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ORIGINAL RESEARCH

Contacts With the Health Care System Before Out-of-Hospital Cardiac Arrest

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BACKGROUND: It remains challenging to identify patients at risk of out-of-hospital cardiac arrest (OHCA). We aimed to examine health care contacts in patients before OHCA compared with the general population that did not experience an OHCA.

METHODS AND RESULTS: Patients with OHCA with a presumed cardiac cause were identified from the Danish Cardiac Arrest Registry (2001–2014) and their health care contacts (general practitioner [GP]/hospital) were examined up to 1 year before OHCA. In a case-control study (1:9), OHCA contacts were compared with an age- and sex-matched background population. Separately, patients with OHCA were examined by the contact type (GP/hospital/both/no contact) within 2 weeks before OHCA. We included 28 955 patients with OHCA. The weekly percentages of patient contacts with GP the year before OHCA were constant (25%) until 1 week before OHCA when they markedly increased (42%). Weekly percentages of patient contacts with hospitals the year before OHCA gradually increased during the last 6 months (3.5%–6.6%), peaking at the second week (6.8%) before OHCA; mostly attributable to cardiovascular diseases (21%). In comparison, there were fewer weekly contacts among controls with 13% for GP and 2% for hospital contacts ($P<0.001$). Within 2 weeks before OHCA, 57.8% of patients with OHCA had a health care contact, and these patients had more contacts with GP (odds ratio [OR], 3.17; 95% CI, 3.09–3.26) and hospital (OR, 2.32; 95% CI, 2.21–2.43) compared with controls.

CONCLUSIONS: The health care contacts of patients with OHCA nearly doubled leading up to the OHCA event, with more than half of patients having health care contacts within 2 weeks before arrest. This could have implications for future preventive strategies.

Key Words: ESCAPE-NET ■ general practitioner ■ health care contact ■ hospital ■ out-of-hospital cardiac arrest

Out-of-hospital cardiac arrest (OHCA) is a significant health problem worldwide with <10% survival.[1,2] OHCA is often considered an unexpected event without forewarning,[3] although previous literature has shown that patients with OHCA often present symptoms[4–7] and have contact with the health care system before their arrest.[8–10]

However, studies on this field have mainly included patients with OHCA witnessed by the emergency medical services (EMS),[7] relatively small study populations,[5,6] or only hospital contacts.[8,9] Thus, it remains unexplored to what extent patients are in contact with the general practitioners (GPs) and hospitals shortly before their OHCA, and whether the pattern of health care use differs from the general population who have not experienced an OHCA. Identifying patients at risk of OHCA is challenging, as many patients with OHCA have no known risk factors.[11,12] Therefore, further

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CLINICAL PERSPECTIVE

What Is New?

- The health care contacts of patients with out-of-hospital cardiac arrest nearly doubled leading up to the out-of-hospital cardiac arrest event, with more than half of patients having health care contacts within 2 weeks before out-of-hospital cardiac arrest.

What Are the Clinical Implications?

- Future research should investigate the reasons behind these general practitioner visits, including potential signs and symptoms leading up to the out-of-hospital cardiac arrest.
- These findings might be the basis for the development of future preventive strategies.

Nonstandard Abbreviations and Acronyms

CCI	Charlson Comorbidity Index
GP	general practitioner
OHCA	out-of-hospital cardiac arrest

insight into predictors of OHCA could be obtained by exploring health care contacts with GP and hospital among patients with OHCA compared with patients without OHCA. This could potentially help to develop future preventive strategies to identify patients at risk of OHCA.

Consequently, this study aimed to examine (1) the weekly contacts with the health care system among patients with OHCA up to 1 year before their arrest with information on both GP and hospital contacts in comparison with the general Danish population; (2) patient characteristics according to the type of health care contact (GP, hospital, both, or no contact) 2 weeks before OHCA; and (3) the outcomes of the health care contacts within 2 weeks before the OHCA, including the type of contact with GPs and diagnoses from the hospital contacts.

METHODS

The data, analytical methods, and study materials cannot be made available to other researchers for purposes of reproducing the results or replicating the procedure. Informed consent is not required for observational studies based on anonymous data.

