BMJ Open

General practitioner discontinuity and health care utilisation in 2.5 million Norwegians

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042391
Article Type:	Original research
Date Submitted by the Author:	06-Jul-2020
Complete List of Authors:	Skarshaug, Lena; Norwegian University of Science and Technology, Department of Public Health and Nursing Kaspersen, Silje; SINTEF, Digital; Norwegian University of Science and Technology, Public Health and Nursing Bjorngaard, Johan; Norwegian University of Science and Technology, Department of Public Health and Nursing; Nord Universitet - Levanger Campus, Faculty of Nursing and Health Sciences Pape, Kristine; Norwegian University of Science and Technology, Public Health and Nursing
Keywords:	PRIMARY CARE, EPIDEMIOLOGY, PUBLIC HEALTH, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

General practitioner discontinuity and health care utilisation in 2.5 million Norwegians

Lena J. Skarshaug* [a]

Silje L. Kaspersen [a, b]

Johan H. Bjørngaard [a, c]

Kristine Pape [a]

a) Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Trondheim, Norway

b) SINTEF Digital, SINTEF, Trondheim, Norway

c) Nord University, Faculty of Nursing and Health Sciences, Levanger, Norway

*Correspondence to Lena J. Skarshaug, Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Håkon Jarls Gate 11, 7030 Trondheim, Norway; E-mail: lena.j.skarshaug@ntnu.no

MeSH keywords: general practice, continuity of patient care, health service research, hospitalization, primary health care.

Word count: 3054 words.

ABSTRACT

Objectives: Patients may benefit from continuity of care by a personal physician (GP), but there are few studies on consequences of a break in continuity of GP. Investigate how a sudden discontinuity of GP care affects their list patients' regular GP consultations, out-of-hours consultations and acute hospital admissions, including admissions for ambulatory care sensitive conditions (ACSC).

Design: Cohort study linking person-level national register data on use of health services and GP affiliation with data on GP activity and GP characteristics.

Setting: Primary Care

Participants: 2,529,311 Norwegians assigned to the patient lists of 2,501 regular GPs who, after 12 months of stable practice, had a sudden discontinuity of practice lasting two or more months between 2007 and 2017.

Primary and secondary outcome measures: Monthly registrations of health care use during the same time periods before (2-7 months before), during (1 month before to 1 month after) and after (2-13 months after) discontinuity. Logistic regression models compared monthly GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in periods during and after the discontinuity with the period before the discontinuity for five age groups separately.

Results: All age groups had a 3-5% decreased odds of monthly regular GP consultations during the discontinuity. Odds of monthly out-of-hours consultations increased 3-7% during the discontinuity for all adult age groups. Odds of hospital admissions increased during and after the discontinuity in those older than 65 years, particularly for ACSC admissions.

Conclusions: Older patients are sensitive to increased acute hospital admissions in the absence of their personal GP.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on person-level registry data on the entire Norwegian population and their GPs in the period 2007 to 2017.
- We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care).
- By following the same patient population over time, we eliminated time-invariant or slow-varying confounding factors related to the composition of patient groups
- It is possible that the consequences of discontinuity would differ according to the causes of the break, which we were unable to measure due to lack of data.

BACKGROUND

Continuity of care is a core value of primary care and general practice, including personal, informational and managerial aspects of continuity.[1] In contrast to the extensive literature suggesting that high continuity of care in general practice reduces hospital admissions,[2-8] readmissions,[9] out-of-hours service visits,[10-12] mortality,[13-16] and health care costs,[17] there is little research on consequences for patients of a break in the continuity of care. In this study, we investigate the consequences regarding health service use for patients who experience discontinuity of care from their regular general practitioner (GP). Patients who experience such discontinuity may have reduced access to regular GPs during office hours and shift to out-of-hours services. Also, not being able to see their regular GP could lead to an increase in avoidable hospital admissions, as the regular GP would be better suited to do a proper assessment of both the medical conditions and the patient's total situation, including alternatives to hospital admission.

The establishment of the Norwegian regular GP scheme in 2001 introduced a structural emphasis on continuity of GP care by entitling all inhabitants to a regular GP within a list-based system,[18] aiming to ensure health services with high availability and continuity for all inhabitants, including vulnerable and marginalized groups.[19] This system has shown the ability to provide a high degree of personal GP continuity.[20] Some discontinuities of GP practice are inevitable, as GPs retire, get sick and take parental leave. Interpretations between patient's level of continuity of care and patient outcomes are problematic since the healthier and less-vulnerable individuals may have fewer incentives to visit different physicians.[21]

We utilised Norwegian register data to design a study comparing healthcare use in populations differing in the continuity of GP care. We identified all registered list patients of contracted GPs with a stable practice pattern who suddenly stopped meeting patients for at least two months. Regardless of the reasons for such GP discontinuity, the list patients had to seek help from other physicians in the period when their GP was temporarily or permanently gone. Synchronization of all patient timelines when their GP had a discontinuity of practice allowed us to assess the use of primary and specialist health care services in periods before, during and after the discontinuity – comparing the entire patient population to itself. Thus, the study aimed to investigate if exposure to GP discontinuity would decrease patients' use of any regular GP but increase their use of the out-of-hours services and potentially also the need for acute hospital admissions.

METHODS

The Norwegian context

Primary care in Norway is organized by the municipalities and includes regular GP services during office hours and out-of-hours services (partly staffed by regular GPs) for emergency medical help. Like the US, the UK and Australia,[22] Norway practices a high level of primary care gatekeeping. Specialist care is generally possible only after a referral from a GP, except for emergency admissions. Health services coverage is universal for all Norwegian residents, and for acute hospital admission, there are no private alternatives. Most GPs work in group practices, most as self-employed (reimbursed by the national insurance system in addition to out-of-pocket payments from patients) and some on fixed salary from the municipality.

Data

This study has a longitudinal design with person-level data from Norwegian national registers on the entire population during the period 2007-2017. We combined demographical information from Statistics Norway[23] with several Norwegian national registers: the Control and Payment of Health Reimbursement register (KUHR)[24] (on regular and out-of-hours consultations with GPs), the Norwegian General Practitioner Register[25] (on GP affiliation, patient list information, individual GP characteristics) and the Norwegian Patient Register[26] (on acute hospital admissions). Linkage of person-level data from different sources was possible by the identification number unique to all Norwegian inhabitants. Individuals were linked to their appointed regular GP, and each GP's doctor ID allowed identification of GP activity and characteristics.

Episodes of GP practice discontinuity

Each time a GP is in contact with a patient, a claim for reimbursement is submitted to the Norwegian Health Economics Administration (Helfo). This claim includes patient ID, time, type of contact, patient diagnosis and information about the GP. These claims are collected in the KUHR database – where both individual patients and doctors may be identified through identification numbers.

For all GPs, we assessed the number of submitted reimbursement claims for ordinary consultations (code 2ad) in the KUHR data each month in the period 2007 to 2017. We linked the monthly

registrations on consultation activity to monthly information on the GP practice characteristics from the Norwegian General Practitioner Register. Episodes of two or more consecutive months with less than 10 consultations per month were identified as discontinuities, with the first month indicating the index month of discontinuity (see (a) exposure in Figure 1). We defined the month two months before the index month as "last month of normal operation".

We only included episodes of discontinuity for regular GPs registered as list owners (excluding locums, interns) in the last month of normal operation (number of GP episodes=5610) and who had a stable practice during at least 12 previous months – with the same list and no month with less than 10 consultations (excluding 2,399 episodes). Furthermore, we excluded 293 episodes for GPs registered with short lists (<500 patients) or low activity during the 12 months before the break (<1000 consultations or ratio<1 for the total number of consultations the last 12 months/registered list size). For each doctor, we only kept the first episode of discontinuity (whereas patients could experience several episodes), removing 415 episodes. The final GP population consisted of 2,501 GPs.

Exposure/discontinuity periods

We defined four different periods according to their time from the index month of discontinuity (see (c) outcome in Figure 1), with monthly registrations of health care use before (2-7 months before), during (1 month before to 1 month after) and after (2-7 months after and 8-13 months after).

Study population

The study population comprised all persons registered as list patients of the GPs with an episode of practice discontinuity 12 months before this discontinuity (see (b) baseline in Figure 1).

Patient and public involvement

Patients and/or the public were not involved in the development of the research question, study design or interpretation of the data.

Outcome/Health care use and follow-up

For each patient, we identified health care use each month during the follow-up period–dichotomised into monthly use/no monthly use (see (c) in Figure 1). Regular and out-of-hours GP consultations were identified by the reimbursement code for a regular GP consultation (code 2ad[27]) and a GP consultation outside normal working hours (code 2ak[27]) from 2006 to 2017. Acute hospital admissions were identified in the Norwegian Patient Registry from 2008 to 2016, using the dates of admission and discharge for hospital stays that were coded as acute.[26] We also used ICD-10 diagnosis codes to identify hospital stays for ambulatory care sensitive conditions (ACSC). These are conditions for which hospitalisation is thought to be avoidable with the application of preventive care and early disease management, usually delivered in ambulatory settings.[28] We included chronic conditions for which effective management prevents flare-ups (angina pectoris, asthma, chronic obstructive pulmonary disease, congestive heart failure, convulsions/epilepsy, diabetes complications, hypertension, iron deficiency anaemia), acute conditions for which early intervention may prevent more serious progression (ear, nose and throat infections, cellulitis, pyelonephritis, dehydration/gastroenteritis, pelvic inflammatory disease, gangrene, dental conditions, nutritional deficiencies, perforated/bleeding ulcer) and vaccine-preventable conditions (Influenza, pneumonia and other) – using NHS Digital's ICD-10 codes for ACSC episodes.[29]

Our main outcomes were monthly regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in the period during (three-month period) and after (two six-month periods) the discontinuity compared to the stable period before (six-month period) the discontinuity of care.

Covariates

We collected information on patient birth year, sex, education and date for migration or death from Statistics Norway.[23] The highest achieved level of education by 2016 was measured in three categories: 'no/primary school', 'secondary school' and 'college/university'. GP characteristics before the episode of discontinuity (assessed 12 months before the index month of discontinuity) were available from the Norwegian General Practitioner Register[26] and included the GPs' sex and age, list size and municipality. Hypothesizing that urbanity/rurality would be of importance, we made two sub-selections consisting of 1) patients linked to GPs practicing in one of the 10 most-populated Norwegian municipalities and 2) patients linked to GPs practicing in one of the municipalities with less than 2000 inhabitants (both assessed per second quarter of 2019). Patient's health status was assessed during a

12-month period prior to follow-up (8-19 months before discontinuity) according to availability. We identified three subgroups for which we considered continuity of care to be of particular benefit: 1) Hypertension – all patients having one or more diagnoses of hypertension (ICPC2 diagnosis K85-87) in the KUHR data. 2) Ischemic heart disease – all patients having one or more diagnoses of (ICPC2 diagnosis K74-80) in the KUHR data and 3) acute hospital stay – all patients having one or more acute hospital stay.

Analyses

Patients were divided into categories according to their age at discontinuity (0-18, 19-44, 45-64, 65-79 and 80+ years), and all analyses were repeated for each category separately. We used logistic regression with generalized estimation equation (GEE)[30] models to estimate the odds ratios (OR) of monthly regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in the period during (1 month before to 1 month after) and for two periods after (2-7 months after and 8-13 months after) compared to the stable period before (2-7 months before) the discontinuity of care.

We did separate analyses according to patient sex, educational level (primary, secondary or tertiary), age of the GP (being older or younger than 50 years at the time of discontinuity), and size of practice municipality. In addition, we performed analyses on the patient subgroups with hypertension, ischemic heart disease and prior hospital stay.

In all analyses, we adjusted for calendar month, calendar year and patient sex (except when doing separate analyses for men and women). Since patients got 21 months older during the follow-up, we also adjusted for the number of follow-up months as a continuous variable. Patients were censored on the exact month of migration or death and periods lacking data. We performed all analyses with STATA version 15.1. Estimates are presented with 95% confidence intervals (CI).

RESULTS

In the period 2007 to 2016, a total of 2,529,311 patients were registered as list patients of our selection of 2,501 unique regular GPs with a stable practice, but who 12 months later had an episode

of discontinuity. The number of patient episodes of discontinuity was 2,818,002, as each patient could experience several episodes of discontinuity related to different GPs; 84% had one episode, 99% had 1 or 2 episodes, and the maximum number of episodes was five (data not shown). For baseline GP and patient characteristics, see Table 1. Patient healthcare use during the year prior to follow-up is available as Supplementary Table 1.

Table 1: Study sample with baseline characteristics of selected GP's with an episode of discontinuity in an earlier stable practice and their list patients (2007-2017).

GP characteristics [1]	*n*	%
Total	2,501	100 %
GP sex		
Female	1,053	42.1 %
Male	1,448	57.9 %
GP age at discontinuity		
GP < 50 years old	1,533	61.3 %
GP 50+ years old	968	38.7 %
GP activity		
Registered list size – mean number of patients (range)	1,127	500-2,500
Mean number of ordinary patient consultations during 12 months before discontinuity (range)	2,664	1,000-10,530
Patient characteristics [1]	***n***	**%**
Patient episodes [2]	2,818,002	100 %
Sex		
Female	1,417,725	50.3 %
Male	1,400,277	49.7 %
Age groups *n* (%)		
0-18	610,454	21.7 %
19-44	1,011,280	35.9 %
46-64	716,846	25.4 %
65-79	332,655	11.8 %
80+	146,767	5.2 %
Educational level[3] *n* (%)		
Primary	667,389	27.8 %
Secondary	997,289	41.5 %
Tertiary	740,153	30.8 %
Geography[4]		
Municipality < 2000 inhabitants	53,283	2 % (of total)
10 most populated municipalities	884,981	31 % (of total)

Monthly health service contact (age groups, % with at least one)	Regular GP	Out-of-hours	Acute admission	ACSC admission
0-18	10.2	2.1	0.3	0.06
19-44	16.0	1.5	0.7	0.04
46-64	19.7	1.1	0.7	0.11
65-79	26.6	1.2	1.5	0.35
80+	30.7	1.8	3.3	0.79

1: Patient- and GP characteristics were identified 12 months before the index month of discontinuity
2: incidents of discontinuity of care. Some patient could experience several episodes of discontinuity during our observation time, and hence be counted more than once.
3: Educational level measured in 2016
4: Municipality in which the patient's GP was registered. Municipality size per 2. quarter of 2019.

As seen in Table 2, patients in all age groups had a 3%-5% decreased odds of monthly consultation during the discontinuity (OR 0.95; 95% CI 0.95,0.96) for 65-79-year-olds, (OR 0.97; 95% CI 0.97,0.98) for 19-44-year-olds, followed by a normalisation after the discontinuity, compared with before the discontinuity. Compared with the period before the discontinuity, all adult age groups had a 3%-6% increased odds of monthly out-of-hours consultations during the discontinuity (OR 1.03; 95% CI 1.01,1.05) for 45-64-year-olds, (OR 1.06; 95% CI 1.03,1.10 and 1.02,1.10) for 65-79-year-olds and 80+-year-olds, respectively, which remained elevated after the discontinuity for most age groups (OR 1.05; 95%CI 1.03,1.08) for 19-44-year-olds, (OR 1.08; 95%CI 1.03,1.13) for 65-79-year olds, and (OR 1.07; 95%CI 1.00,1.14) for 80+-year-olds.

While there was little evidence for differences in acute hospital admissions for those under 65 years old, elderly patients had increased odds of acute hospitalisations after discontinuity. In the age group 65-79 years, the odds for ACSC admissions increased 6% during (95% CI 1.00-1.13), 12% 2-6 months after (95% CI 1.03-1.21) and 18% 7-12 months after (95% CI 1.04-1.35) compared with the period before discontinuity.

Table 2: Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for one or more monthly GP consultations, out-of-hours service consultations, acute hospital admissions and hospital admissions for ambulatory care sensitive conditions (ACSC) during (1 month before to 1 month after) and after (2-7 months after and 8-13 months after) a sudden discontinuity of GP care, compared to a 6-month stable period 2-7 months before the discontinuity. Separate analyses for each patient age group, adjusted for month/time, calendar month, calendar year and patient sex. (2007-2017)

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	0.95	(0.94-0.96)	0.97	(0.97-0.97)	0.95	(0.95-0.96)	0.95	(0.94-0.95)	0.96	(0.95-0.97)
After discontinuity I (2-7 months after)	0.97	(0.96-0.98)	0.99	(0.98-1.00)	0.99	(0.99-1.00)	1.01	(1.00-1.02)	1.01	(1.00-1.03)
After discontinuity II (8-13 months after)	0.96	(0.94-0.98)	0.99	(0.98-1.00)	0.98	(0.97-1.00)	1.00	(0.98-1.01	0.99	(0.97-1.01)
Monthly out-of-hours consultations (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	1.00	(0.98-1.02)	1.05	(1.03-1.06)	1.03	(1.01-1.05)	1.07	(1.04-1.10)	1.06	(1.02-1.10)
After discontinuity I (2-7 months after)	0.99	(0.97-1.02)	1.05	(1.03-1.08)	1.02	(0.99-1.05)	1.09	(1.04-1.14)	1.06	(1.00-1.12)
After discontinuity II (8-13 months after)	0.99	(0.95-1.03)	1.07	(1.03-1.11)	1.02	(0.96-1.06)	1.12	(1.05-1.19)	1.05	(0.97-1.15)
Monthly acute hospital admissions (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	1.01	(0.96-1.06)	1.02	(1.00-1.05)	1.01	(0.98-1.04)	1.03	(1.00-1.06)	1.03	(1.00-1.06)
After discontinuity I (2-7 months after)	1.02	(0.94-1.09)	1.01	(0.98-1.05)	1.01	(0.97-1.05)	1.04	(1.00-1.09)	1.03	(0.99-1.08)
After discontinuity II (8-13 months after)	1.06	(0.94-1.19)	1.01	(0.95-1.07)	1.01	(0.95-1.08)	1.04	(0.98-1.11)	1.01	(0.94-1.08)
Monthly ACSC hospital admissions (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	0.89	(0.79-1.00)	1.02	(0.92-1.13)	1.01	(0.94-1.09)	1.06	(1.00-1.13)	1.07	(1.00-1.14)
After discontinuity I (2-7 months after)	0.96	(0.80-1.14)	0.99	(0.86-1.15)	1.04	(0.93-1.15)	1.12	(1.03-1.21)	1.11	(1.01-1.22)
After discontinuity II (8-13 months after)	0.98	(0.75-1.29)	0.95	(0.76-1.19)	1.01	(0.87-1.21)	1.18	(1.04-1.35)	1.07	(0.93-1.24)

Supplementary analysis

Separate analyses on subgroups according to patient and GP characteristics are shown in Supplementary Tables 2-7. In general, the estimates for the subgroups resembled those from the main analyses. Older patient groups with increased premorbidity showed increased risk of hospital admission.

DISCUSSION

Summary

In this study, we followed all Norwegian inhabitants registered as list patients of stable practising GPs who experienced one or more episodes of discontinuity of GP care between 2007 and 2017. We found that all patient age groups had a small dip in regular GP consultations at the time of discontinuity, followed by normalisation for all adult groups. Out-of-hours consultations increased at the time of discontinuity for all adult groups and remained elevated during the following 12 months for those aged 19-44 years, 65-79 years and 80+ years. Acute admissions, and particularly admissions for ambulatory care sensitive conditions increased during and after the discontinuity in the two oldest age groups.

Strengths and limitations

We used a linkage of several registries, providing person-level data on the entire Norwegian population and their GPs within a rather long observation period, which provided relatively precise estimates, even in the separate subgroup analyses. The Norwegian GP scheme with <1% non-participants since the start in 2001[31] made it possible to link each individual in the population to their regular GP. By including all patients 12 months before the break in GP continuity, we did not condition on the patient surviving until discontinuity. Hence, we did not miss some of the acute (potentially fatal) hospital admissions in our observation time before the discontinuity, thereby avoiding immortal time-bias.[32]

We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care). We assessed the changes in outcome by following the same patient population over time. By design, we thereby eliminated all time-invariant or slow-varying confounding factors related to the composition

of patient lists (groups), including morbidity, help-seeking behaviour, sex and education. There are numerous causes of a break in the GP practice (parental leave, mandatory practice for specialization in general practice medicine, retirement, job change, GP sickness or death etc.), resulting in discontinuity for a shorter or longer period. It is possible that the consequences of discontinuity would differ according to the causes of the break (e.g. planning, speed of replacement, single or group practice).

Comparisons with existing literature

Our results may indicate that the system itself – including all public primary healthcare GP services – usually is robust and capable of absorbing discontinuities without detrimental effects on most patient groups. The observed dip in GP consultations during the discontinuity was transient, indicating that after a few months, most patients were able to consult a GP in the same manner as before the break. However, our results also raise several concerns regarding the observed increase in emergency health care usage.

The increase in monthly odds of out-of-hours consultations seen during the break persisted throughout the follow-up period for several age groups. This may indicate suboptimal quality of care due to temporary solutions and delayed replacement of a new GP and/or that patients have a lower threshold for using the out-of-hours services when the alternative is seeing a locum/unknown GP.

The present study also suggests an increase in hospital admissions, and ACSC admissions in particular, after the discontinuity for older patients. A relationship between interpersonal continuity of care, improved delivery of preventive services and lower rates of hospitalization has been suggested by other studies.[6] Our findings are also coherent with findings from recent large cross-sectional and cohort studies on older patients in other settings, indicating that a lower degree of continuity of care assessed by various indexes for continuity of care is associated with increased risk of hospital admission.[2, 7] Increase in hospital admission could indicate a health deterioration due to lack of proper treatment and follow-up in the absence of the GP, but may also reflect that patients are more likely to be admitted to hospital when meeting unfamiliar doctors. A potential direct negative impact on patient health (and not only an overuse of secondary healthcare) is suggested by the findings of increased mortality with lower levels of continuity of care from other studies.[15]

In contrast to the large body of research on continuity of care, few studies have investigated *cessation* of continuity of care. A recent systematic review assessed how physician retirement impacted patients and found mainly unfavourable outcomes, mainly published as anecdotes and qualitative studies.[33]

The authors point to some possible mechanisms related to difficulty accessing care, difficulty with transition and poor handover of information. Our results indicate that special attention should be given to elderly and frail patient groups as early as possible when the discontinuity is known to happen. Systematic identification of patients at risk and well-established information routines in relation to permanent or temporary GP breaks are possible actions that need to be studied further.

