience (Fig. 2).

Analysis of exposure independence assumption and sensitivity analyses

After applying the matching procedure, we found weak or no associations between the patients and GP characteristics (Supplementary Table 1), supporting our assumption of independence between possible confounders and GP characteristics. The estimates of the GPs' prior admissions proportion were not substantially affected by adjustments for the other GP characteristics (Supplementary Fig. 1). The aOR for immediate admission after contact with a non-GP was slightly higher compared with contact with a GP (1.11, 95% CI 1.09–1.14 for patients 0–10 years, 1.08, 95% CI 1.06–1.09, for patients 11–69 years, and 1.02, 95% CI 1.00–1.04 for patients aged 70 years and older) (Supplementary Table 3).

Discussion

Summary

This study suggested substantial impact from GP characteristics on unplanned hospital admissions following contact with the out-of-hours services. GP age and sex showed modest associations with immediate unplanned hospital admissions. In contrast, the GPs' prior admission proportion was strongly associated with both immediate unplanned hospital admissions and 30-day unplanned hospital admissions and costs. Notably, GPs with a previously higher tendency of admitting patients also more often admitted patients with critical conditions, indicating that a more restrictive referral practice may threaten patient safety through missing out on critical cases. However, there was little evidence of the GP characteristics affecting the 30-day risk of death.

Strengths and limitations

The Norwegian out-of-hours services model with the primary care gatekeeper function resembles the systems in many western European countries providing external validity.[10] Our large study size with comprehensive register data, made it possible with close matching to avoid confounding and still achieve precise estimates

with CIs reasonably narrow. GPs have a key role in Norwegian out-of-hours services, but the recent pressure on primary care services may threaten their position in this setting. Our study did not cover non-GPs working in out-of-hours services. However, non-GP physicians working out-of-hours did not deviate substantially in immediate admissions, results in concurrence with previous research.[14]

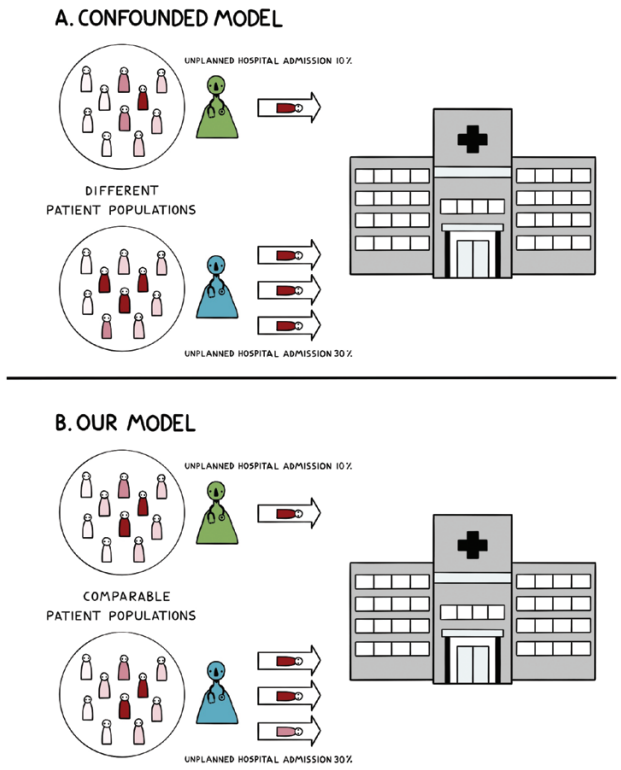

Fig. 3. (A) Different patient populations, where differences in unplanned hospital admission proportion are affected by differences in patient morbidity. (B) Assuming comparable patient populations, where differences in unplanned hospital admission proportion better reflect the differences between the GPs' decisions.

Confounding is the main concern when comparing clinical practice between physicians. A commonly used approach is to use multivariable adjustment to control for confounding. However, this requires detailed information on all important confounders, as well as no measurement error. This is an assumption we find hard to justify. Therefore, we designed our study to mimic the situation of a random distribution of patients meeting different GPs (Fig. 3). Our sensitivity analyses supported our assumption of independence between patient and GP characteristics at the time of the contact. Nevertheless, this was an observational study, and residual confounding cannot be ruled out.