In Denmark, the health care system is universal, free of charge, and with equal access for all inhabitants, which creates a suitable circumstance to examine all patients with OHCA and their contacts to the health care system before arrest.[13] GPs act as gatekeepers to specialized and hospital care, and, except in cases of emergencies, they are usually the patient's first contact with the health care system and thereby play an important role in screening of the patients.[13,14]

Data Sources

All Danish residents are assigned a unique civil registration number,[15] enabling linkage between nationwide registries[16] on an individual level. Patients with OHCA were identified from the Danish Cardiac Arrest Registry (2001–2014),[1,17] which includes the date, time, and location of OHCA; witnessed status (by a bystander or emergency medical services [EMS]), bystander-performed cardiopulmonary resuscitation, and defibrillation; first recorded heart rhythm; time interval estimated from the recognition of OHCA until first heart rhythm analysis; return of spontaneous circulation; and survival status on hospital arrival.[17]

Information on GP contacts (week, year, and type of contact [face-to-face, phone, or e-mail consultation, home visit, etc]) was obtained from the National Health Insurance Service Registry.[13] Information on hospital contacts (emergency department visits, hospital admissions, and outpatient visits) including discharge diagnoses was obtained from the Danish National Patient Registry.[16,18] Information on medical prescriptions up to 180 days before OHCA (14 days for antibiotics because of the short period of use) was obtained from the Danish National Prescription Registry[19] with drugs classified according to the Anatomical Therapeutic Chemical system. Medications and discharge diagnosis up to 10 years before OHCA were also used to define comorbidities and to calculate the associated Charlson Comorbidity Index (CCI). All diagnoses were coded in accordance with the *International Classification of Diseases, Eighth Revision* (*ICD-8*) and Tenth Revision (*ICD-10*).[20]

Information on age, sex, and vital status were obtained from the Danish Civil Registration System,[21] and information on causes of death was obtained from death certificates from the National Causes of Death Registry.[22] Information on the educational level was obtained from the Population Education Registry[23] and categorized into 3 groups following the International Standard Classification of Education[24] levels: (1) basic education including elementary school; (2) high school and short secondary education; and (3) bachelor, master, and doctoral degree or equivalent.

Study Population

The study included all patients with OHCA of presumed cardiac cause between ages 18 and 100 years from

2001 to 2014. The study period ended in 2014, as data after 2014 are still being validated. We excluded arrests of presumed noncardiac cause and EMS-witnessed arrests to obtain a more homogenous population as previously done.[17,25] EMS-witnessed arrests are a subset of the OHCA population,[26] as they differ from the rest of the population because of having symptoms before the arrest. The presumed cardiac cause was defined as events with cardiac disease, unknown disease, or unexpected collapse, as recommended by the Utstein template.[27] The noncardiac cause was defined as other medical disorders as well as trauma, suicide attempt, drowning, and drug overdose.

Cases and Controls

For comparison to the general Danish background population, we conducted an incidence density matching,[28,29] with patients with OHCA as cases matched with up to 9 controls from the entire general Danish population (18–100 years) on age, sex, and date of OHCA. A supplemental analysis included a matched population on age, sex, date of OHCA, and comorbidities (prior ischemic heart disease, congestive heart failure, arrhythmias, obstructive lung disease, hypertension, and diabetes). The matching procedure ensures that controls are not censored before being control and allows repeated selection of controls, including selecting a case as a control prior to becoming a case. The patients were followed for the analyses from June 1, 2001 (beginning of the Danish Cardiac Arrest Registry) until OHCA, death without OHCA, date of emigration, or December 31, 2014, whatever came first.

Outcomes

Outcome measures were (1) weekly percentages of contacts with GP or hospital up to 1 year before arrest for patients with OHCA (cases) compared with the age- and sex-matched background population; (2) patient- and cardiac arrest–related characteristics of the OHCA population according to the status of the health care contacts (GP, hospital, both, or no contact) within 2 weeks before their OHCA; and (3) type of contact with GPs and diagnoses from hospital contacts within the 2 weeks before OHCA.

Statistical Analysis

The frequency of contacts with GPs and hospitals among the patients with OHCA and the matched population up to 1 year before OHCA was examined as weekly percentages and tested using McNemat's test. Additionally, we used conditional logistic regression to estimate an odds ratio (OR) of health care contacts within 2 weeks among patients with OHCA compared with the background population.