CONCLUSION

We investigated the consequences, in terms of health service use, for patients who experienced discontinuity of care from a primary physician who knew their medical and socioeconomic history. We found that in the Norwegian setting, discontinuity of GP care had some minor influence on primary care physician use. Patients continue to consult other GPs in a similar way as before and use the out-of-hours GP services to compensate for reduced access to or quality of care. Discontinuity of GP care might increase acute hospital admissions for ambulatory care sensitive conditions in the older age groups, suggesting a crucial role of the GP for these patient groups. These findings underline the importance of continuity of care in order to keep patient care and costs on the lowest level desired, avoiding some unnecessary health care use (including out-of-hours visits and hospital admissions) and health care costs. This seems particularly important in the perspective of an ageing population since the older age groups seem most sensitive to GP continuity.

DECLERATION

Acknowledgements

We would like to thank Statistics Norway and the Norwegian Directorate of Health for providing data.

Contributors

KP, JHB, LJS and SLK conceived the study and its design. KP and JHB contributed to design of the study protocol and facilitated acquisition of all data. KP and LJS prepared and analysed the data. JHB and SLK provided input on the discussion and interpretation of the findings. LJS drafted the first version of the manuscript. All authors contributed to and approved the final manuscript. All the authors have read the final version of the manuscript and agreed to its submission.

Funding

This work was supported by the Norwegian University of Science and Technology, and is a part of a larger project "Health care services under pressure – Consequences for patient flows, efficiency and patient safety in Norway" funded by the Norwegian Research Council (grant number 256579). JHB was funded by the Norwegian Research Council (grant number 295989).

Competing interests:

None

Patient and public involvement:

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication:

Not required.

Ethics approval:

The Regional Committee for Medical and Health Research Ethics in Central Norway approved the study (2011/2047).

Provenance and peer review:

Not commissioned; externally peer reviewed.

Data availability statement:

The data used in this study are publicly available, given approval.

References

1. Haggerty JL, Reid RJ, Freeman GK, et al. Continuity of care: a multidisciplinary review. *Bmj*. 2003;327(7425):1219-21.
2. Barker I, Steventon A, Deeny SR. Association between continuity of care in general practice and hospital admissions for ambulatory care sensitive conditions: cross sectional study of routinely collected, person level data. *BMJ*. 2017;356:j84.
3. Bayliss EA, Ellis JL, Shoup JA, et al. Effect of continuity of care on hospital utilization for seniors with multiple medical conditions in an integrated health care system. *Annals of family medicine*. 2015;13(2):123-9.
4. Hansen AH, Halvorsen PA, Aaraas IJ, et al. Continuity of GP care is related to reduced specialist healthcare use: a cross-sectional survey. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2013;63(612):482-9.
5. Huntley A, Lasserson D, Wye L, et al. Which features of primary care affect unscheduled secondary care use? A systematic review. *BMJ open*. 2014;4(5).
6. Saultz JW, Lochner J. Interpersonal continuity of care and care outcomes: a critical review. *Annals of family medicine*. 2005;3(2):159-66.
7. Tammes P, Purdy S, Salisbury C, et al. Continuity of Primary Care and Emergency Hospital Admissions Among Older Patients in England. *Annals of family medicine*. 2017;15(6):515-22.
8. van Loenen T, van den Berg MJ, Westert GP, et al. Organizational aspects of primary care related to avoidable hospitalization: a systematic review. *Family practice*. 2014;31(5):502-16.
9. Swanson JO, Vogt V, Sundmacher L, et al. Continuity of care and its effect on readmissions for COPD patients: A comparative study of Norway and Germany. *Health Policy*. 2018;122(7):737-45.
10. Emery DP, Milne T, Gilchrist CA, et al. The impact of primary care on emergency department presentation and hospital admission with pneumonia: a case-control study of preschool-aged children. *NPJ Primary Care Respiratory Medicine*. 2015;25:14113.
11. Kohnke H, Zielinski A. Association between continuity of care in Swedish primary care and emergency services utilisation: a population-based cross-sectional study. *Scandinavian journal of primary health care*. 2017;35(2):113-9.
12. Sarmento G, Leal-Seabra F, Brinquinho M, et al. Continuity of primary care and emergency department utilization among elderly people. *European Geriatric Medicine*. 2016;7:S224.
13. Leleu H, Minvielle E. Relationship between longitudinal continuity of primary care and likelihood of death: analysis of national insurance data. *PLoS One*. 2013;8(8):e71669.
14. Maarsingh OR, Henry Y, van de Ven PM, et al. Continuity of care in primary care and association with survival in older people: a 17-year prospective cohort study. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2016;66(649):e531-9.
15. Pereira Gray DJ, Sidaway-Lee K, White E, et al. Continuity of care with doctors—a matter of life and death? A systematic review of continuity of care and mortality. *BMJ open*. 2018;8(6):e021161.
16. Wolinsky FD, Bentler SE, Liu L, et al. Continuity of care with a primary care physician and mortality in older adults. *The journals of gerontology Series A, Biological sciences and medical sciences*. 2010;65(4):421-8.
17. Hollander MJ, Kadlec H. Financial implications of the continuity of primary care. *The Permanente journal*. 2015;19(1):4-10.
18. The Norwegian Ministry of Health and Care Services. Forskrift om fastlegeordning i kommunene 2012 [updated 2018 Mar 08; cited 2020 May 16]. Available from: https://lovdata.no/dokument/SF/forskrift/2012-08-29-842.
19. The Norwegian Medical Association, The Norwegian Association of General Practitioners, The Medical Speciality Society for General Practice. Utviklingsplan for fastlegeordningen 2015 - 2020 2015 [cited 2020 May 19]. Available from:

https://www.legeforeningen.no/contentassets/743cd468b6d6435ca138de1a2909caf9/utviklingsplan-flo.pdf.
20. Hetlevik O, Gjesdal S. Personal continuity of care in Norwegian general practice: a national cross-sectional study. *Scandinavian journal of primary health care*. 2012;30(4):214-21.
21. Grooss K, Hjertholm P, Carlsen AH, et al. Patients with cancer and change of general practice: a Danish population-based cohort study. *British Journal of General Practice*. 2016;66(648):e491-e8.
22. Greenfield G, Foley K, Majeed A. Rethinking primary care's gatekeeper role. *BMJ*. 2016;354:i4803.
23. Statistics Norway. Statistisk sentralbyrå 2019 [cited 2020 May 16]. Available from: https://www.ssb.no/en.
24. The Norwegian Directorate of Health. KUHR-databasen 2019 [updated 2019 Apr 08; cited 2020 May 16]. Available from: https://www.helsedirektoratet.no/tema/statistikk-registre-og-rapporter/helsedata-og-helseregistre/kuhr
25. The Norwegian Directorate of eHealth. Fastlegeregisteret 2020 [cited 2020 19 Mai]. Available from: https://helsedata.no/forvaltere/helsedirektoratet/fastlegeregisteret/.
26. Bakken IJ, Ariansen AMS, Knudsen GP, et al. The Norwegian Patient Registry and the Norwegian Registry for Primary Health Care: Research potential of two nationwide health-care registries. *Scandinavian journal of public health*. 2019:1403494819859737.
27. The Norwegian Medical Association. Normaltariffen for fastleger og legevakt 2019-2020 [Tariff]. 2019 [cited 2020 May 16]. Available from: https://normaltariffen.legeforeningen.no/asset/pdf/Fastlegetariffen-2019-2020.pdf (page 21).
28. Ansari Z. The Concept and Usefulness of Ambulatory Care Sensitive Conditions as Indicators of Quality and Access to Primary Health Care. *Australian journal of primary health*. 2007;13(3):91-110.
29. NHS Digital. Ambulatory Care Sensitive Conditions (ACSC) 2019 [updated 2019 Dec 12; cited 2020 May 16]. Available from: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/innovative-uses-of-data/demand-on-healthcare/ambulatory-care-sensitive-conditions# (Appendix A).
30. Twisk JWR. Applied Longitudinal Data Analysis for Epidemiology. Cambridge: Cambridge University Press; 2003. 182 p.
31. Gaardsrud PØ. Fastlegestatistikk 2017 hovedtall [Regular General Practitioner Statistics 2017]: The Norwegian Directorate for Health; 2018 [Available from: https://www.helsedirektoratet.no/statistikk/statistikk/fastlegestatistikk
32. Rothman KJ. Epidemiology: an introduction. 2nd ed. ed. New Yourk: Oxford university press; 2012. 268 p.
33. Lam K, Arnold CG, Savage RD, et al. Does Physician Retirement Affect Patients? A Systematic Review. *Journal of the American Geriatrics Society*. 2020;68(3):641-9.

Figure legends:

Figure 1: Illustration of study design and timeline for (a) definition of exposure by at least two months with no/low activity (X) after at least 12 months of ordinary (O) GP activity, (b) linkage and baseline information and (c) patient outcome assessment (four outcomes) in four defined periods (brown).

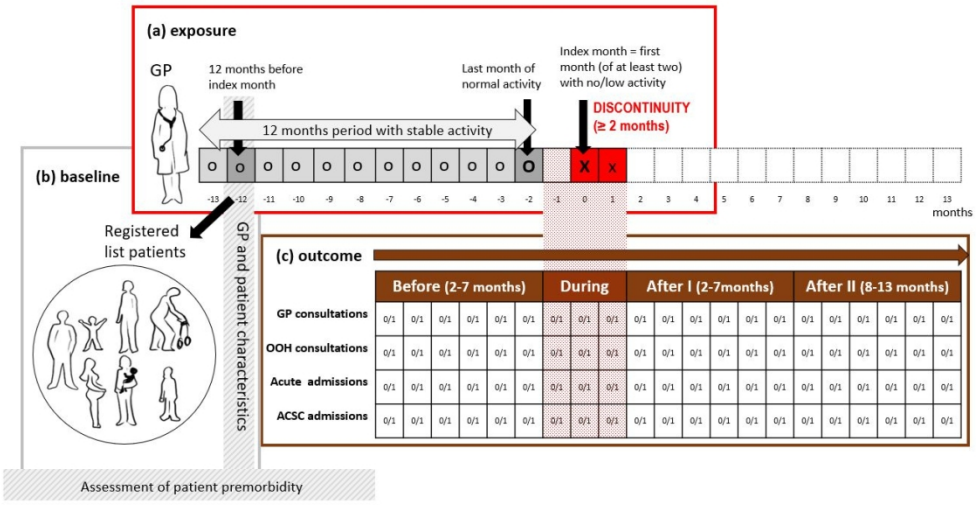


Figure 1: Illustration of study design and timeline for (a) definition of exposure by at least two months with no/low activity (X) after at least 12 months of ordinary (O) GP activity, (b) linkage and baseline information and (c) patient outcome assessment (four outcomes) in four defined periods (brown).

28x15mm (1200 x 1200 DPI)

Supplementary Tables, General practitioner discontinuity and health care utilisation in 2.5 million Norwegians.

Supplementary Table 1: Patient health status during the 12-month period prior to follow-up (8-19 months before discontinuity), assessed by various indicators of health care usage among patients with available data

	0-18 years	19-44 years	45-64 years	65-79 years	80+ years
Regular GP consultations during 12 months					
N	524,709	879,635	621,942	294,798	127,495
mean number of consultations(SD)	1.4 (1.9)	2.4 (3.4)	3.0 (3.8)	4.1 (4.4)	4.8 (5.3)
median number of consultations (IQR)	1 [0-2]	1[0-3]	2[0-4]	3[1-5]	3[1-7]
% with at least one consultation	60	67	73	84	81
% with at least one consultation for hypertension[1]		1.0	8.7	20.3	19.1
% with at least one consultation for ischaemic heart disease[2]		0.1	2.1	8.7	16.9
Acute hospital admission during 12 months					
N	465,801	782,401	555,019	267,068	113,748
% with at least one acute hospital admission[3]	4.2	7.1	6.2	12.2	25.5

1: One or more consultations with hypertension diagnoses (ICPC2 diagnosis K85-87) in the KUHR data
2: One or more consultations with ischemic heart disease diagnoses (ICPC2 diagnosis K74-80) in the KUHR data
3: One or more registered acute hospital stays in the

Supplementary Table 2: Subgroup analysis of patients with hypertension and ischaemic heart disease. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly GP consultations (one or more) in periods during and after a sudden discontinuity of GP care, compared to before the discontinuity), adjusted for month/time, calendar month, calendar year and patient sex. (2008-2017). Analyses include patients who had at least one GP consultation for Hypertension (ICPC2 diagnosis K85-87) and Ischaemic heart disease (ICPC2 diagnosis K74-80) during the 12-month period before follow-up (8-19 months before the index month of discontinuity

	Hypertension						Ischaemic heart disease					
	45-64 years		65-79 years		80+ years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)												
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	0.91	(0.90-0.93)	0.93	(0.92-0.94)	0.93	(0.91-0.95)	0.94	(0.91-0.96)	0.93	(0.92-0.95)	0.95	[0.93-0.97]
After discontinuity I (2-7 months after)	0.97	(0.95-0.99)	1.00	(0.98-1.02)	0.99	(0.96-1.02)	0.97	(0.93- 1.01)	1.00	(0.97-1.03)	1.01	[0.98-1.04]
After discontinuity II (8-13 months after)	0.98	(0.94-1.01)	0.98	(0.95-1.01)	0.94	(0.89-0.98)	1.00	(0.94-1.07)	1.00	(0.96-1.05)	1.00	[0.95-1.05]
Monthly out-of-hours consultations (one or more)												
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (1 month before to 1 month after)	1.05	(0.98-1.13)	1.08	(1.01-1.15)	0.96	(0.88-1.05)	0.99	(0.89-1.11)	1.05	(0.97-1.14)	1.04	[0.96-1.12]
After discontinuity I (2-7 months after)	1.07	(0.97-1.19)	1.13	(1.03-1.24)	0.94	(0.83-1.06)	0.91	(0.77-1.07)	1.11	(0.98-1.25)	1.06	[0.95-1.19]
After discontinuity II (8-13 months after)	1.10	(0.95-1.29)	1.19	(1.02-1.38)	0.83	(0.68-1.01)	0.96	(0.75-1.24)	1.09	(0.91-1.32)	1.05	[0.88-1.25]
Monthly acute hospital admissions (one or more)												
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (1 month before to 1 month after)	1.04	(0.96-1.14)	1.08	(1.01-1.15)	1.03	(0.96-1.11)	1.01	(0.91-1.12)	1.05	(0.98-1.12)	1.03	[0.99-1.10]
After discontinuity I (2-7 months after)	1.03	(0.91-1.17)	1.07	(0.98-1.18)	0.97	(0.87-1.07)	1.01	(0.87-1.18)	1.12	(1.02-1.24)	1.06	[0.97-1.15]
After discontinuity II (8-13 months after)	1.05	(0.86-1.27)	1.07	(0.93-1.23)	0.93	(0.80-1.09)	1.18	(0.94-1.49)	1.14	(0.99-1.32)	1.05	[0.92-1.20]
Monthly ACSC acute hospital admissions (one or more)												
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (1 month before to 1 month after)-	1.32	(1.07-1.65)	1.12	(0.97-1.30)	0.88	(0.75-1.03)	0.77	(0.62-0.94)	1.07	(0.95-1.21)	1.03	[0.93-1.14]
After discontinuity I (2-7 months after)	1.40	(1.02-1.92)	1.32	(1.08-1.62)	0.86	(0.69-1.08)	0.69	(0.51-0.94)	1.24	(1.04-1.47)	1.04	[0.89-1.21]
After discontinuity II (8-13 months after)	1.71	(1.05-2.79)	1.35	(0.99-1.85)	0.74	(0.52-1.04)	0.76	(0.48-1.20)	1.38	(1.06-1.80)	1.00	[0.79-1.26]

Supplementary Table 3: Subgroup analysis of previously hospitalized patients. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly health care use (one or more) in periods during and after a sudden discontinuity of GP care, compared to before the discontinuity; adjusted for month/time, calendar month, calendar year and patient sex (2008-2017). Analyses include patients who had at least one emergency hospital admission during the 12-month period before follow-up (8-19 months before the index month of discontinuity.

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	0.97	(0.94-1.01)	0.98	(0.96-0.99)	0.94	(0.92-0.96)	0.95	(0.93-0.97)	0.98	(0.96-1.00)
After discontinuity I (2-7 months after)	0.98	(0.94-1.04)	1.04	(1.01-1.02)	1.00	(0.97-1.03)	1.02	(0.99-1.05)	1.02	(0.99-1.05)
After discontinuity II (8-13 months after)	0.97	(0.87-1.19)	1.06	(1.02-1.10)	1.04	(1.00-1.09)	1.05	(1.00-1.09)	1.00	(0.95-1.05)
Monthly out-of-hours consultations (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	1.02	(0.95-1.09)	1.02	(0.97-1.07)	1.01	(0.95-1.07)	1.01	(0.94-1.08)	1.07	(0.99-1.15)
After discontinuity I (2-7 months after)	1.01	(0.91-1.11)	1.05	(0.98-1.12)	1.00	(0.92-1.10)	1.05	(0.95-1.15)	1.10	(0.99-1.23)
After discontinuity II (8-13 months after)	1.02	(0.95-1.03)	1.07	(0.96-1.18)	0.97	(0.84-1.11)	1.08	(0.92-1.25)	1.11	(0.94-1.31)
Monthly acute hospital admissions (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)	1.00	(0.88-1.13)	0.98	(0.92-1.03)	1.01	(0.98-1.04)	1.04	(0.99-1.09)	1.05	(1.00-1.11)
After discontinuity I (2-7 months after)	1.14	(0.95-1.36)	1.05	(0.97-1.14)	1.01	(0.97-1.05)	1.12	(1.04-1.21)	1.12	(1.04-1.20)
After discontinuity II (8-13 months after)	1.33	(1.01-1.75)	1.09	(0.96-1.24)	1.01	(0.95-1.08)	1.19	(1.07-1.33)	1.14	(1.02-1.28)
Monthly ACSC acute hospital admissions (one or more)										
Before discontinuity (2-7 months before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (1 month before to 1 month after)-	1.02	(0.81-1.28)	0.97	(0.80-1.16)	1.01	(0.94-1.09)	1.07	(0.98-1.17)	1.16	(1.06-1.27)
After discontinuity I (2-7 months after)	1.10	(0.78-1.56)	1.03	(0.79-1.34)	1.04	(0.93-1.15)	1.15	(1.01-1.30)	1.24	(1.09-1.42)
After discontinuity II (8-13 months after)	1.32	(0.77-2.25)	1.06	(0.70-1.60)	1.01	(0.87-1.21)	1.22	(1.00-1.49)	1.37	(1.11-1.70)

*Supplementary Table 4: Subgroup analysis – GP consultations. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for **monthly GP consultations** during (3 month-period) and after (6 month-period) a sudden discontinuity of GP care, compared to a 6-month stable period before the discontinuity. Separate analyses for each patient age group and according to patient and GP characteristics (GP age, municipality size, patient sex, patient education). All analyses adjusted for month/time, calendar month, calendar year and patient sex. (2007-2017)*

monthly GP consultations	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
GP < 50 years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.94	(0.93-0.95)	0.97	(0.96-0.97)	0.95	(0.95-0.96)	0.95	(0.94-0.95)	0.96	(0.95-0.97)
After discontinuity I (2-7 months after)	0.95	(0.94-0.96)	0.98	(0.97-0.99)	0.97	(0.96-0.98)	0.99	(0.97-1.00)	0.99	(0.97-1.01)
After discontinuity II (8-13 months after)	0.95	(0.93-0.97)	0.98	(0.97-0.99)	0.96	(0.95-0.98)	0.98	(0.96-1.00)	0.96	(0.94-0.99)
GP 50+ years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.97	(0.95-0.98)	0.97	(0.97-0.98)	0.95	(0.95-0.96)	0.95	(0.94-0.96)	0.96	(0.95-0.97)
After discontinuity I (2-7 months after)	1.00	(0.98-1.02)	1.01	(1.00-1.03)	1.02	(1.01-1.03)	1.03	(1.02-1.05)	1.04	(1.02-1.06)
After discontinuity II (8-13 months after)	0.99	(0.96-1.01)	1.01	(0.99-1.03)	1.01	(1.00-1.03)	1.02	(1.00-1.04)	1.01	(0.98-1.04)
GP in 10 most populated municipalities										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.96	(0.94-0.97)	0.99	(0.98-0.99)	0.96	(0.95-0.97)	0.98	(0.97-0.99)	0.99	(0.97-1.00)
After discontinuity I (2-7 months after)	0.98	(0.96-1.00)	1.01	(1.00-1.02)	1.01	(1.00-1.02)	1.05	(1.03-1.07)	1.03	(1.00-1.06)
After discontinuity II (8-13 months after)	0.97	(0.94-1.01)	1.02	(1.01-1.04)	1.00	(0.98-1.03)	1.05	(1.02-1.08)	0.99	(0.95-1.03)
GP in municipalities with < 2000 inhabitants										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.96	(0.90-1.02)	0.95	(0.92-0.99)	0.93	(0.90-0.97)	0.91	(0.87-0.95)	0.95	(0.90-1.01)
After discontinuity I (2-7 months after)	0.93	(0.85-1.01)	0.99	(0.93-1.05)	0.97	(0.92-1.02)	0.95	(0.90-1.01)	0.98	(0.90-1.07)
After discontinuity II (8-13 months after)	0.92	(0.80-1.05)	1.00	(0.92-1.10)	0.96	(0.89-1.04)	0.94	(0.86-1.03)	0.97	(0.85-1.11)
Male patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.95	(0.94-0.96)	0.98	(0.97-0.98)	0.95	(0.95-0.96)	0.95	(0.94-0.96)	0.95	(0.93-0.96)
After discontinuity I (2-7 months after)	0.96	(0.95-0.98)	1.00	(0.98-1.01)	0.99	(0.98-1.00)	1.01	(0.99-1.02)	0.99	(0.97-1.02)
After discontinuity II (8-13 months after)	0.96	(0.93-0.98)	0.99	(0.98-1.01)	0.98	(0.97-1.00)	1.00	(0.98-1.03)	0.97	(0.93-1.00)