Comparison with existing literature

Many approaches have been made to disentangle the factors and mechanisms of importance for decisions on referrals and hospital admissions.[2–7,22–34] With our study design aimed to limit confounding, we found that both older and male GPs were more restrictive in their admissions, which concurs with other studies' findings. [6,7,26,31,34,35] GP specialist status and out-of-hours experience showed some associations with unplanned hospital admissions for the youngest patient group, in concordance with previous literature where specialists in general practice were found to refer fewer of their patients.[26,35] However, the associations were weaker for the older patients.

Implications for research and practice

The increasing pressure on the healthcare system, including rising healthcare expenditure particularly on specialized healthcare, is challenging. New policies often aim to reduce unnecessary hospital use, where reducing variations in unplanned hospital admissions is one of many targets. Still, there is insufficient knowledge on the consequences of this variation. In this study, we found that older and male GPs admitted fewer of their patients in all patient age groups

Table 2. Change in number of unplanned hospital admissions and the cumulative costs from hospital stays starting within 30 days following the index contact according to GP characteristics, presented per 1,000 GP contacts. Linear regression analyses of all Norwegian out-of-hours contacts 2008–2016.

Thirty-day unplanned hospital use[a]	Patients 0–10 years		Patients 11–69 years		Patients 70 years+	
	Change	95% CI	Change	95% CI	Change	95% CI
Thirty-day unplanned admissions per 1,000 patient contacts						
GP[b] age per 10 years	−5	−7 to −4	−5	−6 to −4	−8	−11 to −5
Male vs female GPs	−17	−20 to −14	−14	−16 to −12	−16	−22 to −10
GP specialists vs not	−8	−10 to −6	−11	−13 to −9	−5	−10 to 0
GPs with low OOH[c] experience vs not	12	8 to 16	8	5 to 11	6	−3 to 15
Highest vs lowest quarter in prior admission proportion[d]	35	31 to 39	58	54 to 61	80	71 to 90
Costs from unplanned admissions starting within 30 days (EURO) per 1,000 patient contacts						
GP age per 10 years	−6,284	−12,196 to −373	−11,538	−20,108 to −2,969	−23,580	−61,524 to 14,365
Male vs female GPs	−33,546	−46,739 to −20,354	−25,988	−43,405 to −8,570	−24,057	−104,685 to 56,571
GP specialists vs not	−2,353	−12,516 to 7,811	−24,390	−39,353 to −9,427	68,106	−1,014 to 137,225
GPs with low OOH[c] experience vs not	15,789	−3,555 to 35,133	24,336	−821 to 49,493	38,445	−74,995 to 151,884
Highest vs lowest quarter in prior admission proportion[d]	54,301	36,557 to 72,045	127,344	99,685 to 155,002	412,353	285,561 to 539,145

[a]General practitioner.

[b]The associations were computed by comparing patients in the same 10-year age groups visiting the same out-of-hours services on the same weekdays, during the same month and same time period of the day, and were adjusted for patient sex, age, and age squared.

[c]Out-of-hours.

[d]GP prior admission proportion the previous four calendar months.

and that these differences sustained over 30 days. However, these differences were not reflected in the 30-day risk of death. Further, the differences in 30-day costs from specialized healthcare were modest, especially for the two oldest patient groups. The recruitment and retention problems currently seen in European out-of-hours primary care, as well as in general practice, can influence the composition of GPs and other physicians staffing primary care. In Norway, the cohort of GPs is changing toward a higher share of female and young physicians.[19] Yet, according to our results, even substantial changes in GP sex and age composition will not affect costs substantially. The GPs with the highest prior admission proportion however, had higher numbers of both immediate and 30-day admissions, and substantially higher costs. This implies potential for lowering specialized healthcare expenditure through strengthening the out-of-hours services, with emphasis on optimizing the framework for decision making, rather than raising the requirements for specialist status and experience. Considering the out-of-hours settings with a lack of time, resources, and previous knowledge of the patient, deciding whether to refer a patient to the hospital is more challenging than in normal hours primary care. Facilitating opportunities to confer with a peer or a more specialized physician, implementing new technical solutions like shared patient journals, decision support, and feedback on referrals and patient outcomes may help strengthen the decisions and reduce unwanted variation.