Because of the broad definition of hospital contacts, we subdivided the hospital contacts into (1) outpatient contacts and (2) emergency department visits/hospital admissions. As subgroup analyses, we examined the frequency of health care contacts among the patients with OHCA with preselected groups of (1) CCI (low-level [CCI=0], moderate-level [CCI=1], and high-level [CCI ≥2]), (2) according to small age groups (≤29, 30–39, 40–49, 50–59, 60–69, 70–79, ≥80), and (3) with the preselected groups of CCI and age groups of ≤65 and >65 years.

To explore the characteristics and contacts of patients with OHCA shortly before OHCA, we subdivided the patients into 4 groups according to their type of contact within 2 weeks before their event: (1) only GP, (2) only hospital, (3) GP and hospital, (4) no contact with the health care system. Patient- and cardiac arrest–related characteristics were examined by descriptive statistics according to these 4 groups. Outcomes of the contacts (the type of GP contact and discharge diagnoses from the hospitals) were examined by descriptive statistics and reported as percentages. Categorical variables were presented by counts with related percentages and tested with the chi-square test. Continuous variables were presented as medians with associated 25th to 75th percentiles and tested with the Wilcoxon rank-sum test. For trend analysis, we excluded 2001 as we had data on OHCAs from June 1, 2001 (the start of the register) to 2014, and afterward, data were separated into 2 equal periods: 2002 to 2008 and 2008 to 2014. The Mann-Kendall test was used to test for trends in each period. A 2-sided P value of <0.05 was considered statistically significant. Data management and analyses were performed with SAS version 9.4 (SAS Institute Inc., Cary, NC) and R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).[30]

Ethics

The study was approved by the Danish Data Protection (Agency Ref. no. 2007-58-0015, local ref. no. GEH-2014-017, I-Suite. no. 02735). The information on the study population was encrypted and rendered anonymous by Statistics Denmark. In Denmark, registry-based studies do not require ethical approval.

RESULTS

A total of 28 955 patients with OHCA were included in this study. The selection process is shown in detail in Figure 1.

Weekly Contacts to the Health care System Within 1 Year Before OHCA

Of 28 955 patients with OHCA included in this study, 27 394 (94.6%) had a GP contact and 17 876

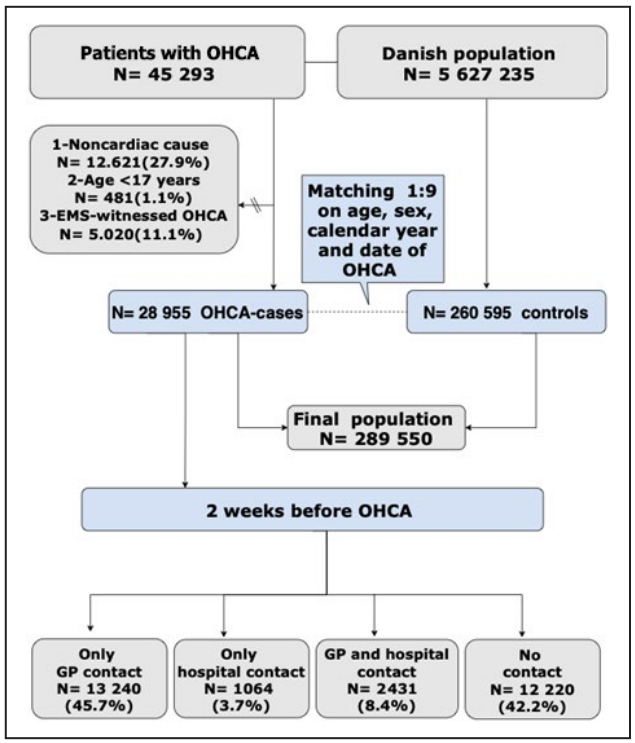

Figure 1. Flowchart.
The patient selection process of the study population from the period of June 1, 2001, to December 31, 2014. GP indicates general practitioner; and OHCA, out-of-hospital cardiac arrest.

(61.7%) had a hospital contact within 1 year before their OHCA. Figure 2 shows the weekly percentages of GP and hospital contacts within 1 year before OHCA among the patients with OHCA and the age- and sex-matched background population. Contacts with the GPs were relatively constant, at around 25% per week until the last week before OHCA, at which time it increased to nearly 42%. In comparison, the matched population had constant lower percentages of GP contacts, at around 13% per week throughout the year. For hospital contacts, a gradual increase was observed for patients with OHCA with a peak in the second week prior to arrest to 6.8%, while the matched population had fewer hospital contacts around 2% per week throughout the year. The observed differences in health care contacts between patients with OHCA and the matched population were found to be statistically significant (P<0.001). When subdividing the hospital contacts into outpatient contacts and emergency department/hospital admissions a similar tendency remained in both, and especially in contacts with emergency department (Figure 3). The same pattern was also observed in the population matched on age, sex, date of OHCA, and comorbidities in the additional analysis (Figure S1).