136/bmjopen-2020-042391 on 16 February 2021. Downloaded from

Female patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.95	(0.94-0.96)	0.97	(0.96-0.97)	0.96	(0.95-0.96)	0.95	(0.94-0.96)	0.97	(0.95-0.98)
After discontinuity I (2-7 months after)	0.97	(0.96-0.99)	0.99	(0.98-1.00)	1.00	(0.99-1.01)	1.01	(1.00-1.02)	1.03	(1.01-1.04)
After discontinuity II (8-13 months after)	0.96	(0.94-0.99)	0.99	(0.97-1.00)	0.99	(0.97-1.00)	1.00	(0.98-1.02)	1.00	(0.97-1.03)
Patients with primary education only										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			0.97	(0.96-0.98)	0.96	(0.95-0.97)	0.94	(0.93-0.95)	0.95	(0.93-0.96)
After discontinuity I (2-7 months after)			0.98	(0.97-1.00)	1.00	(0.98-1.01)	0.99	(0.97-1.01)	1.02	(0.99-1.04)
After discontinuity II (8-13 months after)			0.98	(0.96-1.00)	0.99	(0.97-1.01)	0.98	(0.95-1.00)	0.99	(0.96-1.02)
Patients with secondary education										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			0.97	(0.96-0.97)	0.95	(0.94-0.96)	0.95	(0.94-0.96)	0.97	(0.96-0.99)
After discontinuity I (2-7 months after)			0.99	(0.98-1.00)	0.99	(0.98-1.00)	1.01	(1.00-1.03)	1.01	(0.99-1.04)
After discontinuity II (8-13 months after)			0.98	(0.96-1.00)	0.98	(0.96-0.99)	1.00	(0.98-1.02)	0.99	(0.96-1.02)
Patients with college/university										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			0.98	(0.97-0.98)	0.96	(0.95-0.97)	0.95	(0.94-0.97)	0.96	(0.93-0.99)
After discontinuity I (2-7 months after)			1.00	(0.99-1.01)	1.01	(1.00-1.02)	1.03	(1.01-1.05)	1.00	(0.96-1.04)
After discontinuity II (8-13 months after)			1.00	(0.99-1.02)	1.00	(0.98-1.02)	1.03	(1.00-1.07)	0.94	(0.89-1.00)

*Supplementary Table 5: Subgroup analysis – out-of-hours (OOH) consultations. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for **monthly OOH consultations** during (3 month-period) and after (6 month-period) a sudden discontinuity of GP care, compared to a 6-month stable period before the discontinuity. Separate analyses for each patient age group and according to patient and GP characteristics (GP age, municipality size, patient sex, patient education). All analyses adjusted for month/time, calendar month, calendar year and patient sex. (2007-2017)*

monthly OOH consultations	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
GP < 50 years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.00	(0.98-1.03)	1.05	(1.03-1.07)	1.01	(0.99-1.04)	1.04	(1.00-1.08)	1.07	(1.01-1.12)
After discontinuity I (2-7 months after)	0.99	(0.96-1.03)	1.06	(1.03-1.09)	1.01	(0.97-1.06)	1.08	(1.02-1.14)	1.07	(0.99-1.16)
After discontinuity II (8-13 months after)	1.00	(0.95-1.05)	1.08	(1.03-1.12)	1.00	(0.94-1.06)	1.11	(1.02-1.21)	1.07	(0.95-1.21)
GP 50+ years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.99	(0.96-1.02)	1.04	(1.02-1.07)	1.05	(1.02-1.08)	1.09	(1.05-1.14)	1.04	(0.99-1.10)
After discontinuity I (2-7 months after)	0.99	(0.95-1.04)	1.04	(1.00-1.08)	1.03	(0.98-1.07)	1.10	(1.04-1.17)	1.05	(0.97-1.13)
After discontinuity II (8-13 months after)	0.98	(0.91-1.04)	1.06	(1.00-1.12)	1.02	(0.95-1.10)	1.12	(1.02-1.23)	1.03	(0.91-1.17)
GP in 10 most populated municipalities										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.04	(1.01-1.07)	1.06	(1.03-1.09)	1.01	(0.97-1.05)	1.00	(0.94-1.06)	1.05	(0.97-1.13)
After discontinuity I (2-7 months after)	1.00	(0.95-1.05)	1.07	(1.03-1.11)	1.00	(0.94-1.06)	1.01	(0.92-1.11)	1.08	(0.96-1.21)
After discontinuity II (8-13 months after)	1.01	(0.94-1.09)	1.11	(1.05-1.18)	0.96	(0.87-1.05)	0.99	(0.86-1.13)	1.10	(0.92-1.32)
GP in municipalities with < 2000 inhabitants										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.05	(0.90-1.23)	1.11	(0.96-1.28)	1.04	(0.88-1.22)	1.18	(0.96-1.45)	0.93	(0.70-1.22)
After discontinuity I (2-7 months after)	1.03	(0.81-1.29)	1.12	(0.91-1.38)	1.31	(1.04-1.66)	1.15	(0.84-1.58)	1.01	(0.68-1.50)
After discontinuity II (8-13 months after)	1.05	(0.73-1.51)	1.25	(0.90-1.73)	1.63	(1.13-2.35)	1.27	(0.79-2.05)	1.05	(0.57-1-93)
Male patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)

During discontinuity (1 month before to 1 month after)	0.99	(0.97-1.02)	1.04	(1.02-1.07)	1.02	(0.99-1.05)	1.05	(1.01-1.10)	1.01	(0.95-1.07)
After discontinuity I (2-7 months after)	0.98	(0.94-1.01)	1.05	(1.01-1.08)	1.01	(0.97-1.06)	1.11	(1.04-1.18)	0.98	(0.89-1.07)
After discontinuity II (8-13 months after)	0.96	(0.91-1.02)	1.08	(1.02-1.13)	1.01	(0.95-1.09)	1.14	(1.03-1.25)	0.93	(0.81-1.06)
Female patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.01	(0.99-1.04)	1.05	(1.03-1.07)	1.04	(1.01-1.07)	1.08	(1.04-1.12)	1.09	(1.04-1.14)
After discontinuity I (2-7 months after)	1.01	(0.98-1.05)	1.06	(1.03-1.09)	1.02	(0.98-1.07)	1.08	(1.02-1.14)	1.11	(1.04-1.19)
After discontinuity II (8-13 months after)	1.02	(0.97-1.08)	1.07	(1.02-1.12)	1.00	(0.94-1.07)	1.10	(1.01-1.20)	1.14	(1.02-1.27)
Patients with primary education only										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.01	(0.99-1.04)	1.02	(0.99-1.06)	1.12	(1.07-1.17)	1.06	(1.00-1.12)
After discontinuity I (2-7 months after)			1.02	(0.98-1.07)	1.02	(0.96-1.07)	1.10	(1.03-1.18)	1.06	(0.98-1.15)
After discontinuity II (8-13 months after)			1.01	(0.95-1.08)	1.00	(0.91-1.09)	1.18	(1.06-1.31)	1.06	(0.94-1.20)
Patients with secondary education										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.04	(1.02-1.07)	1.04	(1.01-1.07)	1.03	(0.99-1.08)	1.06	(1.00-1.13)
After discontinuity I (2-7 months after)			1.04	(1.00-1.07)	1.04	(0.99-1.08)	1.09	(1.03-1.16)	1.07	(0.99-1.17)
After discontinuity II (8-13 months after)			1.05	(1.00-1.12)	1.04	(0.97-1.11)	1.10	(1.00-1.21)	1.07	(0.93-1.22)
Patients with college/university										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.08	(1.05-1.11)	1.02	(0.98-1.06)	1.06	(0.99-1.13)	1.02	(0.91-1.15)
After discontinuity I (2-7 months after)			1.09	(1.05-1.13)	0.99	(0.93-1.05)	1.08	(0.97-1.19)	1.03	(0.86-1.22)
After discontinuity II (8-13 months after)			1.12	(1.05-1.19)	0.95	(0.87-1.05)	1.08	(0.92-1.27)	0.99	(0.76-1.29)

*Supplementary Table 6: Subgroup analysis – acute hospital admissions. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for **monthly acute hospital admissions** during (3 month-period) and after (6 month-period) a sudden discontinuity of GP care, compared to a 6-month stable period before the discontinuity. Separate analyses for each patient age group and according to patient and GP characteristics (GP age, municipality size, patient sex, patient education). All analyses adjusted for month/time, calendar month, calendar year and patient sex. (2007-2017)*

Acute hospital admissions	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
GP < 50 years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.00	(0.94-1.07)	1.02	(0.99-1.05)	0.97	(0.93-1.01)	1.03	(0.99-1.07)	1.02	(0.97-1.06)
After discontinuity I (2-7 months after)	1.00	(0.92-1.10)	1.02	(0.97-1.07)	0.96	(0.91-1.02)	1.05	(0.99-1.11)	1.06	(1.00-1.13)
After discontinuity II (8-13 months after)	1.04	(0.90-1.20)	1.03	(0.96-1.10)	0.94	(0.86-1.03)	1.06	(0.97-1.15)	1.08	(0.98-1.19)
GP 50+ years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.02	(0.94-1.11)	1.04	(0.99-1.08)	1.07	(1.02-1.12)	1.03	(0.99-1.07)	1.04	(0.99-1.09)
After discontinuity I (2-7 months after)	1.03	(0.91-1.17)	1.00	(0.94-1.07)	1.08	(1.01-1.15)	1.04	(0.98-1.11)	1.00	(0.94-1.07)
After discontinuity II (8-13 months after)	1.08	(0.89-1.31)	0.99	(0.89-1.09)	1.11	(1.01-1.22)	1.04	(0.94-1.13)	0.93	(0.84-1.03)
GP in 10 most populated municipalities										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	1.09	(0.99-1.20)	1.02	(0.97-1.06)	1.05	(1.00-1.11)	0.99	(0.94-1.05)	1.02	(0.96-1.08)
After discontinuity I (2-7 months after)	1.09	(0.95-1.25)	1.02	(0.95-1.08)	1.09	(1.01-1.17)	1.01	(0.93-1.09)	1.02	(0.93-1.11)
After discontinuity II (8-13 months after)	1.17	(0.94-1.45)	1.02	(0.93-1.13)	1.12	(1.01-1.26)	0.99	(0.88-1.12)	0.98	(0.86-1.12)
GP in municipalities with < 2000 inhabitants										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.84	(0.58-1.22)	1.06	(0.86-1.29)	0.90	(0.74-1.10)	1.12	(0.94-1.33)	0.94	(0.77-1.14)
After discontinuity I (2-7 months after)	1.09	(0.65-1.84)	1.10	(0.82-1.48)	0.92	(0.69-1.22)	1.18	(0.91-1.54)	0.99	(0.74-1.31)
After discontinuity II (8-13 months after)	1.24	(0.55-2.79)	1.12	(0.71-1.79)	0.90	(0.58-1.39)	1.23	(0.82-1.84)	0.86	(0.56-1.33)
Male patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)

During discontinuity (1 month before to 1 month after)	1.03	(0.96-1.10)	1.04	(0.99-1.09)	1.02	(0.99-1.06)	1.02	(0.98-1.06)	1.02	(0.98-1.08)
After discontinuity I (2-7 months after)	1.01	(0.91-1.12)	1.03	(0.96-1.10)	1.02	(0.97-1.07)	1.04	(0.99-1.10)	1.03	(0.96-1.11)
After discontinuity II (8-13 months after)	1.04	(0.89-1.22)	1.03	(0.93-1.15)	1.03	(0.95-1.12)	1.03	(0.95-1.12)	1.01	(0.90-1.12)
Female patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.99	(0.92-1.07)	1.02	(0.99-1.05)	1.00	(0.96-1.05)	1.04	(1.00-1.08)	1.03	(0.99-1.07)
After discontinuity I (2-7 months after)	1.02	(0.92-1.14)	1.01	(0.96-1.05)	1.00	(0.94-1.07)	1.05	(0.98-1.11)	1.04	(0.98-1.10)
After discontinuity II (8-13 months after)	1.07	(0.91-1.27)	1.00	(0.94-1.07)	0.99	(0.90-1.10)	1.06	(0.97-1.16)	1.01	(0.92-1.11)
Patients with primary education only										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.03	(0.99-1.08)	1.06	(1.01-1.12)	1.04	(0.99-1.09)	1.04	(0.99-1.09)
After discontinuity I (2-7 months after)			0.99	(0.92-1.06)	1.05	(0.97-1.13)	1.04	(0.97-1.11)	1.08	(1.01-1.15)
After discontinuity II (8-13 months after)			0.97	(0.87-1.08)	1.12	(1.00-1.26)	1.08	(0.98-1.20)	1.05	(0.95-1.16)
Patients with secondary education										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.05	(1.00-1.09)	1.01	(0.96-1.05)	1.03	(0.99-1.07)	1.02	(0.97-1.07)
After discontinuity I (2-7 months after)			1.05	(0.99-1.12)	1.01	(0.95-1.08)	1.06	(1.00-1.12)	0.99	(0.93-1.07)
After discontinuity II (8-13 months after)			1.07	(0.97-1.19)	0.98	(0.89-1.08)	1.04	(0.95-1.13)	0.97	(0.87-1.08)
Patients with college/university										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.02	(0.98-1.06)	0.98	(0.92-1.04)	1.01	(0.94-1.08)	1.00	(0.91-1.10)
After discontinuity I (2-7 months after)			1.02	(0.96-1.08)	0.95	(0.87-1.04)	1.01	(0.91-1.11)	1.01	(0.88-1.16)
After discontinuity II (8-13 months after)			1.02	(0.93-1.13)	0.93	(0.81-1.07)	0.99	(0.85-1.16)	0.99	(0.80-1.22)

*Supplementary Table 7: Subgroup analysis – admissions for ambulatory care sensitive conditions (ACSC) . Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for **monthly ACSC admissions** during (3 month-period) and after (6 month-period) a sudden discontinuity of GP care, compared to a 6-month stable period before the discontinuity. Separate analyses for each patient age group and according to patient and GP characteristics (GP age, municipality size, patient sex, patient education). All analyses adjusted for month/time, calendar month, calendar year and patient sex. (2007-2017)*

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
ACSC hospital admissions	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
GP < 50 years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.88	(0.76-1.02)	1.03	(0.91-1.17)	0.91	(0.82-1.00)	1.10	(1.02-1.19)	1.05	(0.96-1.14)
After discontinuity I (2-7 months after)	0.96	(0.77-1.19)	1.07	(0.89-1.28)	0.90	(0.79-1.04)	1.17	(1.04-1.31)	1.14	(1.00-1.29)
After discontinuity II (8-13 months after)	1.03	(0.73-1.45)	1.11	(0.84-1.46)	0.88	(0.71-1.09)	1.25	(1.05-1.49)	1.16	(0.95-1.41)
GP 50+ years old										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.91	(0.74-1.12)	0.99	(0.84-1.17)	1.18	(1.06-1.31)	1.02	(0.94-1.11)	1.09	(1.00-1.20)
After discontinuity I (2-7 months after)	0.98	(0.73-1.32)	0.86	(0.68-1.10)	1.25	(1.07-1.47)	1.06	(0.93-1.19)	1.09	(0.96-1.25)
After discontinuity II (8-13 months after)	0.93	(0.58-1.49)	0.72	(0.49-1.06)	1.28	(1.00-1.63)	1.11	(0.91-1.37)	1.00	(0.81-1.23)
GP in 10 most populated municipalities										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.99	(0.80-1.23)	0.99	(0.84-1.17)	1.22	(1.07-1.39)	1.05	(0.94-1.17)	1.10	(0.98-1.23)
After discontinuity I (2-7 months after)	1.23	(0.90-1.68)	0.86	(0.68-1.09)	1.35	(1.12-1.63)	1.09	(0.93-1.28)	1.11	(0.93-1.31)
After discontinuity II (8-13 months after)	1.07	(0.65-1.75)	0.74	(0.51-1.07)	1.52	(1.14-2.04)	1.07	(0.84-1.36)	0.99	(0.76-1.29)
GP in municipalities with < 2000 inhabitants										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.86	(0.34-2.18)	1.31	(0.50-3.43)	0.72	(0.44-1.16)	1.05	(0.73-1.50)	0.84	(0.57-1.25)
After discontinuity I (2-7 months after)	1.95	(0.56-6.81)	3.06	(0.80-11.63)	0.49	(0.23-1.05)	0.96	(0.56-1.62)	0.80	(0.44-1.42)
After discontinuity II (8-13 months after)	3.81	(0.57-25.70)	4.26	(0.51-35.81)	0.31	(0.09-1.02)	0.98	(0.44-2.20)	0.45	(0.18-1.15)
Male patients										
Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.82	(0.70-0.97)	1.04	(0.89-1.20)	0.98	(0.90-1.07)	1.07	(0.99-1.14)	1.11	(1.01-1.22)
After discontinuity I (2-7 months after)	0.80	(0.63-1.02)	1.12	(0.91-1.38)	0.95	(0.84-1.08)	1.13	(1.01-1.27)	1.13	(0.99-1.30)
After discontinuity II (8-13 months after)	0.79	(0.54-1.16)	1.09	(0.79-1.52)	0.92	(0.76-1.12)	1.23	(1.04-1.45)	1.14	(0.92-1.41)
Female patients										

Before discontinuity (2-7 months before)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)	0.95	(0.79-1.14)	1.01	(0.89-1.16)	1.01	(0.90-1.14)	1.05	(0.96-1.15)	1.03	(0.95-1.12)
After discontinuity I (2-7 months after)	1.16	(0.90-1.50)	0.91	(0.75-1.11)	1.09	(0.93-1.28)	1.09	(0.96-1.24)	1.09	(0.96-1.23)
After discontinuity II (8-13 months after)	1.23	(0.83-1.83)	0.86	(0.63-1.16)	1.10	(0.85-1.41)	1.12	(0.92-1.36)	1.01	(0.84-1.22)
Patients with primary education only										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			0.95	(0.81-1.12)	0.95	(0.84-1.07)	1.05	(0.96-1.14)	1.10	(1.01-1.20)
After discontinuity I (2-7 months after)			1.00	(0.80-1.27)	0.97	(0.82-1.15)	1.08	(0.95-1.23)	1.15	(1.01-1.31)
After discontinuity II (8-13 months after)			0.98	(0.68-1.41)	1.01	(0.78-1.31)	1.14	(0.93-1.40)	1.10	(0.90-1.34)
Patients with secondary education										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.11	(0.94-1.32)	1.05	(0.94-1.17)	1.07	(0.98-1.17)	0.99	(0.90-1.09)
After discontinuity I (2-7 months after)			1.13	(0.88-1.45)	1.11	(0.95-1.30)	1.16	(1.03-1.31)	1.02	(0.89-1.18)
After discontinuity II (8-13 months after)			1.17	(0.80-1.73)	1.05	(0.83-1.34)	1.24	(1.03-1.50)	0.95	(0.76-1.18)
Patients with college/university										
Before discontinuity (2-7 months before)			1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
During discontinuity (1 month before to 1 month after)			1.03	(0.85-1.26)	1.04	(0.88-1.24)	1.08	(0.92-1.28)	1.16	(0.94-1.41)
After discontinuity I (2-7 months after)			0.92	(0.68-1.23)	0.94	(0.73-1.22)	1.04	(0.82-1.32)	1.27	(0.93-1.71)
After discontinuity II (8-13 months after)			0.80	(0.51-1.26)	0.91	(0.61-1.35)	1.09	(0.75-1.59)	1.44	(0.91-2.30)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	a) 5-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	6-8
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	a) 5-8
		(*b*) Describe any methods used to examine subgroups and interactions	b) 8
		(*c*) Explain how missing data were addressed	c) 8
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	e) 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 + Table 1
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

How does general practitioner discontinuity affect health care utilisation? An observational cohort study of 2.4 million Norwegians 2007-2017

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042391.R1
Article Type:	Original research
Date Submitted by the Author:	07-Oct-2020
Complete List of Authors:	Skarshaug, Lena; Norwegian University of Science and Technology, Department of Public Health and Nursing Kaspersen, Silje; SINTEF, Digital; Norwegian University of Science and Technology, Public Health and Nursing Bjorngaard, Johan; Norwegian University of Science and Technology, Department of Public Health and Nursing; Nord Universitet - Levanger Campus, Faculty of Nursing and Health Sciences Pape, Kristine; Norwegian University of Science and Technology, Public Health and Nursing
Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	Health services research, Epidemiology, General practice / Family practice, Patient-centred medicine, Public health
Keywords:	PRIMARY CARE, EPIDEMIOLOGY, PUBLIC HEALTH, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

How does general practitioner discontinuity affect health care utilisation?

An observational cohort study of 2.4 million Norwegians 2007-2017

Lena J. Skarshaug* [a]

Silje L. Kaspersen [a, b]

Johan H. Bjørngaard [a, c]

Kristine Pape [a]

a) Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Trondheim, Norway

b) SINTEF Digital, SINTEF, Trondheim, Norway

c) Nord University, Faculty of Nursing and Health Sciences, Levanger, Norway

*Correspondence to Lena J. Skarshaug, Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Håkon Jarls Gate 11, 7030 Trondheim, Norway; E-mail: lena.j.skarshaug@ntnu.no

MeSH keywords: general practice, continuity of patient care, health service research, hospitalization, primary health care.

Word count: 3346 words.

ABSTRACT

Objectives: Patients may benefit from continuity of care by a personal physician (GP), but there are few studies on consequences of a break in continuity of GP. Investigate how a sudden discontinuity of GP care affects their list patients' regular GP consultations, out-of-hours consultations and acute hospital admissions, including admissions for ambulatory care sensitive conditions (ACSC).

Design: Cohort study linking person-level national register data on use of health services and GP affiliation with data on GP activity and GP characteristics.