Importantly, this study also recognizes the differences in admissions for critical conditions that may nuance the picture, suggesting that more restrictive referral practices may delay admissions for such critical urgent cases and threaten patient safety. This is an important aspect in the use of referral rates as quality measures for primary care physicians,[36] and in the debate on limiting referral options on the individual GP level as a means to reduce hospital admissions.

We found no apparent associations with short term risk of death from differences in admission practices, a result that is reassuring from a patient perspective. However, the increase in 30-day risk of death after contact with GPs with low out-of-hours experience should receive further investigations.

Conclusions

This study's results provide evidence of substantial differences between GP admission practices, indicating a need for systematic work to optimize the framework for GPs' admission decisions. However, raising the requirements for experience and specialist status, or altering the age or sex in the group of GPs staffing the out-of-hours services, may not affect the consequences of the observed differences. Improving feedback on both GP admission practices and patient outcomes in the existing out-of-hours services system are possible targets.

Supplementary material

Supplementary material is available at *Family Practice* online.

Funding

This project was funded by the Research Council of Norway with grant numbers 256579 and 295989.

Ethical approval

This study has been approved by the Regional Committees for Medical and Health Research Ethics (2016/2158/REK midt). Participant consent was not required.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. All authors have completed the ICMJE COI form.

References

1. Sripa P, Hayhoe B, Garg P, Majeed A, Greenfield G. Impact of GP gatekeeping on quality of care, and health outcomes, use, and expenditure: a systematic review. *Br J Gen Pract*. 2019;**69**(682):e294–e303.
2. Bankart MJG BR, Rashid A, *et al*. Characteristics of general practices associated with emergency admission rates to hospital: a cross-sectional study. *Emerg Med J*. 2011;**2011**(28):558–563.
3. Forrest CB, Nutting PA, von Schrader S, Rohde C, Starfield B. Primary care physician specialty referral decision making: patient, physician, and health care system determinants. *Med Decis Making*. 2006;**26**(1):76–85.
4. O'Donnell CA. Variation in GP referral rates: what can we learn from the literature? *Fam Pract*. 2000;**17**(6):462–471.
5. Calnan M, Payne S, Kemple T, Rossdale M, Ingram J. A qualitative study exploring variations in GPs' out-of-hours referrals to hospital. *Br J Gen Pract*. 2007;**57**(542):706–713.
6. Ringberg U, Fleten N, Forde OH. Examining the variation in GPs' referral practice: a cross-sectional study of GPs' reasons for referral. *Br J Gen Pract*. 2014;**64**(624):e426–e433.
7. Rossdale M, Kemple T, Payne S, Calnan M, Greenwood R. An observational study of variation in GPs' out-of-hours emergency referrals. *Br J Gen Pract*. 2007;**57**(535):152–154.
8. Sullivan CO, Omar RZ, Ambler G, Majeed A. Case-mix and variation in specialist referrals in general practice. *Br J Gen Pract*. 2005;**55**(516):529–533.
9. Blinkenberg J, Pahlavanyali S, Hetlevik Ø, Sandvik H, Hunskaar S. General practitioners' and out-of-hours doctors' role as gatekeeper in emergency admissions to somatic hospitals in Norway: registry-based observational study. *BMC Health Services Res*. 2019;**19**(1).
10. Steeman L, Uijen M, Plat E, Huibers L, Smits M, Giesen P. Out-of-hours primary care in 26 European countries: an overview of organizational models. *Fam Pract*. 2020;**37**(6):744–750.
11. Berchet C, Nader C. *The organisation of out-of-hours primary care in OECD countries*. Paris; 2016. Report No: 89.
12. Marchand C, Peckham S. Addressing the crisis of GP recruitment and retention: a systematic review. *Br J Gen Pract*. 2017;**67**(657):e227–e237.
13. Svedahl ER, Pape K, Toch-Marquardt M, Skarshaug LJ, Kaspersen SL, Bjorngaard JH, *et al*. Increasing workload in Norwegian general practice - a qualitative study. *BMC Fam Pract*. 2019;**20**(1):68.
14. Sandvik H, Hunskar S. [Working style among regular general practitioners and other doctors in the out-of-hours services]. *Tidsskr Nor Laegeforen*. 2010;**130**(2):135–138.
15. The Norwegian Directorate of Health. KUHR-databasen 2019. https://www.helsedirektoratet.no/tema/statistikk-registre-og-rapporter/helsedata-og-helseregistre/kuhr.
16. Bakken IJ, Ariansen AMS, Knudsen GP, Johansen KI, Vollset SE. The Norwegian Patient Registry and the Norwegian Registry for Primary Health Care: Research potential of two nationwide health-care registries. *Scand J Public Health*. 2020;**48**(1):49–55.
17. Statistics Norway. Statistisk sentralbyrå. https://www.ssb.no/en.
18. Norwegian Insitute of Public Health. The Norwegian Cause of Death Registry 2020. https://www.fhi.no/en/hn/health-registries/cause-of-death-registry/.
19. The Norwegian Directorate of eHealth. The regular general practitioner register (Fastlegeregisteret) 2020. https://helsedata.no/forvaltere/helsedirektoratet/fastlegeregisteret/.