Patients with OHCA were overall found to have higher odds for having GP (OR, 3.17; 95% CI, 3.09–3.26) and hospital (OR, 2.32; 95% CI, 2.21–2.43) contacts compared with the general population within the 2 weeks before the event (Table 1). In overall characteristics, the OHCA population had more comorbidities and medicine use compared with the background population (Table S1).

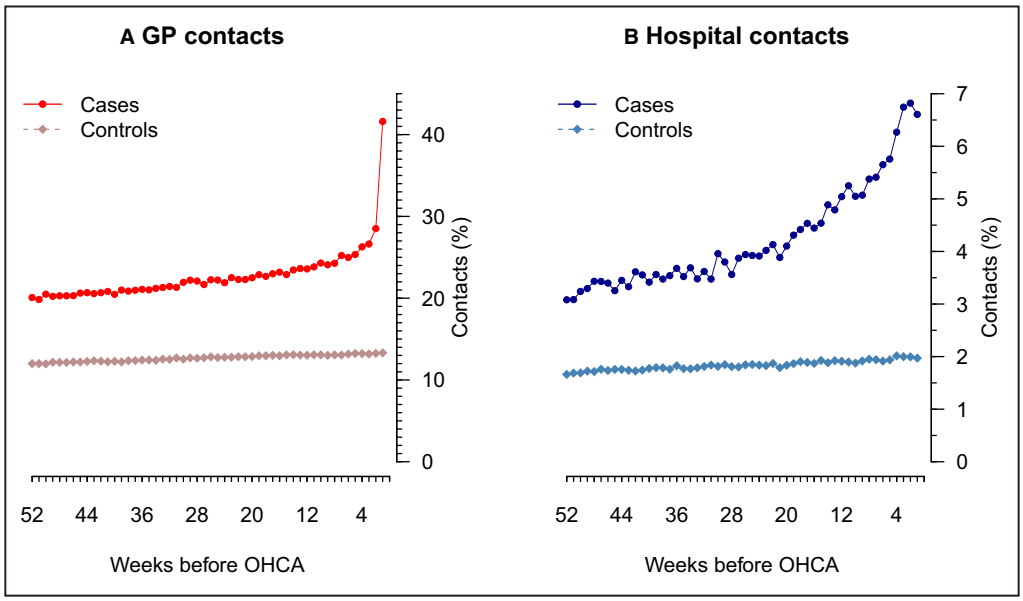

Figure 2. Health care contacts within 1 year before OHCA.
The weekly percentages of health care contacts within 1 year before OHCA compared with an age-, sex-, and index date–matched control population divided by (**A**) contacts to GP and (**B**) contacts to hospital. Number of cases=28 955; number of controls=260 595. GP indicates general practitioner; and OHCA, out-of-hospital cardiac arrest.