Setting: Primary Care

Participants: 2,409,409 Norwegians assigned to the patient lists of 2,560 regular GPs who, after 12 months of stable practice, had a sudden discontinuity of practice lasting two or more months between 2007 and 2017.

Primary and secondary outcome measures: Monthly GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in periods during and 12 months after the discontinuity, compared with the 12 month period before the discontinuity using logistic regression models.

Results: All patient age groups had a 3-5% decreased odds of monthly regular GP consultations during the discontinuity. Odds of monthly out-of-hours consultations increased 2-6% during the discontinuity for all adult age groups. A 7-9% increase in odds of ACSC admissions during the period 1-6 months after discontinuity was indicated in patients over the age of 65, but in general little or no change in acute hospital admissions was observed during or after the period of discontinuity.

Conclusions: Modest changes in health service use were observed during and after a sudden discontinuity in practice among patients with a previously stable regular GP. Older patients seem sensitive to increased acute hospital admissions in the absence of their personal GP.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on person-level registry data on the entire Norwegian population and their GPs in the period 2007 to 2017.
- We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care).
- By following the same patient population over time, we eliminated time-invariant or slow-varying confounding factors related to the composition of patient groups
- It is possible that the consequences of discontinuity would differ according to the causes of the break, which we were unable to measure due to lack of data.

BACKGROUND

Loosing access to your general practitioner (GP) can be emotionally stressful,[1] and patients can be vulnerable during transition of care from one GP to another.[2] Some discontinuities of GP practice are inevitable, as GPs retire, get sick and take parental leave. A study on American patients forced to change their physician due to health care insurance changes, indicated this disruption to be damaging to the patient receipt of quality GP care.[3] Continuity of care is a core value of primary care and general practice, including personal, informational and managerial aspects of continuity.[4] An extensive literature suggest that high continuity of care in general practice reduces hospital admissions,[5-12] readmissions,[13] out-of-hours service visits,[14-16] mortality,[17-20] and health care costs,[21] but there is little research on how a break in this continuity of care affect patients.

A limitation in some of the previous studies on GP continuity of care, is the comparison of patients who receive continuity of care with patients who do not receive continuity of care, the latter a potentially more vulnerable group.[22] In this study, we investigate the consequences regarding health service use for patients with a stable practising regular GP who suddenly experience a discontinuity of care. Patients who experience such discontinuity may have reduced access to regular GPs during office hours and shift to out-of-hours services. Also, not being able to see their regular GP could lead to an increase in avoidable hospital admissions, as the regular GP would be better suited to do a proper assessment of both the medical conditions and the patient's total situation, including alternatives to hospital admission.

The establishment of the Norwegian regular GP scheme in 2001 introduced a structural emphasis on continuity of GP care by entitling all inhabitants to a regular GP within a list-based system,[23] aiming to ensure health services with high availability and continuity for all inhabitants, including vulnerable and marginalized groups.[24] This system has shown the ability to provide a high degree of personal GP continuity.[25]

We utilised Norwegian register data to design a study comparing healthcare use in populations differing in the continuity of GP care. We identified all registered list patients of contracted GPs with a stable practice pattern who suddenly stopped meeting patients for at least two months. Regardless of the reasons for such GP discontinuity, the list patients had to seek help from other physicians in the period when their GP was temporarily or permanently gone. Synchronization of all patient timelines when their GP had a discontinuity of practice allowed us to assess the use of primary and specialist health care services around the time of discontinuity – comparing the entire patient population during and after the discontinuity to itself during a control period before the discontinuity. Thus, the study

aimed to investigate if exposure to GP discontinuity would decrease patients' use of any regular GP but increase their use of the out-of-hours services and potentially also the need for acute hospital admissions.

METHODS

The Norwegian context

Primary care in Norway is organized by the municipalities and includes regular GP services during office hours and out-of-hours services (partly staffed by regular GPs) for emergency medical help. Like the US, the UK and Australia,[26] Norway practices a high level of primary care gatekeeping. Specialist care is generally possible only after a referral from a GP, except for emergency admissions. Health services coverage is universal for all Norwegian residents. Most GPs work in group practices (on average 93% in 2010-2019),[27] most as self-employed (reimbursed by the national insurance system in addition to out-of-pocket payments from patients) and some on fixed salary from the municipality. The use of locums is increasing in Norway. Last quartal of 2018, 21% of all GP practises had been served by a locum, steadily increasing from 12.4% in 2016 (no older data available).[28]

Study design and data

This study has a longitudinal design with person-level data from Norwegian national registers on the entire population during the period 2007-2017. We combined demographical information from Statistics Norway[29] with several Norwegian national registers: the Control and Payment of Health Reimbursement register (KUHR)[30] (on regular and out-of-hours consultations with GPs), the Norwegian General Practitioner Register[31] (on GP affiliation, patient list information, individual GP characteristics) and the Norwegian Patient Register[32] (on acute hospital admissions). Linkage of person-level data from different sources was possible by the identification number unique to all Norwegian inhabitants. Individuals were linked to their appointed regular GP, and each GP's doctor ID allowed identification of GP activity and characteristics.

Study population

The study population comprised all persons registered as list patients of the GPs with an episode of practice discontinuity (GP population) 12 months before this discontinuity took place (see (a) population in Figure 1).

Each time a GP is in contact with a patient, a claim for reimbursement is submitted to the Norwegian Health Economics Administration (Helfo). This claim includes patient ID, time, type of contact, patient diagnosis and information about the GP. These claims are collected in the KUHR database – where both individual patients and doctors may be identified through identification numbers.

For all GPs, we assessed the number of submitted reimbursement claims for ordinary consultations (code 2ad) in the KUHR data each month in the period 2007 to 2017. We linked the monthly registrations on consultation activity to monthly information on the GP practice characteristics from the Norwegian General Practitioner Register. Episodes of two or more consecutive months with less than 10 consultations per month were identified as discontinuities (see Figure 1).

We only included episodes of discontinuity for regular GPs registered as list owners (excluding locums, interns, number of GP episodes=5610) and who had a stable practice on that same list during at least 12 months prior to the break, and none of these months with less than 10 consultations (excluding 2,694 episodes). Furthermore, we excluded 326 episodes for GPs registered with short lists (<500 patients) or low activity during the 12 months before the break (<1000 consultations or ratio<1 for the total number of consultations the last 12 months/registered list size). For each doctor, we only kept the first episode of discontinuity (whereas patients could experience several episodes), removing 492 episodes. The final study population consisted of 2,560 GP's and their registered list patients 12 months before the discontinuity – in total 2,862,717 patient episodes.

Exposure time periods

We defined three exposure periods according to their time from the discontinuity (see (b) exposure in Figure 1); the period defining the discontinuity itself (two consecutive months with no/low practice and the preceding month, a likely starting point of the break since GP activity was measured by calendar month) and the twelve following months divided into two six-month periods. The period before discontinuity served as a control/comparison period.

Outcome/Health care use and follow-up

Our main outcomes were patients' monthly regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in the period during (three-month period) and after (two six-month periods) the discontinuity, compared to the control period before (twelve-month period) the discontinuity of GP care.

For each patient, we identified health care use each month during the follow-up period–dichotomised into monthly use/no monthly use (see (c) in Figure 1). Regular and out-of-hours GP consultations were identified by the reimbursement code for a regular GP consultation (code 2ad[33]) and a GP consultation outside normal working hours (code 2ak[33]) from 2006 to 2017. Acute hospital admissions were identified in the Norwegian Patient Registry from 2008 to 2016, using the dates of admission and discharge for hospital stays that were coded as acute.[32] We also used ICD-10 diagnosis codes to identify hospital stays for ambulatory care sensitive conditions (ACSC). These are conditions for which hospitalisation is thought to be avoidable with the application of preventive care and early disease management, usually delivered in ambulatory settings.[34] We included chronic conditions for which effective management prevents flare-ups (angina pectoris, asthma, chronic obstructive pulmonary disease, congestive heart failure, convulsions/epilepsy, diabetes complications, hypertension, iron deficiency anaemia), acute conditions for which early intervention may prevent more serious progression (ear, nose and throat infections, cellulitis, pyelonephritis, dehydration/gastroenteritis, pelvic inflammatory disease, gangrene, dental conditions, nutritional deficiencies, perforated/bleeding ulcer) and vaccine-preventable conditions (Influenza, pneumonia and other) – using NHS Digital's ICD-10 codes for ACSC episodes.[35]

Covariates

We collected information on patient birth year, sex, education and date for migration or death from Statistics Norway.[29] The highest achieved level of education by 2016 was measured in three categories: 'no/primary school', 'secondary school' and 'college/university'. GP characteristics before the episode of discontinuity (assessed in the first month of the control period, 12 months before the discontinuity) were available from the Norwegian General Practitioner Register[32] and included the GPs' sex and age, list size and municipality. Information on patient health prior to follow-up was collected by monthly assessments of selected health indicators from the Control and Payment of Health Reimbursement register (KUHR)[31] and the Norwegian Patient Register[33].

Analyses

We assessed the associations between patients' distance in time from the discontinuity and use of health services using logistic regression analyses, comparing the same patient population during three exposure periods (at the time of discontinuity, 1-6 months after and 7-12 months after) with itself during a control period before the discontinuity (12 month period before). . We used generalized estimation equation (GEE)[36] models with repeated monthly observations within patients within GPs, to estimate odds ratios (OR) of each of the four outcome measures; monthly regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions. Patients were divided into categories according to their age at discontinuity (0-18, 19-44, 45-64, 65-79 and 80+ years), and all analyses were repeated for each category separately.[36] We adjusted for patient sex and the patient age (in years, categorical variable) at baseline within each age group. We also adjusted for observation calendar month (categorical variable) and calendar year (categorical variable) in order to take into account confounding from periodic and secular variance. Finally, we adjusted for a continuous variable measuring number of months after follow-up (ranging from 0-27 months) in order to adjust for confounding by increasing age within the follow up period, since age is likely to increase use of services rapidly among the elderly.

In addition, we performed analyses on the patient subgroups with hypertension, ischemic heart disease, mental illness and prior hospital stay. Patient's health status was assessed during a 12-month period prior to the control period (for these analyses defined by the six month period before discontinuity, see supplementary figure 1). We identified three subgroups for which we considered continuity of care to be of particular benefit: 1) Hypertension – all patients having one or more diagnoses of hypertension (ICPC2 diagnosis K85-87) in the KUHR data. 2) Ischemic heart disease – all patients having one or more diagnoses of (ICPC2 diagnosis K74-80) in the KUHR data and 3) Mental illness – all patients having one or more diagnoses of (ICPC2 diagnosis P70-P99) in the KUHR data and 4)acute hospital stay – all patients having one or more acute hospital stay.

Patients were censored on the exact month of migration or death and periods lacking data. We performed all analyses with STATA version 15.1. Precision was presented with 95% confidence intervals (CI) using robust standard errors, and taking into account clustering of information within patients within the same GP.

Patient and public involvement

Patients and/or the public were not involved in the development of the research question, study design or interpretation of the data.

RESULTS

In the period 2007 to 2016, a total of 2,409,409 patients were registered as list patients of our selection of 2,560 unique regular GPs with a stable practice, but who 12 months later had an episode of discontinuity. The number of patient episodes of discontinuity was 2,862,717, as each patient could experience several episodes of discontinuity related to different GPs; 85% had one episode, 99% had 1 or 2 episodes, and the maximum number of episodes was five (data not shown). For baseline GP and patient characteristics, see Table 1. Patient healthcare use during the year prior to follow-up is available as Supplementary Table 1.

Table 1: Study sample with baseline characteristics of selected GP's with an episode of discontinuity in an earlier stable practice and their list patients (2007-2017).

GP characteristics [1]	*n*	%
Total	2,560	100 %
GP sex		
Female	1,084	42 %
Male	1,476	58 %
GP age at discontinuity		
<30	22	1 %
30-39	1010	39 %
40-49	548	21 %
50-59	431	17 %
60+	549	21%
GP in group practice	2,244	88%
GP activity before discontinuity		
Registered list size – mean number of patients (range)	1,126	500-2,483
Mean number of ordinary patient consultations during 12 months before discontinuity (range)	2,657	1,000-10,530
GP activity 12 months after discontinuity		
Registered with same list as before	1,586	62 %
Registered with same list as before and active (> 10 consultations)	1,112	43 %
Registered with same list as before and normal activity (number of consultations ≥ 75% compared with 12 months before discontinuity)	813	32%
Patient episode characteristics [1]	***n***	**%**
Patient episodes [2]	2,862,717	100 %
Sex		

Female	1,441,798	50.4 %
Male	1,420,919	49.6 %
Age groups		
0-18	614,576	21.5 %
19-44	1,026,774	35.9 %
46-64	729,031	25.5 %
65-79	339,833	11.9 %
80+	152,503	5.3 %
Educational level[3]		
Primary	680,098	27.8 %
Secondary	1,014,323	41.5 %
Tertiary	752,697	30.8 %
Geography[4]		
Municipality < 2000 inhabitants	55,576	2 % (of total)
10 most populated municipalities	892,857	31 % (of total)

Monthly health service contact (age groups, % with at least one)	Regular GP	Out-of-hours	Acute admission	ACSC admission
0-18	9.9	2.0	0.3	0.07
19-44	16.0	1.5	0.7	0.04
46-64	19.4	1.1	0.7	0.11
65-79	26.3	1.2	1.5	0.34
80+	30.3	1.8	3.3	0.85

1: Patient- and GP characteristics were identified 12 months before the identified discontinuity, unless otherwise stated
2: incidents of discontinuity of care. Some patient could experience several episodes of discontinuity during our observation time, and hence be counted more than once.
3: Educational level measured in 2016
4: Municipality in which the patient's GP was registered. Municipality size per 2. quarter of 2019.

As seen in Table 2, patients in all age groups had a 3%-5% decreased odds of monthly consultation during the discontinuity, compared with the control period before the discontinuity. Most age-groups then had a normalisation after the discontinuity. Compared with the control period before the discontinuity, all adult age groups had a 2%-6% increased odds of monthly out-of-hours consultations during the discontinuity, which remained elevated after the discontinuity for most age groups. In general, there was little or no difference in acute hospital admissions during or after the period of discontinuity, but some evidence of an increase in ACSC admissions after discontinuity in patients over the age of 65. In the age group 65-79 years, the odds for ACSC admissions increased 7-11% after discontinuity (OR 1.07, 95% CI 1.01,1.14 and OR 1.11, 95% CI 1.01,1.21 for periods 1-6 months and 7-12 months after discontinuity) compared with the period before discontinuity.

Table 2: Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for one or more monthly GP consultations, out-of-hours service consultations, acute hospital admissions and hospital admissions for ambulatory care sensitive conditions (ACSC) during (3 month period) and after (1-6 months after and 7-12 months after) a sudden discontinuity of GP care, compared to a 12-month stable control period before the discontinuity. Separate analyses for each patient age group, adjusted for month/time, calendar month, calendar year, patient age and sex. (2007-2017)

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.96	(0.95-0.96)	0.97	(0.97-0.98)	0.96	(0.95-0.96)	0.95	(0.95-0.96)	0.96	(0.96-0.97)
After discontinuity I (1-6 months after)	0.97	(0.96-0.98)	1.00	(0.99-1.00)	1.00	(1.00-1.01)	1.01	(1.00-1.02)	1.03	(1.01-1.04)
After discontinuity II (7-12 months after)	0.97	(0.96-0.99)	1.00	(0.99-1.01)	1.00	(0.99-1.01)	1.01	(1.00-1.02	1.01	(0.99-1.02)
Monthly out-of-hours consultations (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.00	(0.98-1.02)	1.04	(1.02-1.05)	1.02	(1.01-1.04)	1.05	(1.02-1.07)	1.06	(1.02-1.09)
After discontinuity I (1-6 months after)	0.98	(0.96-1.00)	1.03	(1.01-1.05)	1.01	(0.99-1.03)	1.06	(1.02-1.09)	1.07	(1.03-1.11)
After discontinuity II (7-12 months after)	0.97	(0.95-1.00)	1.02	(1.00-1.05)	0.99	(0.96-1.03)	1.06	(1.02-1.11)	1.06	(1.00-1.12)
Monthly acute hospital admissions (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.02	(0.97-1.07)	1.03	(1.00-1.05)	1.01	(0.99-1.04)	1.02	(1.00-1.05)	1.03	(1.00-1.06)
After discontinuity I (1-6 months after)	1.04	(0.98-1.10)	1.02	(0.99-1.05)	1.01	(0.98-1.05)	1.04	(1.01-1.08)	1.04	(1.00-1.08)
After discontinuity II (7-12 months after)	1.10	(1.02-1.20)	1.02	(0.98-1.07)	1.01	(0.97-1.06)	1.04	(0.99-1.09)	1.02	(0.97-1.07)
Monthly ACSC hospital admissions (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-contrmonth period)	0.91	(0.82-1.02)	1.05	(0.96-1.15)	1.02	(0.95-1.09)	1.03	(0.98-1.09)	1.06	(1.00-1.12)
After discontinuity I (1-6 months after)	0.97	(0.85-1.10)	1.07	(0.96-1.19)	1.04	(0.96-1.12)	1.07	(1.01-1.14)	1.09	(1.02-1.16)
After discontinuity II (7-12 months after)	0.99	(0.83-1.19)	1.05	(0.90-1.22)	1.02	(0.91-1.14)	1.11	(1.01-1.21)	1.04	(0.94-1.14)

Subgroup analysis

Separate analyses on subgroups according to patient health status prior to follow-up (hypertension, ischaemic heart disease, mental illness and previously hospitalized) are shown in Supplementary tables 2, 3 and 4. Compared to the main analysis, the subgroup analysis on patients with hypertension and ischaemic heart disease showed only marginal differences, but with somewhat more decreased OR of GP consultations during discontinuity, followed by normalisation. Patients with previous hypertension aged 65-79 had an increasing OR for out-of-hours consultations during and after discontinuity. For example, in the main analysis patients aged 65-79 had an OR 1.06 (95% CI 1.02-1.09) for monthly out-of-hours consultations 1-6 months after discontinuity, whereas patients with hypertension had an OR 1.13 (95% CI 1.03-1.25). For patients with previous ischaemic heart disease the largest differences between main and subgroup analyses applied to those aged 45-64 years who had decreased OR for ACSC acute hospital admissions during and the first period after discontinuity in the subgroup analysis, whereas those aged 65-79 years had more increased OR for ACSC acute hospital admissions in the subgroup analysis, compared to the main analysis. Previously hospitalised in the age-group 80+ had increased OR for acute hospital admissions compared to patients included in the main analysis, particularly ACSC admissions. For example, in the main analysis patients aged 80+ had an OR 1.09 (95% CI 1.02-1.16) for monthly ACSC hospital admissions 1-6 months after discontinuity, whereas previously hospitalized patients had an OR 1.24 (95% CI 1.08-1.42).

DISCUSSION

Summary

In this study, we followed all Norwegian inhabitants registered as list patients of stable practising GPs who experienced one or more episodes of discontinuity of GP care between 2007 and 2017. We found that all patient age groups had a small dip in regular GP consultations at the time of discontinuity compared with before the discontinuity, followed by normalisation for all adult groups. Out-of-hours consultations increased at the time of discontinuity for all adult groups compared with before the discontinuity and remained elevated during the following 12 months for those aged 19-44 years, 65-79 years and 80+ years. An increase in ACSC admissions after discontinuity was indicated in patients over the age of 65, but in general little or no differences in acute hospital admissions were observed during or after the period of discontinuity.

Strengths and limitations

We used a linkage of several registries, providing person-level data on the entire Norwegian population and their GPs within a rather long observation period, which provided relatively precise estimates, even in the separate subgroup analyses. The Norwegian GP scheme with <1% non-participants since the start in 2001[37] made it possible to link each individual in the population to their regular GP. By including all patients 12 months before the break in GP continuity, we did not condition on the patient surviving until discontinuity. Hence, we did not miss some of the acute (potentially fatal) hospital admissions in our observation time before the discontinuity, thereby avoiding immortal time-bias.[38]

We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care). We assessed the changes in outcome by following the same patient population over time. By design, we thereby eliminated all time-invariant or slow-varying confounding factors related to the composition of patient lists (groups), including morbidity, help-seeking behaviour, sex and education. There are numerous causes of a break in the GP practice (parental leave, mandatory practice for specialization in general practice medicine, retirement, job change, GP sickness or death etc.), resulting in discontinuity for a shorter or longer period. It is possible that the consequences of discontinuity would differ according to the causes of the break (e.g. planning, speed of replacement, single or group practice).

Comparisons with existing literature

Our results may indicate that the system itself – including all public primary healthcare GP services – usually is robust and capable of absorbing discontinuities without detrimental effects on most patient groups. The observed dip in GP consultations during the discontinuity was transient, indicating that after a few months, most patients were able to consult a GP in the same manner as before the break. However, our results also raise several concerns regarding the observed increase in emergency health care usage.

The increase in monthly odds of out-of-hours consultations seen during the break persisted throughout the follow-up period for several age groups. This may indicate suboptimal quality of care

due to temporary solutions and delayed replacement of a new GP and/or that patients have a lower threshold for using the out-of-hours services when the alternative is seeing a locum/unknown GP.

The present study also indicates a small increase in ACSC admissions after the discontinuity for older patients. A relationship between interpersonal continuity of care, improved delivery of preventive services and lower rates of hospitalization has been suggested by other studies.[9] Our findings are also coherent with findings from recent large cross-sectional and cohort studies on older patients in other settings, indicating that a lower degree of continuity of care assessed by various indexes for continuity of care is associated with increased risk of hospital admission.[5, 10] Increase in hospital admission could indicate a health deterioration due to lack of proper treatment and follow-up in the absence of the GP, but may also reflect that patients are more likely to be admitted to hospital when meeting unfamiliar doctors. A potential direct negative impact on patient health (and not only an overuse of secondary healthcare) is suggested by the findings of increased mortality with lower levels of continuity of care from other studies.[19]

In contrast to the large body of research on continuity of care, few studies have investigated *cessation* of continuity of care. A recent systematic review assessed how physician retirement impacted patients and found mainly unfavourable outcomes, mainly published as anecdotes and qualitative studies.[2] The authors point to some possible mechanisms related to difficulty accessing care, difficulty with transition and poor handover of information. Our results indicate that special attention should be given to elderly and frail patient groups as early as possible when the discontinuity is known to happen. Systematic identification of patients at risk and well-established information routines in relation to permanent or temporary GP breaks are possible actions that need to be studied further.