20. The Norwegian Diractorate of Health. Activity based funding 2016 (Innsatsstyrt finansiering 2016). 12/2015. Report No. ISBN-nr. 978-82-8081-417-3.
21. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;**40**(5):373–383.
22. Evans E AH, Edwards A. Reducing variation in general practitioner referral rates through clinical engagement and peer review of referrals: a service improvement project. *Qual Prim Care* 2011;**19**(4):263–272.
23. Barnett ML, Song Z, Landon BE. Trends in physician referrals in the United States, 1999-2009. *Arch Intern Med*. 2012;**172**(2):163–170.
24. Burton CD, McLernon DJ, Lee AJ, Murchie P. Distinguishing variation in referral accuracy from referral threshold: analysis of a national dataset of referrals for suspected cancer. *BMJ open*. 2017;**7**(8):e016439.
25. Reid FD, Cook DG, Majeed A. Explaining variation in hospital admission rates between general practices: cross sectional study. *BMJ*. 1999;**319**(7202):98–103.
26. Franks P, Williams GC, Zwanziger J, Mooney C, Sorbero M. Why do physicians vary so widely in their referral rates? *J Gen Intern Med*. 2000;**15**(3):163–8.
27. Geissler KH. Differences in referral patterns for rural primary care physicians from 2005 to 2016. *Health Serv Res*. 2020;**55**(1):94–102.
28. Grondahl JR, Fossdal O, Hauge-Iversen T, Husebye E, Rosvold EO, Kongshavn T. [Admissions to the medical department - who admits and why]. *Tidsskr Nor Laegeforen*. 2018;**138**(8).
29. Gunther S, Taub N, Rogers S, Baker R. What aspects of primary care predict emergency admission rates? A cross sectional study. *BMC Health Serv Res*. 2013;**13**:11.
30. Huntley A, Lasserson D, Wye L, Morris R, Checkland K, England H, *et al*. Which features of primary care affect unscheduled secondary care use? A systematic review. *BMJ Open*. 2014;**4**(5):e004746.
31. Ingram JC, Calnan MW, Greenwood RJ, Kemple T, Payne S, Rossdale M. Risk taking in general practice: GP out-of-hours referrals to hospital. *Br J Gen Pract*. 2009;**59**(558):e16–e24.
32. McBride D, Hardoon S, Walters K, Gilmour S, Raine R. Explaining variation in referral from primary to secondary care: cohort study. *BMJ*. 2010;**341**:c6267.
33. Oslislo S, Heintze C, Schmiedhofer M, Möckel M, Schenk L, Holzinger F. How to decide adequately? Qualitative study of GPs' view on decision-making in self-referred and physician-referred emergency department consultations in Berlin, Germany. *BMJ open*. 2019;**9**(4):e026786.
34. Gehring ND, Kebbe M, Rathwell S, Perez A, Peng C, Zendher E, *et al*. Physician-related predictors of referral for multidisciplinary paediatric obesity management: a population-based study. *Fam Pract*. 2021;**38**(5):576–581.
35. Ringberg U, Fleten N, Deraas TS, Hasvold T, Forde O. High referral rates to secondary care by general practitioners in Norway are associated with GPs' gender and specialist qualifications in family medicine, a study of 4350 consultations. *BMC Health Serv Res*. 2013;**13**:147.
36. Love T, Dowell AC, Salmond C, Crampton P. Quality indicators and variation in primary care: modelling GP referral patterns. *Fam Pract*. 2004;**21**(2):160–165.