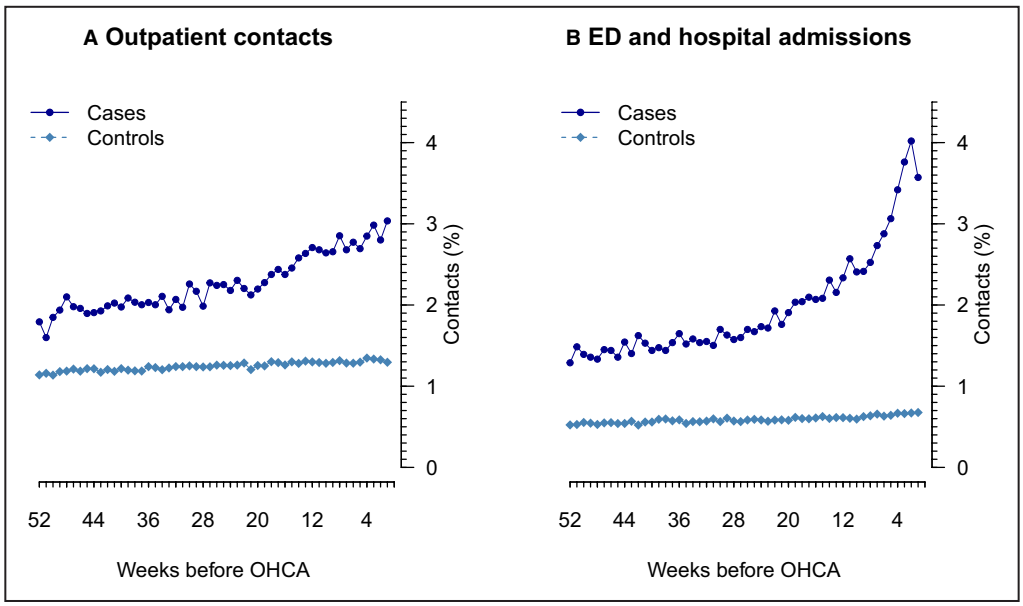

Figure 3. Hospital contacts within 1 year before OHCA divided by (A) outpatient clinic contacts and (B) ED contacts and hospital admissions.
The weekly percentages of hospital contacts are divided into (**A**) outpatient contacts; (**B**) emergency department (ED) contacts and hospital admissions within 1 year before OHCA compared with an age-, sex-, and index date–matched control population. Number of cases=28 955; Number of controls=260 595. OHCA indicates out-of-hospital cardiac arrest.

Characteristics of the OHCA Patients According to Their Health care Contacts Within 2 Weeks Before OHCA

Table 2 shows the overall characteristics of patients with OHCA according to their health care contact within 2 weeks before their OHCA. In total, 57.8% of the 28 955 patients with OHCA had contact with the health care system within 2 weeks before OHCA, divided by 13 240 (45.7%) patients with GP contact; 1064 (3.7%) patients with hospital contact; 2431 (8.4%) patients with both GP and hospital contact; and 12 220 (42.2%) patients with no health care contact. The patients with OHCA with health care contact within the 2 weeks before OHCA were overall older, more likely to be men, and had a higher frequency of most comorbidities and medicine (Table 2). With regard to OHCA-related factors, the patients with health care contacts had less chance of having a public arrest, bystander cardiopulmonary resuscitation, shockable rhythm, and 30-day survival (P<0.001) compared with patients without health care contact before arrest. Patients with both GP and hospital contacts had overall the most comorbidities and medicine use, the lowest chance of bystander cardiopulmonary resuscitation, shockable rhythm, and survival compared with the other groups.

Table 1. Odds Ratio of GP and Hospital Contacts Within 2 Weeks Before OHCA of Patients With Cardiac Arrest (Cases) as Compared With General Population (Controls)

OHCA			
Characteristic	**OR**	**95% CI**	***P* value**
GP contact	3.17	3.09–3.26	<0.001
Hospital contact	2.32	2.21–2.43	<0.001

GP indicates general practitioner; OHCA, out-of-hospital cardiac arrest; and OR, odds ratio.

Characteristics of the Health care Contacts Within the 2 Weeks Before OHCA

Examining the frequency of health care contacts within the 2 weeks before OHCA, 53.8% had >1 GP contact, and 27.6% had >1 hospital contact (Figure S2). Among the patients with GP contacts, 71.6% had a phone or e-mail contact, followed by 51% of patients having a face-to-face consultation, of which 11.3% were preceded by telephone consultation, and 29% of the patients had a home visit (Figure 4).

For the 3495 patients (12.1%) that had contact with the hospital in the 2 weeks before OHCA the most frequent discharge diagnoses were circulatory system–related disorders (20.9%) including ischemic heart disease, congestive heart failure, and arrhythmia, followed by respiratory-related disorders (10.9%), of which chronic obstructive lung disease alone was nearly 4.3%. In comparison, the most frequent discharge diagnoses among

Table 2. Patient Characteristics and Cardiac Arrest–Related Factors According to Health care Contacts Within 2 Weeks Before OHCA