CONCLUSION

We investigated the consequences, in terms of health service use, for patients who experienced discontinuity of care from a primary physician who knew their medical and socioeconomic history. We found that in the Norwegian setting, discontinuity of GP care had some minor influence on primary care physician use. Patients continue to consult other GPs in a similar way as before and use the out-of-hours GP services to compensate for reduced access to or quality of care. Discontinuity of GP care might increase acute hospital admissions for ambulatory care sensitive conditions in the older age groups, suggesting a crucial role of the GP for these patient groups. These findings underline the importance of continuity of care in order to keep patient care and costs on the lowest level desired,

avoiding some unnecessary health care use (including out-of-hours visits and hospital admissions) and health care costs. This seems particularly important in the perspective of an ageing population since the older age groups seem most sensitive to GP continuity.

DECLARATION

Acknowledgements

We would like to thank Statistics Norway and the Norwegian Directorate of Health for providing data.

Contributors

KP, JHB, LJS and SLK conceived the study and its design. KP and JHB contributed to design of the study protocol and facilitated acquisition of all data. KP and LJS prepared and analysed the data. JHB and SLK provided input on the discussion and interpretation of the findings. LJS drafted the first version of the manuscript. All authors contributed to and approved the final manuscript. All the authors have read the final version of the manuscript and agreed to its submission.

Funding

This work was supported by the Norwegian University of Science and Technology, and is a part of a larger project "Health care services under pressure – Consequences for patient flows, efficiency and patient safety in Norway" funded by the Norwegian Research Council (grant number 256579). JHB was funded by the Norwegian Research Council (grant number 295989).

Competing interests:

None

Patient and public involvement:

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication:

Not required.

Ethics approval:

The Regional Committee for Medical and Health Research Ethics in Central Norway approved the study (2011/2047).

Provenance and peer review:

Not commissioned; externally peer reviewed.

Data availability statement:

The data used in this study are publicly available, given approval.

References

1. Freeman T, Brown JB, Reid G, et al. Patients' perceptions on losing access to FPs: qualitative study. *Canadian family physician Medecin de famille canadien*. 2013;59(4):e195-201.
2. Lam K, Arnold CG, Savage RD, et al. Does Physician Retirement Affect Patients? A Systematic Review. *Journal of the American Geriatrics Society*. 2020;68(3):641-9.
3. Flocke SA, Stange KC, Zyzanski SJ. The impact of insurance type and forced discontinuity on the delivery of primary care. *J Fam Pract*. 1997;45(2):129-35.
4. Haggerty JL, Reid RJ, Freeman GK, et al. Continuity of care: a multidisciplinary review. *Bmj*. 2003;327(7425):1219-21.
5. Barker I, Steventon A, Deeny SR. Association between continuity of care in general practice and hospital admissions for ambulatory care sensitive conditions: cross sectional study of routinely collected, person level data. *BMJ*. 2017;356:j84.
6. Bayliss EA, Ellis JL, Shoup JA, et al. Effect of continuity of care on hospital utilization for seniors with multiple medical conditions in an integrated health care system. *Annals of family medicine*. 2015;13(2):123-9.
7. Hansen AH, Halvorsen PA, Aaraas IJ, et al. Continuity of GP care is related to reduced specialist healthcare use: a cross-sectional survey. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2013;63(612):482-9.
8. Huntley A, Lasserson D, Wye L, et al. Which features of primary care affect unscheduled secondary care use? A systematic review. *BMJ open*. 2014;4(5).
9. Saultz JW, Lochner J. Interpersonal continuity of care and care outcomes: a critical review. *Annals of family medicine*. 2005;3(2):159-66.
10. Tammes P, Purdy S, Salisbury C, et al. Continuity of Primary Care and Emergency Hospital Admissions Among Older Patients in England. *Annals of family medicine*. 2017;15(6):515-22.
11. van Loenen T, van den Berg MJ, Westert GP, et al. Organizational aspects of primary care related to avoidable hospitalization: a systematic review. *Family practice*. 2014;31(5):502-16.
12. Menec VH, Sirski M, Attawar D, et al. Does continuity of care with a family physician reduce hospitalizations among older adults? *Journal of health services research & policy*. 2006;11(4):196-201.
13. Swanson JO, Vogt V, Sundmacher L, et al. Continuity of care and its effect on readmissions for COPD patients: A comparative study of Norway and Germany. *Health Policy*. 2018;122(7):737-45.
14. Emery DP, Milne T, Gilchrist CA, et al. The impact of primary care on emergency department presentation and hospital admission with pneumonia: a case-control study of preschool-aged children. *NPJ Primary Care Respiratory Medicine*. 2015;25:14113.
15. Kohnke H, Zielinski A. Association between continuity of care in Swedish primary care and emergency services utilisation: a population-based cross-sectional study. *Scandinavian journal of primary health care*. 2017;35(2):113-9.
16. Sarmento G, Leal-Seabra F, Brinquinho M, et al. Continuity of primary care and emergency department utilization among elderly people. *European Geriatric Medicine*. 2016;7:S224.
17. Leleu H, Minvielle E. Relationship between longitudinal continuity of primary care and likelihood of death: analysis of national insurance data. *PLoS One*. 2013;8(8):e71669.
18. Maarsingh OR, Henry Y, van de Ven PM, et al. Continuity of care in primary care and association with survival in older people: a 17-year prospective cohort study. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2016;66(649):e531-9.
19. Pereira Gray DJ, Sidaway-Lee K, White E, et al. Continuity of care with doctors—a matter of life and death? A systematic review of continuity of care and mortality. *BMJ open*. 2018;8(6):e021161.

20. Wolinsky FD, Bentler SE, Liu L, et al. Continuity of care with a primary care physician and mortality in older adults. *The journals of gerontology Series A, Biological sciences and medical sciences*. 2010;65(4):421-8.
21. Hollander MJ, Kadlec H. Financial implications of the continuity of primary care. *The Permanente journal*. 2015;19(1):4-10.
22. Sweeney KG, Gray DP. Patients who do not receive continuity of care from their general practitioner--are they a vulnerable group? *The British journal of general practice : the journal of the Royal College of General Practitioners*. 1995;45(392):133-5.
23. The Norwegian Ministry of Health and Care Services. Forskrift om fastlegeordning i kommunene 2012 [updated 2018 Mar 08; cited 2020 May 16]. Available from: https://lovdata.no/dokument/SF/forskrift/2012-08-29-842.
24. The Norwegian Medical Association, The Norwegian Association of General Practitioners, The Medical Speciality Society for General Practice. Utviklingsplan for fastlegeordningen 2015 - 2020 2015 [cited 2020 May 19]. Available from: https://www.legeforeningen.no/contentassets/743cd468b6d6435ca138de1a2909caf9/utviklingsplan-flo.pdf.
25. Hetlevik O, Gjesdal S. Personal continuity of care in Norwegian general practice: a national cross-sectional study. *Scandinavian journal of primary health care*. 2012;30(4):214-21.
26. Greenfield G, Foley K, Majeed A. Rethinking primary care's gatekeeper role. *BMJ*. 2016;354:i4803.
27. EY and Vista Analysis. Evaluering av fastlegeordningen 2019 [cited 2020 May 16]. Available from: https://www.regjeringen.no/contentassets/7cd212bf5f0642c1a5d0d480f0923e6d/evaluering-av-fastlegeordningen---sluttrapport-fra-ey-og-vista-analyse.pdf
28. Gaardsrud PØ. Fastlegestatistikk 2018 hovedtall The Norwegian Directorate of Health; 2019 [cited 2020 May 16]. Available from: https://www.helsedirektoratet.no/statistikk/fastlegestatistikk
29. Statistics Norway. Statistisk sentralbyrå 2019 [cited 2020 May 16]. Available from: https://www.ssb.no/en.
30. The Norwegian Directorate of Health. KUHR-databasen 2019 [updated 2019 Apr 08; cited 2020 May 16]. Available from: https://www.helsedirektoratet.no/tema/statistikk-registre-og-rapporter/helsedata-og-helseregistre/kuhr
31. The Norwegian Directorate of eHealth. Fastlegeregisteret 2020 [cited 2020 19 Mai]. Available from: https://helsedata.no/forvaltere/helsedirektoratet/fastlegeregisteret/.
32. Bakken IJ, Ariansen AMS, Knudsen GP, et al. The Norwegian Patient Registry and the Norwegian Registry for Primary Health Care: Research potential of two nationwide health-care registries. *Scandinavian journal of public health*. 2019:1403494819859737.
33. The Norwegian Medical Association. Normaltariffen for fastleger og legevakt 2019-2020 [Tariff]. 2019 [cited 2020 May 16]. Available from: https://normaltariffen.legeforeningen.no/asset/pdf/Fastlegetariffen-2019-2020.pdf (page 21).
34. Ansari Z. The Concept and Usefulness of Ambulatory Care Sensitive Conditions as Indicators of Quality and Access to Primary Health Care. *Australian journal of primary health*. 2007;13(3):91-110.
35. NHS Digital. Ambulatory Care Sensitive Conditions (ACSC) 2019 [updated 2019 Dec 12; cited 2020 May 16]. Available from: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/innovative-uses-of-data/demand-on-healthcare/ambulatory-care-sensitive-conditions# (Appendix A).
36. Twisk JWR. Applied Longitudinal Data Analysis for Epidemiology. Cambridge: Cambridge University Press; 2003. 182 p.
37. Gaardsrud PØ. Fastlegestatistikk 2017 hovedtall [Regular General Practitioner Statistics 2017]: The Norwegian Directorate for Health; 2018 [Available from: https://www.helsedirektoratet.no/statistikk/statistikk/fastlegestatistikk

38. Rothman KJ. Epidemiology: an introduction. 2nd ed. ed. New Yourk: Oxford university press; 2012. 268 p.

Figure legends:

Figure 1: Illustration of study design and timeline for the (a) study population and GPs, (b) definition of control period (12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in four defined periods.

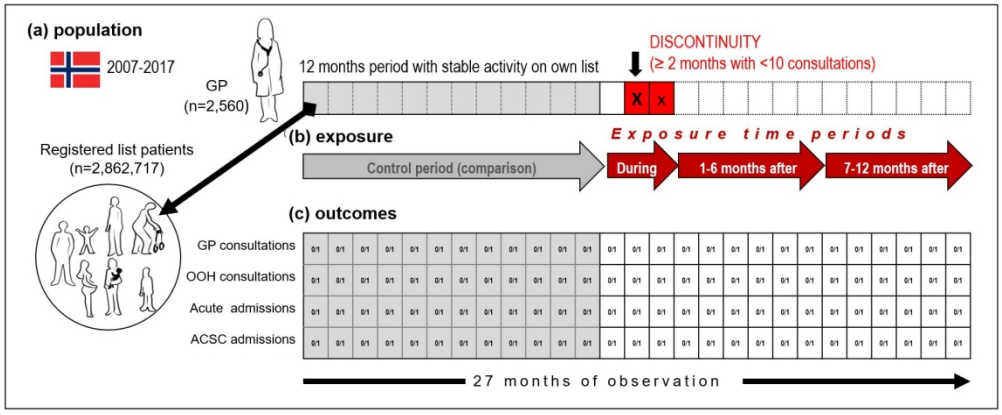


Illustration of study design and timeline for the (a) study population and GPs, (b) definition of control period (12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in four defined periods

Supplementary Tables, How does general practitioner discontinuity affect health care utilisation? An observational cohort study of 2.4 million Norwegians 2007-2017

Supplementary Table 1: Patient health status during the 12-month period prior to follow-up, assessed by various indicators of health care usage among patients with available data. Gray shading indicate groups included in the sub-group analyses.

	0-18 years	19-44 years	45-64 years	65-79 years	80+ years
Regular GP consultations during 12 months					
N (patient episodes)	559,509	939,841	664,549	311,647	138,929
mean number of consultations(SD)	1.4 (1.9)	2.4 (3.4)	2.9(3.8)	4.0 (4.4)	4.8 (5.3)
median number of consultations (IQR)	1 [0-2]	1[0-3]	2[0-4]	3[1-5]	3[1-7]
% with at least one consultation	59.4	67.1	73.0	84.1	80.6
% with at least one consultation for hypertension[1]	0.0	1.0	8.6	20.4	19.2
% with at least one consultation for ischaemic heart disease[2]	0.0	0.1	2.0	8.6	16.8
% with at least one consultation for mental illness[3]	1.4	6.1	6.1	4.1	5.7
Acute hospital admission during 12 months					
N	441,434	751,145	532,225	257,262	111,526
% with at least one acute hospital admission[4]	4.1	6.8	6.0	11.7	25.5

1: One or more consultations with hypertension diagnoses (ICPC2 diagnosis K85-87) in the KUHR data
2: One or more consultations with ischemic heart disease diagnoses (ICPC2 diagnosis K74-80) in the KUHR data
3: One or more consultations with mental illness diagnoses (ICPC2 diagnosis P70-99) in the KUHR data
4: One or more registered acute hospital stays in the Norwegian Patient Registry (excl. psychiatric care)

Supplementary Table 2: Subgroup analysis of patients who had at least one GP consultation for Hypertension (ICPC2 diagnosis K85-87) or Ischaemic heart disease (ICPC2 diagnosis K74-80) during the 12-month period before the control period and follow-up. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly healthcare use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; adjusted for month/time, calendar month, calendar year, patient age and sex.

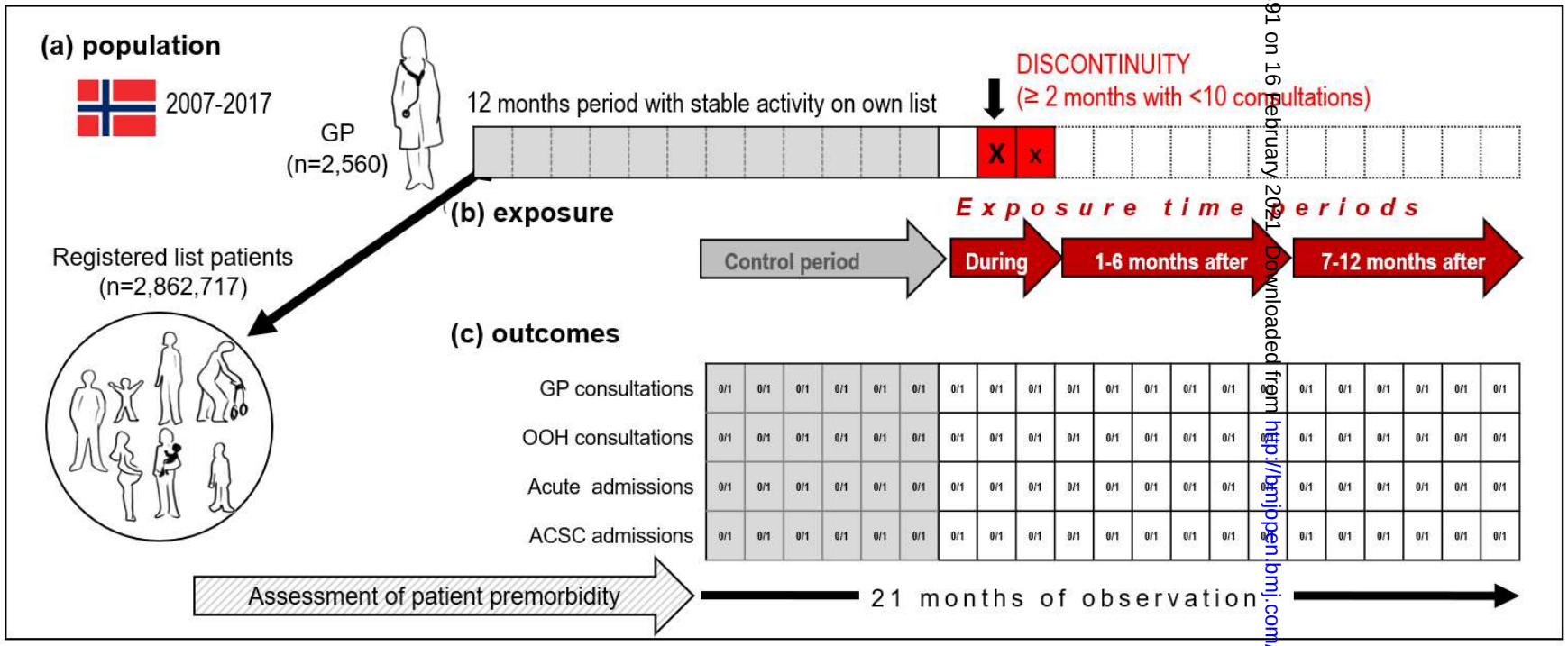
	Hypertension						Ischaemic heart disease					
	45-64 years		65-79 years		80+ years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	0.91	(0.90-0.93)	0.93	(0.92-0.94)	0.94	(0.92-0.96)	0.93	(0.91-0.96)	0.93	(0.91-0.95)	0.95	[0.93-0.97]
After discontinuity I (1-6 months after)	0.97	(0.95-0.99)	1.00	(0.98-1.02)	1.00	(0.97-1.03)	0.97	(0.93- 1.01)	1.00	(0.97-1.02)	1.01	[0.98-1.04]
After discontinuity II (7-12 months after)	0.98	(0.95-1.02)	0.99	(0.96-1.02)	0.96	(0.91-1.01)	1.00	(0.94-1.07)	1.00	(0.96-1.05)	1.01	[0.96-1.06]
Monthly out-of-hours consultations (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (3-month period)	1.05	(0.98-1.12)	1.08	(1.01-1.16)	0.96	(0.88-1.05)	1.00	(0.89-1.12)	1.03	(0.95-1.12)	1.03	[0.95-1.11]
After discontinuity I (1-6 months after)	1.08	(0.98-1.20)	1.13	(1.02-1.24)	0.95	(0.84-1.08)	0.95	(0.80-1.12)	1.07	(0.95-1.21)	1.05	[0.93-1.18]
After discontinuity II (7-12 months after)	1.12	(0.96-1.31)	1.18	(1.01-1.37)	0.84	(0.69-1.02)	1.03	(0.79-1.33)	1.04	(0.86-1.25)	1.03	[0.86-1.23]
Monthly acute hospital admissions (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (3-month period)	1.05	(0.96-1.14)	1.07	(1.00-1.14)	1.04	(0.97-1.12)	0.99	(0.89-1.10)	1.04	(0.97-1.11)	1.03	[0.98-1.10]
After discontinuity I (1-6 months after)	1.03	(0.91-1.18)	1.08	(0.98-1.19)	0.99	(0.90-1.10)	0.99	(0.85-1.15)	1.13	(1.03-1.25)	1.06	[0.97-1.16]
After discontinuity II (7-12 months after)	1.06	(0.87-1.28)	1.07	(0.93-1.23)	0.96	(0.82-1.13)	1.14	(0.90-1.44)	1.15	(0.99-1.34)	1.05	[0.92-1.20]
Monthly ACSC acute hospital admissions (one or more)												
Control period (6-monthperiod before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
During discontinuity (3-month period)	1.22	(0.99-1.52)	1.11	(0.95-1.28)	0.88	(0.75-1.03)	0.78	(0.63-0.96)	1.06	(0.94-1.20)	1.04	[0.93-1.15]
After discontinuity I (1-6 months after)	1.26	(0.92-1.72)	1.31	(1.07-1.61)	0.87	(0.70-1.08)	0.68	(0.50-0.93)	1.27	(1.06-1.51)	1.04	[0.90-1.21]
After discontinuity II (7-12 months after)	1.46	(0.90-2.38)	1.33	(0.97-1.82)	0.74	(0.53-1.04)	0.73	(0.46-1.18)	1.38	(1.05-1.81)	1.01	[0.80-1.28]

Supplementary Table 3: Subgroup analysis of patients who had at least one GP consultation for mental illness (ICPC2 diagnosis P70-99) during the 12-month period before the control period and follow-up. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly healthcare use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; adjusted for month/time, calendar month, calendar year, patient age and sex.

	19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	0.93	(0.92-0.94)	0.92	(0.91-0.94)	0.94	(0.91-0.97)	0.96	(0.92-1.00)
After discontinuity I (1-6 months after)	0.96	(0.94-0.99)	0.99	(0.96-1.01)	0.98	(0.94-1.03)	0.99	(0.93-1.05)
After discontinuity II (7-12 months after)	1.00	(0.97-1.04)	1.02	(0.98-1.06)	1.00	(0.94-1.07)	0.98	(0.90-1.08)
4Monthly out-of-hours consultations (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	1.04	(1.00-1.09)	1.06	(1.00-1.12)	1.03	(0.93-1.15)	1.08	(0.94-1.24)
After discontinuity I (1-6 months after)	1.03	(0.97-1.10)	1.02	(0.94-1.12)	1.07	(0.92-1.25)	0.97	(0.79-1.20)
After discontinuity II (7-12 months after)	1.04	(0.95-1.15)	1.03	(0.90-1.18)	1.15	(0.91-1.47)	0.92	(0.66-1.27)
Monthly acute hospital admissions (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	1.09	(1.02-1.17)	1.01	(0.93-1.09)	1.02	(0.92-1.13)	1.03	(0.92-1.15)
After discontinuity I (1-6 months after)	1.01	(0.91-1.11)	0.99	(0.88-1.11)	1.05	(0.90-1.22)	0.98	(0.84-1.16)
After discontinuity II (7-12 months after)	1.00	(0.86-1.17)	1.01	(0.85-1.21)	1.06	(0.84-1.35)	1.03	(0.80-1.33)
Monthly ACSC acute hospital admissions (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	0.99	(0.82-1.19)	0.88	(0.78-1.00)	1.05	(0.96-1.15)	1.15	(1.04-1.26)
After discontinuity I (1-6 months after)	1.07	(0.82-1.40)	0.87	(0.73-1.03)	1.14	(1.00-1.29)	1.24	(1.08-1.43)
After discontinuity II (7-12 months after)	1.08	(0.71-1.65)	0.90	(0.69-1.18)	1.19	(0.98-1.46)	1.38	(1.11-1.72)

Supplementary Table 4: Subgroup analysis of patients who had at least one emergency hospital admission during the 12-month period before the control period and follow-up (2008-2017). Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly health care use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; adjusted for month/time, calendar month, calendar year, patient age and sex

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	0.97	(0.93-1.01)	0.97	(0.96-0.99)	0.94	(0.92-0.96)	0.95	(0.93-0.96)	0.97	(0.95-0.99)
After discontinuity I (1-6 months after)	0.99	(0.94-1.04)	1.03	(1.01-1.06)	0.99	(0.97-1.02)	1.02	(0.99-1.05)	1.02	(0.99-1.05)
After discontinuity II (7-12 months after)	0.98	(0.91-1.07)	1.06	(1.02-1.10)	1.04	(0.99-1.09)	1.04	(0.99-1.08)	1.00	(0.95-1.05)
Monthly out-of-hours consultations (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	1.03	(0.96-1.11)	1.03	(0.98-1.08)	1.00	(0.94-1.07)	1.00	(0.94-1.07)	1.06	(0.98-1.14)
After discontinuity I (1-6 months after)	1.01	(0.91-1.12)	1.06	(0.99-1.14)	1.00	(0.91-1.09)	1.06	(0.96-1.17)	1.09	(0.98-1.22)
After discontinuity II (7-12 months after)	1.02	(0.87-1.20)	1.09	(0.97-1.21)	0.95	(0.82-1.10)	1.09	(0.94-1.28)	1.10	(0.92-1.30)
Monthly acute hospital admissions (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	0.99	(0.87-1.13)	0.98	(0.92-1.04)	0.99	(0.94-1.05)	1.03	(0.98-1.08)	1.06	(1.01-1.11)
After discontinuity I (1-6 months after)	1.15	(0.96-1.38)	1.04	(0.95-1.13)	1.03	(0.95-1.12)	1.10	(1.02-1.19)	1.13	(1.05-1.22)
After discontinuity II (7-12 months after)	1.36	(1.02-1.81)	1.07	(0.94-1.22)	1.15	(1.01-1.31)	1.16	(1.03-1.30)	1.16	(1.03-1.30)
Monthly ACSC acute hospital admissions (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
During discontinuity (3-month period)	1.02	(0.80-1.29)	0.99	(0.82-1.19)	0.88	(0.78-1.00)	1.05	(0.96-1.15)	1.15	(1.04-1.26)
After discontinuity I (1-6 months after)	1.14	(0.80-1.63)	1.07	(0.82-1.40)	0.87	(0.73-1.03)	1.14	(1.00-1.29)	1.24	(1.08-1.43)
After discontinuity II (7-12 months after)	1.38	(0.80-2.39)	1.08	(0.71-1.65)	0.90	(0.69-1.18)	1.19	(0.98-1.46)	1.38	(1.11-1.72)



Supplementary figure 1: Illustration of subgroup study design and timeline for the (a) study population and GPs, (b) definition of control period (6 last of 12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in four defined periods. Patients premorbidity was assessed 12 months prior to the control period.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	a) 5-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	6-8
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	a) 5-8
		(*b*) Describe any methods used to examine subgroups and interactions	b) 8
		(*c*) Explain how missing data were addressed	c) 8
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	e) 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 + Table 1
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

How does general practitioner discontinuity affect health care utilisation? An observational cohort study of 2.4 million Norwegians 2007-2017

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042391.R2
Article Type:	Original research
Date Submitted by the Author:	10-Jan-2021
Complete List of Authors:	Skarshaug, Lena; Norwegian University of Science and Technology, Department of Public Health and Nursing Kaspersen, Silje; SINTEF, Digital; Norwegian University of Science and Technology, Public Health and Nursing Bjorngaard, Johan; Norwegian University of Science and Technology, Department of Public Health and Nursing; Nord Universitet - Levanger Campus, Faculty of Nursing and Health Sciences Pape, Kristine; Norwegian University of Science and Technology, Public Health and Nursing
Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	Health services research, Epidemiology, General practice / Family practice, Patient-centred medicine, Public health
Keywords:	PRIMARY CARE, EPIDEMIOLOGY, PUBLIC HEALTH, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

How does general practitioner discontinuity affect health care utilisation?

An observational cohort study of 2.4 million Norwegians 2007-2017

Lena J. Skarshaug* [a]

Silje L. Kaspersen [a, b]

Johan H. Bjørngaard [a, c]

Kristine Pape [a]

a) Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Trondheim, Norway

b) SINTEF Digital, SINTEF, Trondheim, Norway

c) Nord University, Faculty of Nursing and Health Sciences, Levanger, Norway

*Correspondence to Lena J. Skarshaug, Department of Public Health and Nursing at the Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Håkon Jarls Gate 11, 7030 Trondheim, Norway; E-mail: lena.j.skarshaug@ntnu.no

MeSH keywords: general practice, continuity of patient care, health service research, hospitalization, primary health care.

Word count: 3413 words.

ABSTRACT

Objectives: Patients may benefit from continuity of care by a personal physician (GP), but there are few studies on consequences of a break in continuity of GP. Investigate how a sudden discontinuity of GP care affects their list patients' regular GP consultations, out-of-hours consultations and acute hospital admissions, including admissions for ambulatory care sensitive conditions (ACSC).

Design: Cohort study linking person-level national register data on use of health services and GP affiliation with data on GP activity and GP characteristics.

Setting: Primary Care

Participants: 2,409,409 Norwegians assigned to the patient lists of 2,560 regular GPs who, after 12 months of stable practice, had a sudden discontinuity of practice lasting two or more months between 2007 and 2017.

Primary and secondary outcome measures: Monthly GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions in periods during and 12 months after the discontinuity, compared with the 12-month period before the discontinuity using logistic regression models.

Results: All patient age groups had a 3-5% decreased odds of monthly regular GP consultations during the discontinuity. Odds of monthly out-of-hours consultations increased 2-6% during the discontinuity for all adult age groups. A 7-9% increase in odds of ACSC admissions during the period 1-6 months after discontinuity was indicated in patients over the age of 65, but in general little or no change in acute hospital admissions was observed during or after the period of discontinuity.

Conclusions: Modest changes in health service use were observed during and after a sudden discontinuity in practice among patients with a previously stable regular GP. Older patients seem sensitive to increased acute hospital admissions in the absence of their personal GP.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study was based on person-level registry data on the entire Norwegian population and their GPs in the period 2007 to 2017.

- We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care).
- By following the same patient population over time, we eliminated time-invariant or slow-varying confounding factors related to the composition of patient groups
- It is possible that the consequences of discontinuity would differ according to the causes of the break, which we were unable to measure due to lack of data.

BACKGROUND

Loosing access to your general practitioner (GP) can be emotionally stressful,[1] and patients can be vulnerable during transition of care from one GP to another.[2] Some discontinuities of GP practice are inevitable, as GPs retire, get sick and take parental leave. A study on American patients forced to change their physician due to health care insurance changes, indicated this disruption to be damaging to the patient receipt of quality GP care.[3] Continuity of care is a core value of primary care and general practice, including personal, informational and managerial aspects of continuity.[4] An extensive literature suggest that high continuity of care in general practice reduces hospital admissions,[5-12] readmissions,[13] out-of-hours service visits,[14-16] mortality,[17-20] and health care costs,[21] but there is little research on how a break in this continuity of care affect patients.

Patients who experience such discontinuity may have reduced access to regular GPs during office hours and shift to out-of-hours services. Also, not being able to see their regular GP could lead to an increase in avoidable hospital admissions, as the regular GP would be better suited to do a proper assessment of both the medical conditions and the patient's total situation, including alternatives to hospital admission.

The establishment of the Norwegian regular GP scheme in 2001 introduced a structural emphasis on continuity of GP care by entitling all inhabitants to a regular GP within a list-based system,[22] aiming to ensure health services with high availability and continuity for all inhabitants, including vulnerable and marginalized groups.[23]This system has shown the ability to provide a high degree of personal GP continuity.[24]

We utilised Norwegian register data to design a study comparing healthcare use in populations differing in the continuity of GP care. We identified all registered list patients of contracted GPs with a stable practice pattern who suddenly stopped meeting patients for at least two months. Regardless of the reasons for such GP discontinuity, the list patients had to seek help from other physicians in the period when their GP was temporarily or permanently gone. Synchronization of all patient timelines when their GP had a discontinuity of practice allowed us to assess the use of primary and specialist health care services around the time of discontinuity – comparing the entire patient population during and after the discontinuity to itself during a control period before the discontinuity. Thus, the study aimed to investigate if exposure to GP discontinuity would decrease patients' use of any regular GP but increase their use of the out-of-hours services and potentially also the need for acute hospital admissions.

METHODS

The Norwegian context

Primary care in Norway is organized by the municipalities and includes regular GP services during office hours and out-of-hours services (partly staffed by regular GPs) for emergency medical help. Like the UK,[25] Norway practices a high level of primary care gatekeeping. Specialist care is generally possible only after a referral from a GP, except for emergency admissions. Health services coverage is universal for all Norwegian residents. Most GPs work in group practices (on average 93% in 2010-2019),[26] most as self-employed (reimbursed by the national insurance system in addition to out-of-pocket payments from patients) and some on fixed salary from the municipality. The use of locums is increasing in Norway. Last quartal of 2018, 21% of all GP practises had been served by a locum, steadily increasing from 12.4% in 2016 (no older data available).[27]

Study design and data

This study has a longitudinal design with person-level data from Norwegian national registers on the entire population during the period 2007-2017. We combined demographical information from Statistics Norway[28] with several Norwegian national registers: the Control and Payment of Health Reimbursement register (KUHR)[29] (on regular and out-of-hours consultations with GPs), the Norwegian General Practitioner Register[30] (on GP affiliation, patient list information, individual GP characteristics) and the Norwegian Patient Register[31] (on acute hospital admissions). Linkage of person-level data from different sources was possible by the identification number unique to all Norwegian inhabitants. Individuals were linked to their appointed regular GP, and each GP's doctor ID allowed identification of GP activity and characteristics.

Study population

The study population comprised all persons registered as list patients of the GPs with an episode of practice discontinuity (GP population) during the month 12 months prior to the time of discontinuity (see (a) population in Figure 1).

Each time a GP is in contact with a patient, a claim for reimbursement is submitted to the Norwegian Health Economics Administration (Helfo). This claim includes patient ID, time, type of contact, patient

diagnosis and information about the GP. These claims are collected in the KUHR database – where both individual patients and doctors may be identified through identification numbers.

For all GPs, we assessed the number of submitted reimbursement claims for ordinary consultations (code 2ad) in the KUHR data each month in the period 2007 to 2017. We linked the monthly registrations on consultation activity to monthly information on the GP practice characteristics from the Norwegian General Practitioner Register. Episodes of two or more consecutive months with less than 10 consultations per month were identified as discontinuities (see Figure 1).

We only included episodes of discontinuity for regular GPs registered as owners of lists identified with a unique list ID (excluding locums, interns, number of GP episodes=5610) and who had a stable practice on that same list during at least 12 months prior to the break, and none of these months with less than 10 consultations (excluding 2,694 episodes). Furthermore, we excluded 326 episodes for GPs registered with short lists (<500 patients) or low activity during the 12 months before the break (<1000 consultations or ratio<1 for the total number of consultations the last 12 months/registered list size). For each doctor, we only kept the first episode of discontinuity (whereas patients could experience several episodes), removing 492 episodes. The final study population consisted of 2,560 GP's and all patients registered on their lists at the time point 12 months before the discontinuity – in total 2,862,717 patient episodes.

Exposure time periods

We defined three exposure periods in relation to the time of discontinuity (see (b) exposure in Figure 1); the period defining the discontinuity itself (two consecutive months with no/low practice and the preceding month, a likely starting point of the break since GP activity was measured by calendar month) and the twelve following months divided into two six-month periods. The period before discontinuity served as a control/comparison period.

Outcome/Health care use and follow-up

Our main outcomes were patients' monthly regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions. Patient follow-up started 12 months before the discontinuity when identified as list patient of GPs with a later practice discontinuity.

For each patient health care use was assessed during 27 consecutive months (dichotomised measure of use/no use for each month (see (c) in Figure 1)) – providing 27 monthly repeated observations per patient unless they died or emigrated. Regular and out-of-hours GP consultations were identified by

the reimbursement code for a regular GP consultation (code 2ad[32]) and a GP consultation outside normal working hours (code 2ak[32]) from 2006 to 2017. Acute (unplanned) hospital admissions were identified in the Norwegian Patient Registry from 2008 to 2016, using the dates of admission and discharge for hospital stays that were coded as acute.[31] We also used ICD-10 diagnosis codes to identify hospital stays for ambulatory care sensitive conditions (ACSC). These are conditions for which hospitalisation is thought to be avoidable with the application of preventive care and early disease management, usually delivered in ambulatory settings.[33] We included chronic conditions for which effective management prevents flare-ups (angina pectoris, asthma, chronic obstructive pulmonary disease, congestive heart failure, convulsions/epilepsy, diabetes complications, hypertension, iron deficiency anaemia), acute conditions for which early intervention may prevent more serious progression (ear, nose and throat infections, cellulitis, pyelonephritis, dehydration/gastroenteritis, pelvic inflammatory disease, gangrene, dental conditions, nutritional deficiencies, perforated/bleeding ulcer) and vaccine-preventable conditions (Influenza, pneumonia and other) – using NHS Digital's ICD-10 codes for ACSC episodes.[34]

Covariates

We collected information on patient birth year, sex, education and date for migration or death from Statistics Norway.[28] The highest achieved level of education by 2016 was measured in three categories: 'no/primary school', 'secondary school' and 'college/university'. GP characteristics before the episode of discontinuity (assessed in the first month of the control period,12 months before the discontinuity) were available from the Norwegian General Practitioner Register[31] and included the GPs' sex and age, list size and municipality. Information on patient health prior to follow-up was collected by monthly assessments of selected health indicators from the Control and Payment of Health Reimbursement register (KUHR)[29] and the Norwegian Patient Register[31].

Analyses

We used generalized estimation equation (GEE)[35] models with repeated (maximum 27) monthly observations within patients within GPs, to estimate odds ratios (OR) of monthly use of health services during the three exposure periods (at the time of discontinuity, 1-6 months after and 7-12 months after), comparing the patient population with itself during the control period before discontinuity (12-month period before). Analyses were repeated for each of the four outcome measures; monthly

regular GP consultations, out-of-hours consultations, acute hospital admissions and ACSC admissions. Patients were divided into categories according to their age at discontinuity (0-18, 19-44, 45-64, 65-79 and 80+ years), and all analyses were repeated for each category separately. We adjusted for patient sex and the patient age (in years, categorical variable) at baseline within each age group. We also adjusted for observation calendar month (categorical variable) and calendar year (categorical variable) in order to take into account confounding from periodic and secular trends. Finally, we adjusted for increasing age (time passing) during follow-up (continuous variable measuring number of months after follow-up (ranging from 0-27 months) in order to adjust for confounding by increasing age within the follow up period, since age is likely to increase use of services rapidly among the elderly.

In addition, we performed analyses on the patient subgroups with hypertension, ischemic heart disease, mental illness and prior hospital stay. Patient's health status was assessed during a 12-month period prior to the control period (for these analyses defined by the six-month period before discontinuity, see supplementary figure 1). We identified four subgroups for which we considered continuity of care to be of particular benefit: 1) Hypertension – all patients having one or more diagnoses of hypertension (ICPC2 diagnosis K85-87) in the KUHR data. 2) Ischemic heart disease – all patients having one or more diagnoses of (ICPC2 diagnosis K74-80) in the KUHR data and 3) Mental illness – all patients having one or more diagnoses of (ICPC2 diagnosis P70-P99) in the KUHR data and 4) Acute hospital stay – all patients having one or more acute hospital stay.

Patients were censored on the exact month of migration or death and at 31.12.2016. We performed all analyses with STATA version 15.1. Precision was presented with 95% confidence intervals (CI) using robust standard errors and taking into account clustering of information within patients within the same GP.

Patient and public involvement

Patients and/or the public were not involved in the development of the research question, study design or interpretation of the data.

RESULTS

In the period 2007 to 2016, a total of 2,409,409 patients were registered as list patients of our selection of 2,560 unique regular GPs with a stable practice, but who 12 months later had an episode

of discontinuity. The number of patient episodes of discontinuity was 2,862,717, as each patient could experience several episodes of discontinuity related to different GPs; 85% had one episode, 99% had 1 or 2 episodes, and the maximum number of episodes was five (data not shown). For baseline GP and patient characteristics, see Table 1. Patient healthcare use during the year prior to follow-up is available as Supplementary Table 1.

Table 1: Study sample with baseline characteristics of selected GP's with an episode of discontinuity in an earlier stable practice and their list patients (2007-2017).

GP characteristics [1]	*n*	%
Total	2,560	100 %
GP sex		
Female	1,084	42 %
Male	1,476	58 %
GP age at discontinuity		
<30	22	1 %
30-39	1010	39 %
40-49	548	21 %
50-59	431	17 %
60+	549	21%
GP in group practice	2,244	88%
GP activity before discontinuity		
Registered list size – mean number of patients (range)	1,126	500-2,483
Mean number of ordinary patient consultations during 12 months before discontinuity (range)	2,657	1,000-10,530
GP activity 12 months after discontinuity		
Registered with same list ID as before	1,586	62 %
Registered with same list ID as before and active (> 10 consultations)	1,112	43 %
Registered with same list ID as before and normal activity (number of consultations ≥ 75% compared with 12 months before discontinuity)	813	32%
Patient episode characteristics [1]	***n***	**%**
Patient episodes [2]	2,862,717	100 %
Sex		
Female	1,441,798	50.4 %
Male	1,420,919	49.6 %
Age groups		
0-18	614,576	21.5 %
19-44	1,026,774	35.9 %
46-64	729,031	25.5 %
65-79	339,833	11.9 %
80+	152,503	5.3 %
Educational level[3]		
Primary	680,098	27.8 %
Secondary	1,014,323	41.5 %
Tertiary	752,697	30.8 %
Geography[4]		
Municipality < 2000 inhabitants	55,576	2 % (of total)
10 most populated municipalities	892,857	31 % (of total)

Monthly health service contact (age groups, % with at least one)	Regular GP	Out-of-hours	Acute admission	ACSC admission
0-18	9.9	2.0	0.3	0.07
19-44	16.0	1.5	0.7	0.04
46-64	19.4	1.1	0.7	0.11
65-79	26.3	1.2	1.5	0.34
80+	30.3	1.8	3.3	0.85

1: Patient- and GP characteristics were identified 12 months before the identified discontinuity, unless otherwise stated
2: incidents of discontinuity of care. Some patient could experience several episodes of discontinuity during our observation time, and hence be counted more than once.
3: Educational level measured in 2016
4: Municipality in which the patient's GP was registered. Municipality size per 2. quarter of 2019.

As seen in Table 2, patients in all age groups had a 3%-5% decreased odds of monthly regular GP consultation during the discontinuity, compared with the control period before the discontinuity. Most age-groups then had a normalisation after the discontinuity. Compared with the control period before the discontinuity, all adult age groups had a 2%-6% increased odds of monthly out-of-hours consultations during the discontinuity, which remained elevated after the discontinuity for most age groups. In general, there was little or no difference in acute hospital admissions during or after the period of discontinuity, but some evidence of an increase in ACSC admissions after discontinuity in patients over the age of 65. In the age group 65-79 years, the odds for ACSC admissions increased 7-11% after discontinuity (OR 1.07, 95% CI 1.01,1.14 and OR 1.11, 95% CI 1.01,1.21 for periods 1-6 months and 7-12 months after discontinuity) compared with the period before discontinuity. These findings are also illustrated by the estimated absolute levels of healthcare use (regular GP consultation, out-of-hours consultation, acute hospital admission and ACSC admission) for each month during follow-up in Supplementary Figures 2-5. These figures show the underlying trends for each age group, in addition to level changes of healthcare use during and after the discontinuity, corresponding to main findings (Table 2).

Table 2: Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for one or more monthly GP consultations, out-of-hours service consultations, acute hospital admissions and hospital admissions for ambulatory care sensitive conditions (ACSC) during (3 month period) and after (1-6 months after and 7-12 months after) a sudden discontinuity of GP care, compared to a 12-month stable control period before the discontinuity. GEE analyses (generalizing estimating equations) based on repeated monthly measurements within patient within GP, with separate analyses for each patient age group and adjustment for month/time, calendar month, calendar year, patient age and sex. (2007-2017)

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.96	(0.95-0.96)	0.97	(0.97-0.98)	0.96	(0.95-0.96)	0.95	(0.95-0.96)	0.96	(0.96-0.97)
After discontinuity I (1-6 months after)	0.97	(0.96-0.98)	1.00	(0.99-1.00)	1.00	(1.00-1.01)	1.01	(1.00-1.02)	1.03	(1.01-1.04)
After discontinuity II (7-12 months after)	0.97	(0.96-0.99)	1.00	(0.99-1.01)	1.00	(0.99-1.01)	1.01	(1.00-1.02	1.01	(0.99-1.02)
Monthly out-of-hours consultations (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.00	(0.98-1.02)	1.04	(1.02-1.05)	1.02	(1.01-1.04)	1.05	(1.02-1.07)	1.06	(1.02-1.09)
After discontinuity I (1-6 months after)	0.98	(0.96-1.00)	1.03	(1.01-1.05)	1.01	(0.99-1.03)	1.06	(1.02-1.09)	1.07	(1.03-1.11)
After discontinuity II (7-12 months after)	0.97	(0.95-1.00)	1.02	(1.00-1.05)	0.99	(0.96-1.03)	1.06	(1.02-1.11)	1.06	(1.00-1.12)
Monthly acute hospital admissions (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.02	(0.97-1.07)	1.03	(1.00-1.05)	1.01	(0.99-1.04)	1.02	(1.00-1.05)	1.03	(1.00-1.06)
After discontinuity I (1-6 months after)	1.04	(0.98-1.10)	1.02	(0.99-1.05)	1.01	(0.98-1.05)	1.04	(1.01-1.08)	1.04	(1.00-1.08)
After discontinuity II (7-12 months after)	1.10	(1.02-1.20)	1.02	(0.98-1.07)	1.01	(0.97-1.06)	1.04	(0.99-1.09)	1.02	(0.97-1.07)
Monthly ACSC hospital admissions (one or more)										
Control period (12-month period before discontinuity)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-contrmonth period)	0.91	(0.82-1.02)	1.05	(0.96-1.15)	1.02	(0.95-1.09)	1.03	(0.98-1.09)	1.06	(1.00-1.12)
After discontinuity I (1-6 months after)	0.97	(0.85-1.10)	1.07	(0.96-1.19)	1.04	(0.96-1.12)	1.07	(1.01-1.14)	1.09	(1.02-1.16)
After discontinuity II (7-12 months after)	0.99	(0.83-1.19)	1.05	(0.90-1.22)	1.02	(0.91-1.14)	1.11	(1.01-1.21)	1.04	(0.94-1.14)

Subgroup analysis

Separate analyses on subgroups according to patient health status prior to follow-up (hypertension, ischaemic heart disease, mental illness and previously hospitalized) are shown in Supplementary tables 2, 3 and 4. Compared to the main analysis, the subgroup analysis on patients with hypertension and ischaemic heart disease showed only marginal differences, but with somewhat more decreased OR of GP consultations during discontinuity, followed by normalisation. Patients with previous hypertension aged 65-79 had an increasing OR for out-of-hours consultations during and after discontinuity. For example, in the main analysis patients aged 65-79 had an OR 1.06 (95% CI 1.02-1.09) for monthly out-of-hours consultations 1-6 months after discontinuity, whereas patients with hypertension had an OR 1.13 (95% CI 1.03-1.25). For patients with previous ischaemic heart disease the largest differences between main and subgroup analyses applied to those aged 45-64 years who had decreased OR for ACSC acute hospital admissions during and the first period after discontinuity in the subgroup analysis, whereas those aged 65-79 years had more increased OR for ACSC acute hospital admissions in the subgroup analysis, compared to the main analysis. Previously hospitalised in the age-group 80+ had increased OR for acute hospital admissions compared to patients included in the main analysis, particularly ACSC admissions. For example, in the main analysis patients aged 80+ had an OR 1.09 (95% CI 1.02-1.16) for monthly ACSC hospital admissions 1-6 months after discontinuity, whereas previously hospitalized patients had an OR 1.24 (95% CI 1.08-1.42).

DISCUSSION

Summary

In this study, we followed all Norwegian inhabitants registered as list patients of stable practising GPs who experienced one or more episodes of sudden discontinuity of GP care between 2007 and 2017. We found that all patient age groups had a small dip in regular GP consultations at the time of discontinuity compared with before the discontinuity, followed by normalisation for all adult groups. Out-of-hours consultations increased at the time of discontinuity for all adult groups compared with before the discontinuity and remained elevated during the following 12 months for those aged 19-44 years, 65-79 years and 80+ years. An increase in ACSC admissions after discontinuity was indicated in patients over the age of 65, but in general little or no differences in acute hospital admissions were observed during or after the period of discontinuity.

Strengths and limitations

We used a linkage of several registries, providing person-level data on the entire Norwegian population and their GPs within a rather long observation period, which provided relatively precise estimates, even in the separate subgroup analyses. The Norwegian GP scheme with <1% non-participants since the start in 2001[36] made it possible to link each individual in the population to their regular GP. By including all patients 12 months before the break in GP continuity, we did not condition on the patient surviving until discontinuity. Hence, we did not miss some of the acute (potentially fatal) hospital admissions in our observation time before the discontinuity, thereby avoiding immortal time-bias.[37]

We had exact dates and objectivity in the ascertainment of outcomes (GP consultations, out-of-hours consultations, acute hospital admissions) and strict criteria for exposure (discontinuity of GP care). We assessed the changes in outcome by following the same patient population over time. By design, we thereby eliminated all time-invariant or slow-varying confounding factors related to the composition of patient lists (groups), including morbidity, help-seeking behaviour, sex and education. There are numerous causes of a break in the GP practice (parental leave, mandatory practice for specialization in general practice medicine, retirement, job change, GP sickness or death etc.), resulting in discontinuity for a shorter or longer period. It is possible that the consequences of discontinuity would differ according to the causes of the break (e.g. planning, speed of replacement, single or group practice). Also, our results primarily apply to situations with a sudden discontinuity of practice, and not necessarily to situations characterized by a constant instability or more gradual changes. As we present several estimates as sensitivity analyses in this paper, one should refrain from evaluation single effects based on any threshold of statistical significance.

Comparisons with existing literature

Our results may indicate that the system itself – including all public primary healthcare GP services – usually is robust and capable of absorbing discontinuities without detrimental effects on most patient groups. The observed dip in GP consultations during the discontinuity was transient, indicating that after a few months, most patients were able to consult a GP in the same manner as before the break. However, our results also raise several concerns regarding the observed increase in emergency health care usage.

The increase in monthly odds of out-of-hours consultations seen during the break persisted throughout the follow-up period for several age groups. This may indicate suboptimal quality of care due to temporary solutions and delayed replacement of a new GP and/or that patients have a lower threshold for using the out-of-hours services when the alternative is seeing a locum/unknown GP.

The present study also indicates a small increase in ACSC admissions after the discontinuity for older patients. A relationship between interpersonal continuity of care, improved delivery of preventive services and lower rates of hospitalization has been suggested by other studies.[9] Our findings are also coherent with findings from recent large cross-sectional and cohort studies on older patients in other settings, indicating that a lower degree of continuity of care assessed by various indexes for continuity of care is associated with increased risk of hospital admission.[5, 10] Increase in hospital admission could indicate a health deterioration due to lack of proper treatment and follow-up in the absence of the GP, but may also reflect that patients are more likely to be admitted to hospital when meeting unfamiliar doctors. A potential direct negative impact on patient health (and not only an overuse of secondary healthcare) is suggested by the findings of increased mortality with lower levels of continuity of care from other studies.[19]

In contrast to the large body of research on continuity of care, few studies have investigated *cessation* of continuity of care. A recent systematic review assessed how physician retirement impacted patients and found mainly unfavourable outcomes, mainly published as anecdotes and qualitative studies.[2] The authors point to some possible mechanisms related to difficulty accessing care, difficulty with transition and poor handover of information. Our results indicate that special attention should be given to elderly and frail patient groups as early as possible when the discontinuity is known to happen. Systematic identification of patients at risk and well-established information routines in relation to permanent or temporary GP breaks are possible actions that need to be studied further.

CONCLUSION

We investigated the consequences, in terms of health service use, for patients who experienced discontinuity of care from a primary physician who knew their medical and socioeconomic history. We found that in the Norwegian setting, discontinuity of GP care had some minor influence on primary care physician use. Patients continue to consult other GPs in a similar way as before and use the out-of-hours GP services to compensate for reduced access to or quality of care. Discontinuity of GP care might increase acute hospital admissions for ambulatory care sensitive conditions in the older age

groups, suggesting a crucial role of the GP for these patient groups. These findings underline the importance of continuity of care in order to keep patient care and costs on the lowest level desired, avoiding some unnecessary health care use (including out-of-hours visits and hospital admissions) and health care costs. This seems particularly important in the perspective of an ageing population since the older age groups seem most sensitive to GP continuity.

DECLARATION

Acknowledgements

We would like to thank Statistics Norway and the Norwegian Directorate of Health for providing data.

Contributors

KP, JHB, LJS and SLK conceived the study and its design. KP and JHB contributed to design of the study protocol and facilitated acquisition of all data. KP and LJS prepared and analysed the data. JHB and SLK provided input on the discussion and interpretation of the findings. LJS drafted the first version of the manuscript. All authors contributed to and approved the final manuscript. All the authors have read the final version of the manuscript and agreed to its submission.

Funding

This work was supported by the Norwegian University of Science and Technology, and is a part of a larger project "Health care services under pressure – Consequences for patient flows, efficiency and patient safety in Norway" funded by the Norwegian Research Council (grant number 256579). JHB was funded by the Norwegian Research Council (grant number 295989).

Competing interests:

None

Patient consent for publication:

Not required.

Ethics approval:

The Regional Committee for Medical and Health Research Ethics in Central Norway approved the study (2011/2047).

Provenance and peer review:

Not commissioned; externally peer reviewed.

Data availability statement:

The data used in this study are publicly available, given approval.

References

1. Freeman T, Brown JB, Reid G, et al. Patients' perceptions on losing access to FPs: qualitative study. *Canadian family physician Medecin de famille canadien*. 2013;59(4):e195-201.
2. Lam K, Arnold CG, Savage RD, et al. Does Physician Retirement Affect Patients? A Systematic Review. *Journal of the American Geriatrics Society*. 2020;68(3):641-9.
3. Flocke SA, Stange KC, Zyzanski SJ. The impact of insurance type and forced discontinuity on the delivery of primary care. *J Fam Pract*. 1997;45(2):129-35.
4. Haggerty JL, Reid RJ, Freeman GK, et al. Continuity of care: a multidisciplinary review. *Bmj*. 2003;327(7425):1219-21.
5. Barker I, Steventon A, Deeny SR. Association between continuity of care in general practice and hospital admissions for ambulatory care sensitive conditions: cross sectional study of routinely collected, person level data. *BMJ*. 2017;356:j84.
6. Bayliss EA, Ellis JL, Shoup JA, et al. Effect of continuity of care on hospital utilization for seniors with multiple medical conditions in an integrated health care system. *Annals of family medicine*. 2015;13(2):123-9.
7. Hansen AH, Halvorsen PA, Aaraas IJ, et al. Continuity of GP care is related to reduced specialist healthcare use: a cross-sectional survey. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2013;63(612):482-9.
8. Huntley A, Lasserson D, Wye L, et al. Which features of primary care affect unscheduled secondary care use? A systematic review. *BMJ open*. 2014;4(5).
9. Saultz JW, Lochner J. Interpersonal continuity of care and care outcomes: a critical review. *Annals of family medicine*. 2005;3(2):159-66.
10. Tammes P, Purdy S, Salisbury C, et al. Continuity of Primary Care and Emergency Hospital Admissions Among Older Patients in England. *Annals of family medicine*. 2017;15(6):515-22.
11. van Loenen T, van den Berg MJ, Westert GP, et al. Organizational aspects of primary care related to avoidable hospitalization: a systematic review. *Family practice*. 2014;31(5):502-16.
12. Menec VH, Sirski M, Attawar D, et al. Does continuity of care with a family physician reduce hospitalizations among older adults? *Journal of health services research & policy*. 2006;11(4):196-201.
13. Swanson JO, Vogt V, Sundmacher L, et al. Continuity of care and its effect on readmissions for COPD patients: A comparative study of Norway and Germany. *Health Policy*. 2018;122(7):737-45.
14. Emery DP, Milne T, Gilchrist CA, et al. The impact of primary care on emergency department presentation and hospital admission with pneumonia: a case-control study of preschool-aged children. *NPJ Primary Care Respiratory Medicine*. 2015;25:14113.
15. Kohnke H, Zielinski A. Association between continuity of care in Swedish primary care and emergency services utilisation: a population-based cross-sectional study. *Scandinavian journal of primary health care*. 2017;35(2):113-9.
16. Sarmento G, Leal-Seabra F, Brinquinho M, et al. Continuity of primary care and emergency department utilization among elderly people. *European Geriatric Medicine*. 2016;7:S224.
17. Leleu H, Minvielle E. Relationship between longitudinal continuity of primary care and likelihood of death: analysis of national insurance data. *PLoS One*. 2013;8(8):e71669.
18. Maarsingh OR, Henry Y, van de Ven PM, et al. Continuity of care in primary care and association with survival in older people: a 17-year prospective cohort study. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2016;66(649):e531-9.
19. Pereira Gray DJ, Sidaway-Lee K, White E, et al. Continuity of care with doctors—a matter of life and death? A systematic review of continuity of care and mortality. *BMJ open*. 2018;8(6):e021161.

20. Wolinsky FD, Bentler SE, Liu L, et al. Continuity of care with a primary care physician and mortality in older adults. *The journals of gerontology Series A, Biological sciences and medical sciences*. 2010;65(4):421-8.
21. Hollander MJ, Kadlec H. Financial implications of the continuity of primary care. *The Permanente journal*. 2015;19(1):4-10.
22. The Norwegian Ministry of Health and Care Services. Forskrift om fastlegeordning i kommunene 2012 [updated 2018 Mar 08; cited 2020 May 16]. Available from: https://lovdata.no/dokument/SF/forskrift/2012-08-29-842.
23. The Norwegian Medical Association, The Norwegian Association of General Practitioners, The Medical Speciality Society for General Practice. Utviklingsplan for fastlegeordningen 2015 - 2020 2015 [cited 2020 May 19]. Available from: https://www.legeforeningen.no/contentassets/743cd468b6d6435ca138de1a2909caf9/utviklingsplan-flo.pdf.
24. Hetlevik O, Gjesdal S. Personal continuity of care in Norwegian general practice: a national cross-sectional study. *Scandinavian journal of primary health care*. 2012;30(4):214-21.
25. Greenfield G, Foley K, Majeed A. Rethinking primary care's gatekeeper role. *BMJ*. 2016;354:i4803.
26. EY and Vista Analysis. Evaluering av fastlegeordningen 2019 [cited 2020 May 16]. Available from: https://www.regjeringen.no/contentassets/7cd212bf5f0642c1a5d0d480f0923e6d/evaluering-av-fastlegeordningen---sluttrapport-fra-ey-og-vista-analyse.pdf
27. Gaardsrud PØ. Fastlegestatistikk 2018 hovedtall The Norwegian Directorate of Health; 2019 [cited 2020 May 16]. Available from: https://www.helsedirektoratet.no/statistikk/fastlegestatistikk
28. Statistics Norway. Statistisk sentralbyrå 2019 [cited 2020 May 16]. Available from: https://www.ssb.no/en.
29. The Norwegian Directorate of Health. KUHR-databasen 2019 [updated 2019 Apr 08; cited 2020 May 16]. Available from: https://www.helsedirektoratet.no/tema/statistikk-registre-og-rapporter/helsedata-og-helseregistre/kuhr
30. The Norwegian Directorate of eHealth. Fastlegeregisteret 2020 [cited 2020 19 Mai]. Available from: https://helsedata.no/forvaltere/helsedirektoratet/fastlegeregisteret/.
31. Bakken IJ, Ariansen AMS, Knudsen GP, et al. The Norwegian Patient Registry and the Norwegian Registry for Primary Health Care: Research potential of two nationwide health-care registries. *Scandinavian journal of public health*. 2019:1403494819859737.
32. The Norwegian Medical Association. Normaltariffen for fastleger og legevakt 2019-2020 [Tariff]. 2019 [cited 2020 May 16]. Available from: https://normaltariffen.legeforeningen.no/asset/pdf/Fastlegetariffen-2019-2020.pdf (page 21).
33. Ansari Z. The Concept and Usefulness of Ambulatory Care Sensitive Conditions as Indicators of Quality and Access to Primary Health Care. *Australian journal of primary health*. 2007;13(3):91-110.
34. NHS Digital. Ambulatory Care Sensitive Conditions (ACSC) 2019 [updated 2019 Dec 12; cited 2020 May 16]. Available from: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/innovative-uses-of-data/demand-on-healthcare/ambulatory-care-sensitive-conditions# (Appendix A).
35. Twisk JWR. Applied Longitudinal Data Analysis for Epidemiology. Cambridge: Cambridge University Press; 2003. 182 p.
36. Gaardsrud PØ. Fastlegestatistikk 2017 hovedtall [Regular General Practitioner Statistics 2017]: The Norwegian Directorate for Health; 2018 [Available from: https://www.helsedirektoratet.no/statistikk/statistikk/fastlegestatistikk
37. Rothman KJ. Epidemiology: an introduction. 2nd ed. ed. New Yourk: Oxford university press; 2012. 268 p.

Figure legends:

Figure 1: Illustration of study design and timeline for (a) study population and GPs, (b) definition of control period (12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in our four defined periods.

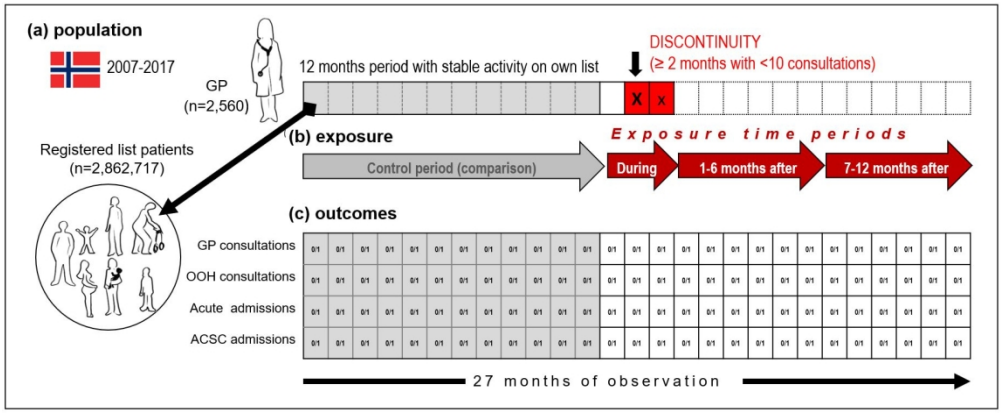


Figure 1: Illustration of study design and timeline for (a) study population and GPs, (b) definition of control period (12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in our four defined periods.

Supplementary Tables, How does general practitioner discontinuity affect health care utilisation? An observational cohort study of 2.4 million Norwegians 2007-2017

Supplementary Table 1: Patient health status during the 12-month period prior to follow-up, assessed by various indicators of health care usage among patients with available data. Gray shading indicate groups included in the sub-group analyses.

	0-18 years	19-44 years	45-64 years	65-79 years	80+ years
Regular GP consultations during 12 months					
N (patient episodes)	559,509	939,841	664,549	311,647	138,929
mean number of consultations(SD)	1.4 (1.9)	2.4 (3.4)	2.9(3.8)	4.0 (4.4)	4.8 (5.3)
median number of consultations (IQR)	1 [0-2]	1[0-3]	2[0-4]	3[1-5]	3[1-7]
% with at least one consultation	59.4	67.1	73.0	84.1	80.6
% with at least one consultation for hypertension[1]	0.0	1.0	8.6	20.4	19.2
% with at least one consultation for ischaemic heart disease[2]	0.0	0.1	2.0	8.6	16.8
% with at least one consultation for mental illness[3]	1.4	6.1	6.1	4.1	5.7
Acute hospital admission during 12 months					
N	441,434	751,145	532,225	257,262	111,526
% with at least one acute hospital admission[4]	4.1	6.8	6.0	11.7	25.5

1: One or more consultations with hypertension diagnoses (ICPC2 diagnosis K85-87) in the KUHR data
2: One or more consultations with ischemic heart disease diagnoses (ICPC2 diagnosis K74-80) in the KUHR data
3: One or more consultations with mental illness diagnoses (ICPC2 diagnosis P70-99) in the KUHR data
4: One or more registered acute hospital stays in the Norwegian Patient Registry (excl. psychiatric care)

Supplementary Table 2: Subgroup analysis of patients who had at least one GP consultation for Hypertension (ICPC2 diagnosis K85-87) or Ischaemic heart disease (ICPC2 diagnosis K74-80) during the 12-month period before follow-up. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly healthcare use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; GEE analyses (generalizing estimating equations) based on repeated monthly measurements within patient within GP and adjusted for month/time, calendar month, calendar year, patient age and sex.

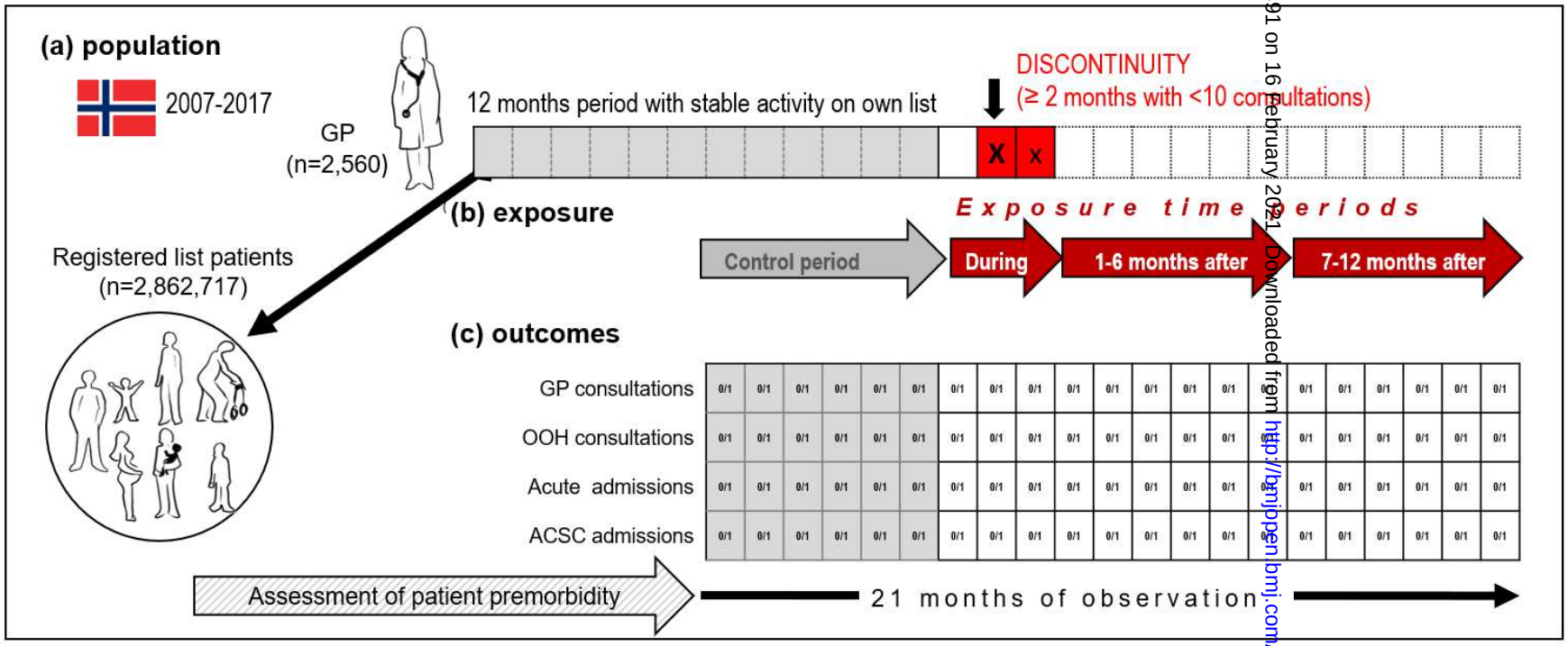
	Hypertension						Ischaemic heart disease					
	45-64 years		65-79 years		80+ years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.91	(0.90-0.93)	0.93	(0.92-0.94)	0.94	(0.92-0.96)	0.93	(0.91-0.96)	0.93	(0.91-0.95)	0.95	[0.93-0.97]
After discontinuity I (1-6 months after)	0.97	(0.95-0.99)	1.00	(0.98-1.02)	1.00	(0.97-1.03)	0.97	(0.93- 1.01)	1.00	(0.97-1.02)	1.01	[0.98-1.04]
After discontinuity II (7-12 months after)	0.98	(0.95-1.02)	0.99	(0.96-1.02)	0.96	(0.91-1.01)	1.00	(0.94-1.07)	1.00	(0.96-1.05)	1.01	[0.96-1.06]
Monthly out-of-hours consultations (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
Discontinuity (3-month period)	1.05	(0.98-1.12)	1.08	(1.01-1.16)	0.96	(0.88-1.05)	1.00	(0.89-1.12)	1.03	(0.95-1.12)	1.03	[0.95-1.11]
After discontinuity I (1-6 months after)	1.08	(0.98-1.20)	1.13	(1.02-1.24)	0.95	(0.84-1.08)	0.95	(0.80-1.12)	1.07	(0.95-1.21)	1.05	[0.93-1.18]
After discontinuity II (7-12 months after)	1.12	(0.96-1.31)	1.18	(1.01-1.37)	0.84	(0.69-1.02)	1.03	(0.79-1.33)	1.04	(0.86-1.25)	1.03	[0.86-1.23]
Monthly acute hospital admissions (one or more)												
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
Discontinuity (3-month period)	1.05	(0.96-1.14)	1.07	(1.00-1.14)	1.04	(0.97-1.12)	0.99	(0.89-1.10)	1.04	(0.97-1.11)	1.03	[0.98-1.10]
After discontinuity I (1-6 months after)	1.03	(0.91-1.18)	1.08	(0.98-1.19)	0.99	(0.90-1.10)	0.99	(0.85-1.15)	1.13	(1.03-1.25)	1.06	[0.97-1.16]
After discontinuity II (7-12 months after)	1.06	(0.87-1.28)	1.07	(0.93-1.23)	0.96	(0.82-1.13)	1.14	(0.90-1.44)	1.15	(0.99-1.34)	1.05	[0.92-1.20]
Monthly ACSC acute hospital admissions (one or more)												
Control period (6-monthperiod before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	Ref	1.00	Ref
Discontinuity (3-month period)	1.22	(0.99-1.52)	1.11	(0.95-1.28)	0.88	(0.75-1.03)	0.78	(0.63-0.96)	1.06	(0.94-1.20)	1.04	[0.93-1.15]
After discontinuity I (1-6 months after)	1.26	(0.92-1.72)	1.31	(1.07-1.61)	0.87	(0.70-1.08)	0.68	(0.50-0.93)	1.27	(1.06-1.51)	1.04	[0.90-1.21]
After discontinuity II (7-12 months after)	1.46	(0.90-2.38)	1.33	(0.97-1.82)	0.74	(0.53-1.04)	0.73	(0.46-1.18)	1.38	(1.05-1.81)	1.01	[0.80-1.28]

Supplementary Table 3: Subgroup analysis of patients who had at least one GP consultation for mental illness (ICPC2 diagnosis P70-99) during the 12-month period before follow-up. Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly healthcare use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; GEE analyses (generalizing estimating equations) based on repeated monthly measurements within patient within GP and adjusted for month/time, calendar month, calendar year, patient age and sex.

	19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.93	(0.92-0.94)	0.92	(0.91-0.94)	0.94	(0.91-0.97)	0.96	(0.92-1.00)
After discontinuity I (1-6 months after)	0.96	(0.94-0.99)	0.99	(0.96-1.01)	0.98	(0.94-1.03)	0.99	(0.93-1.05)
After discontinuity II (7-12 months after)	1.00	(0.97-1.04)	1.02	(0.98-1.06)	1.00	(0.94-1.07)	0.98	(0.90-1.08)
4Monthly out-of-hours consultations (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.04	(1.00-1.09)	1.06	(1.00-1.12)	1.03	(0.93-1.15)	1.08	(0.94-1.24)
After discontinuity I (1-6 months after)	1.03	(0.97-1.10)	1.02	(0.94-1.12)	1.07	(0.92-1.25)	0.97	(0.79-1.20)
After discontinuity II (7-12 months after)	1.04	(0.95-1.15)	1.03	(0.90-1.18)	1.15	(0.91-1.47)	0.92	(0.66-1.27)
Monthly acute hospital admissions (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.09	(1.02-1.17)	1.01	(0.93-1.09)	1.02	(0.92-1.13)	1.03	(0.92-1.15)
After discontinuity I (1-6 months after)	1.01	(0.91-1.11)	0.99	(0.88-1.11)	1.05	(0.90-1.22)	0.98	(0.84-1.16)
After discontinuity II (7-12 months after)	1.00	(0.86-1.17)	1.01	(0.85-1.21)	1.06	(0.84-1.35)	1.03	(0.80-1.33)
Monthly ACSC acute hospital admissions (one or more)								
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.99	(0.82-1.19)	0.88	(0.78-1.00)	1.05	(0.96-1.15)	1.15	(1.04-1.26)
After discontinuity I (1-6 months after)	1.07	(0.82-1.40)	0.87	(0.73-1.03)	1.14	(1.00-1.29)	1.24	(1.08-1.43)
After discontinuity II (7-12 months after)	1.08	(0.71-1.65)	0.90	(0.69-1.18)	1.19	(0.98-1.46)	1.38	(1.11-1.72)

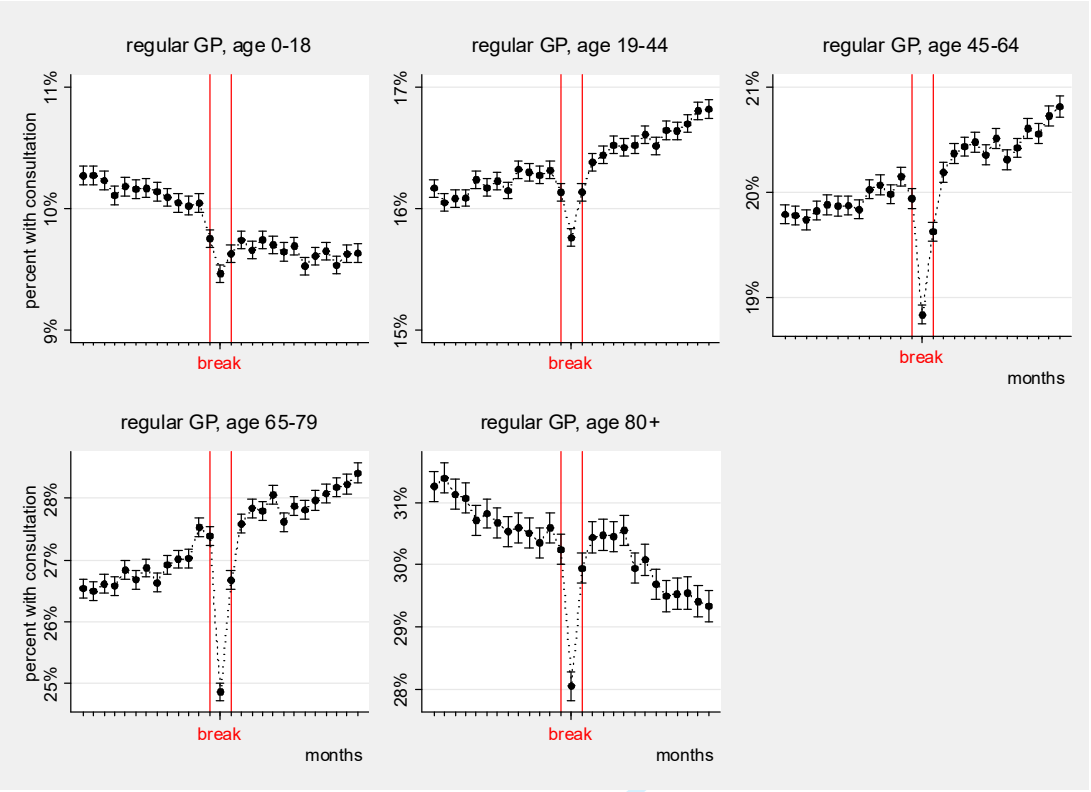
Supplementary Table 4: Subgroup analysis of patients who had at least one emergency hospital admission during the 12-month period before follow-up (2008-2017). Estimated Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for monthly health care use (one or more) in periods during and after a sudden discontinuity of GP care, compared to a 6-month control period before the discontinuity; GEE analyses (generalizing estimating equations) based on repeated monthly measurements within patient within GP and adjusted for month/time, calendar month, calendar year, patient age and sex.

	0-18 years		19-44 years		45-64 years		65-79 years		80+ years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Monthly GP consultations (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.97	(0.93-1.01)	0.97	(0.96-0.99)	0.94	(0.92-0.96)	0.95	(0.93-0.96)	0.97	(0.95-0.99)
After discontinuity I (1-6 months after)	0.99	(0.94-1.04)	1.03	(1.01-1.06)	0.99	(0.97-1.02)	1.02	(0.99-1.05)	1.02	(0.99-1.05)
After discontinuity II (7-12 months after)	0.98	(0.91-1.07)	1.06	(1.02-1.10)	1.04	(0.99-1.09)	1.04	(0.99-1.08)	1.00	(0.95-1.05)
Monthly out-of-hours consultations (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.03	(0.96-1.11)	1.03	(0.98-1.08)	1.00	(0.94-1.07)	1.00	(0.94-1.07)	1.06	(0.98-1.14)
After discontinuity I (1-6 months after)	1.01	(0.91-1.12)	1.06	(0.99-1.14)	1.00	(0.91-1.09)	1.06	(0.96-1.17)	1.09	(0.98-1.22)
After discontinuity II (7-12 months after)	1.02	(0.87-1.20)	1.09	(0.97-1.21)	0.95	(0.82-1.10)	1.09	(0.94-1.28)	1.10	(0.92-1.30)
Monthly acute hospital admissions (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	0.99	(0.87-1.13)	0.98	(0.92-1.04)	0.99	(0.94-1.05)	1.03	(0.98-1.08)	1.06	(1.01-1.11)
After discontinuity I (1-6 months after)	1.15	(0.96-1.38)	1.04	(0.95-1.13)	1.03	(0.95-1.12)	1.10	(1.02-1.19)	1.13	(1.05-1.22)
After discontinuity II (7-12 months after)	1.36	(1.02-1.81)	1.07	(0.94-1.22)	1.15	(1.01-1.31)	1.16	(1.03-1.30)	1.16	(1.03-1.30)
Monthly ACSC acute hospital admissions (one or more)										
Control period (6-month period before)	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Discontinuity (3-month period)	1.02	(0.80-1.29)	0.99	(0.82-1.19)	0.88	(0.78-1.00)	1.05	(0.96-1.15)	1.15	(1.04-1.26)
After discontinuity I (1-6 months after)	1.14	(0.80-1.63)	1.07	(0.82-1.40)	0.87	(0.73-1.03)	1.14	(1.00-1.29)	1.24	(1.08-1.43)
After discontinuity II (7-12 months after)	1.38	(0.80-2.39)	1.08	(0.71-1.65)	0.90	(0.69-1.18)	1.19	(0.98-1.46)	1.38	(1.11-1.72)

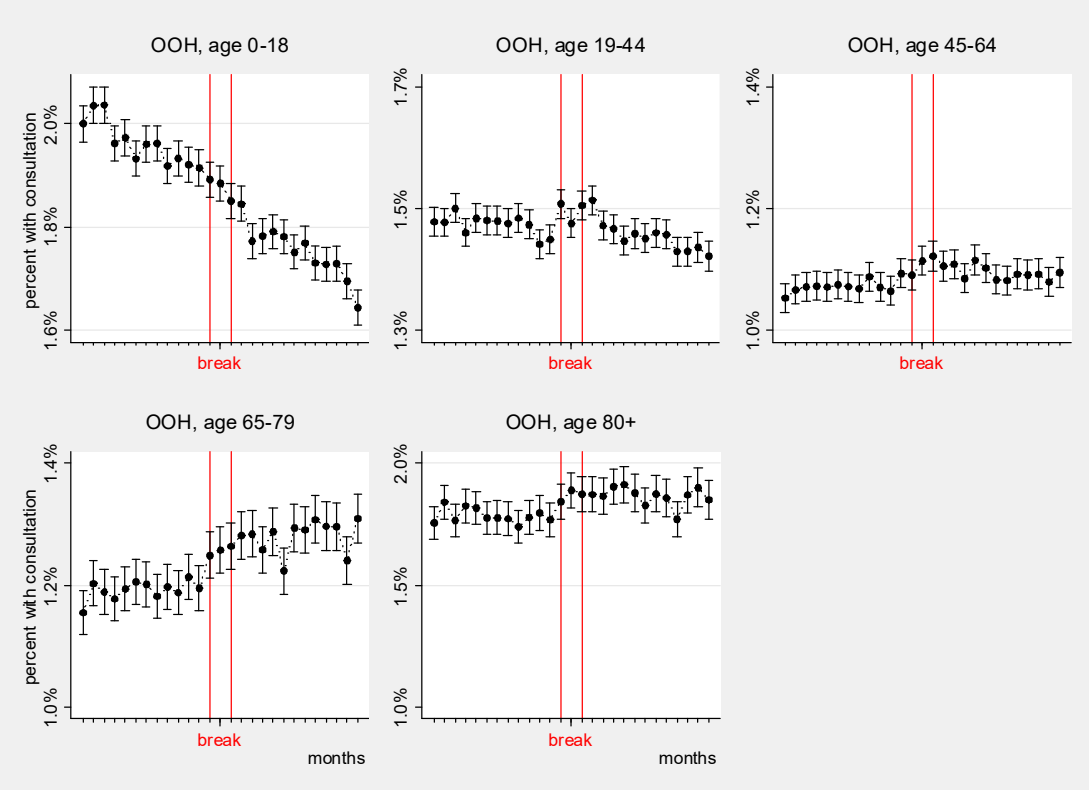


Supplementary figure 1: Illustration of subgroup study design and timeline for the (a) study population and GPs, (b) definition of control period (6 last of 12 months of stable GP activity on own patient list), exposure time periods during (3-month period defined discontinuity with at least two months with no/low activity (X)), 1-6 months after discontinuity and 7-12 months after discontinuity, and (c) patient outcome assessment (four outcomes) in four defined periods. Patients premorbidity was assessed 12 months prior to the control period.

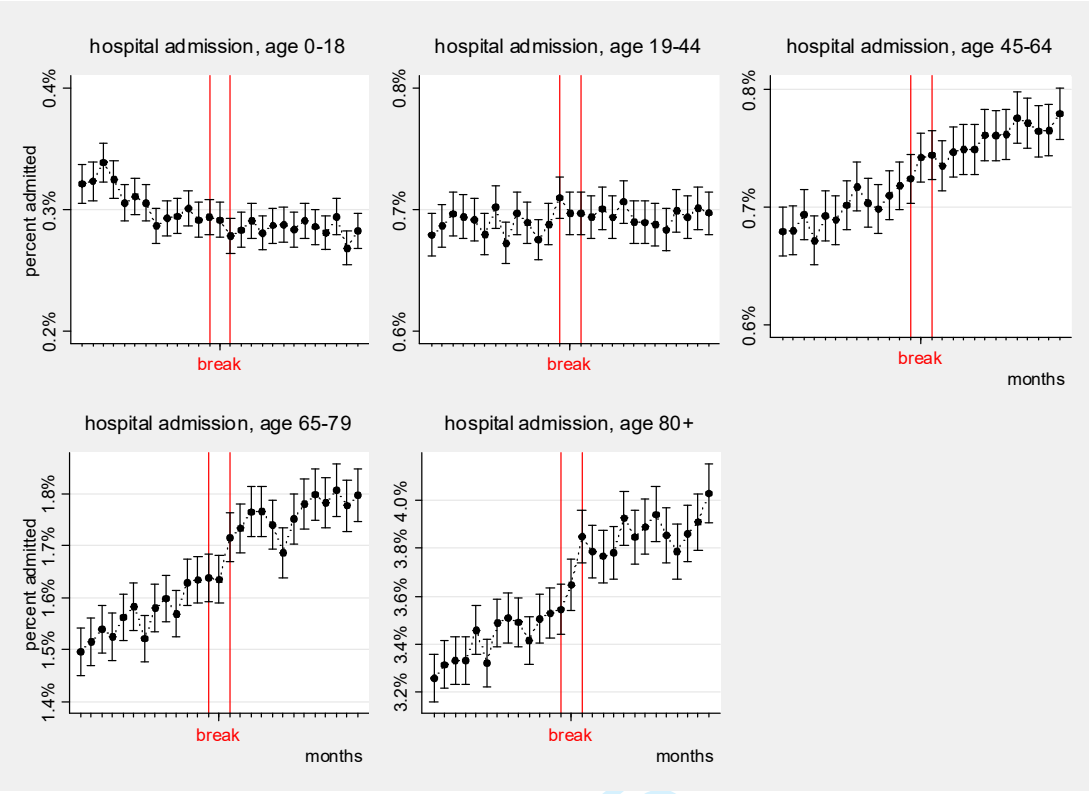
Supplementary Figure 2: Estimated percentage with regular general practitioner (GP) consultation per month for 27 months follow-up (x-axis, with time of discontinuity/break indicated in red) according to age group. Adjusted for calendar month, calendar year, patient age and sex. (2007-2017)



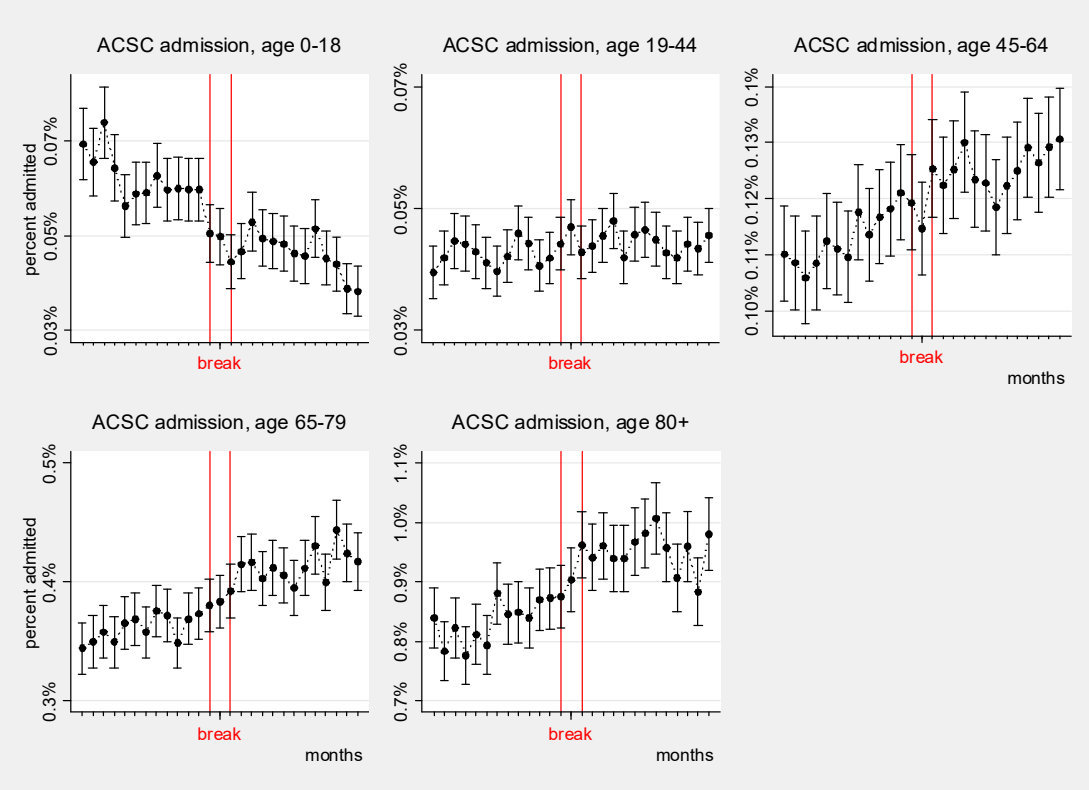
Supplementary Figure 3: Estimated percentage with out-of-hours (OOH) consultation per month for 27 months follow-up (x-axis, with time of discontinuity/break indicated in red) according to age group. Adjusted for calendar month, calendar year, patient age and sex. (2007-2017)



Supplementary Figure 4: Estimated percentage with acute hospital admission per month for 27 months follow-up (x-axis, with time of discontinuity/break indicated in red) according to age group. Adjusted for calendar month, calendar year, patient age and sex. (2008-2016)



Supplementary Figure 5: Estimated percentage with hospital admission for ambulatory care sensitive condition (ACSC) per month for 27 months follow-up (x-axis, with time of discontinuity/break indicated in red) according to age group. Adjusted for calendar month, calendar year, patient age and sex. (2008-2016)



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	a) 5-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	6-8
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	a) 5-8
		(*b*) Describe any methods used to examine subgroups and interactions	b) 8
		(*c*) Explain how missing data were addressed	c) 8
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	e) 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8 + Table 1
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.