Number (%)	Only GP contact 13 240 (45.7)	Only hospital contact 1064 (3.7)	Both GP and hospital contact 2431 (8.4)	No contact 12 220 (42.2)	*P* value
Patient characteristics					
Median age, y (IQR)	74 (65–82)	72 (63–79.5)	74 (65–82)	69 (59–79)	<0.001
Male sex	8408 (63.5)	715 (67.2)	1566 (64.4)	8760 (71.7)	<0.001
Education level					
Basic education	7907 (59.7)	539 (50.6)	1429 (58.7)	6335 (51.8)	<0.001
High school or short secondary	4033 (35.2)	373 (38.3)	757 (35.6)	4279 (39.1)	<0.001
Bachelor, master, or doctoral degree	1300 (11.3)	152 (15.6)	245 (11.6)	1606 (14.7)	<0.001
Comorbidities					
Ischemic heart disease	3609 (27.3)	364 (34.2)	916 (37.7)	2551 (20.9)	<0.001
Previous myocardial infarction	1669 (12.6)	208 (19.5)	480 (19.7)	1201 (9.8)	<0.001
Arrythmias	3145 (23.8)	304 (28.6)	769 (31.6)	1762 (14.4)	<0.001
Congestive heart failure	3015 (22.8)	350 (32.9)	811 (33.4)	1909 (15.6)	<0.001
Peripheral vascular disease	1669 (12.6)	171 (16.1)	409 (16.8)	1085 (8.9)	<0.001
Chronic obstructive pulmonary disease	2330 (17.6)	219 (20.6)	624 (25.7)	1158 (9.5)	<0.001
Diabetes	2226 (16.8)	195 (18.3)	484 (19.9)	1371 (11.2)	<0.001
Malignancy	1631 (12.3)	216 (20.3)	523 (21.5)	1131 (9.3)	<0.001
Pharmacotherapy					
Antithrombotic treatment	6650 (50.2)	558 (52.4)	1407 (57.9)	4480 (36.7)	<0.001
Beta-blocker	4095 (30.9)	393 (36.9)	945 (38.9)	2842 (23.3)	<0.001
Calcium antagonist	2912 (22.0)	214 (20.1)	530 (21.8)	2082 (17.0)	<0.001
Renin-angiotensin-aldosterone inhibitor	5295 (40.0)	447 (42.0)	1072 (44.1)	4008 (32.8)	<0.001
Diuretics	6775 (51.2)	543 (51.0)	1474 (60.6)	4017 (32.9)	<0.001
Antiarrhythmic medication, Vaughan-Williams class I or III	281 (2.1)	38 (3.6)	93 (3.8)	123 (1.0)	0.001
Digoxin	2030 (15.3)	164 (15.4)	465 (19.1)	1110 (9.1)	<0.001
Antidepressant medication	2965 (22.4)	194 (18.2)	620 (25.5)	1468 (12.0)	<0.001
Antipsychotic medication	1274 (9.6)	66 (6.2)	270 (11.1)	639 (5.2)	<0.001
Antidiabetic medication	2226 (16.8)	195 (18.3)	484 (19.9)	1371 (11.2)	<0.001
Antibiotics	1653 (12.5)	102 (9.6)	477 (19.6)	257 (2.1)	<0.001
Cardiac arrest-related factors					
Private home	8846 (66.8)	725 (68.1)	1724 (70.9)	7467 (61.1)	<0.001
Witnessed arrest	6422 (48.5)	547 (51.4)	1236 (50.8)	6294 (51.5)	<0.001
Bystander CPR	5024 (37.9)	453 (42.6)	945 (38.9)	5253 (43.0)	<0.001
Bystander defibrillation	222 (1.7)	21 (2.0)	28 (1.2)	338 (2.8)	<0.001
Median time interval,* min (IQR)	12 (7–19)	11 (7–17)	11 (6–18)	11 (7–18)	0.005
Shockable initial rhythm	2745 (20.7)	241 (22.7)	476 (19.6)	3890 (31.8)	<0.001
Outcomes					
ROSC	1571 (11.9)	176 (16.5)	296 (12.2)	2375 (19.4)	<0.001
30-d survival	741 (5.6)	79 (7.4)	108 (4.4)	1604 (13.1)	<0.001

CPR indicates cardiopulmonary resuscitation; GP, general practitioner; IQR, interquartile range; OHCA, out-of-hospital cardiac arrest; and ROSC, return of spontaneous circulation.

*Time interval is estimated time interval from recognition of OHCA (by bystander or call received at dispatch center) to the first heart rhythm analysis by emergency medical services.

the age- and sex-matched background population were circulatory system–related (9.8%), digestive-related (5.2%), and respiratory-related disorders (3.9%) (Figure 5).

Subgroup Analyses

When examining the weekly percentages of health care contacts among the patients with OHCA according to CCI (Figure S3), we observed a similar pattern to the main

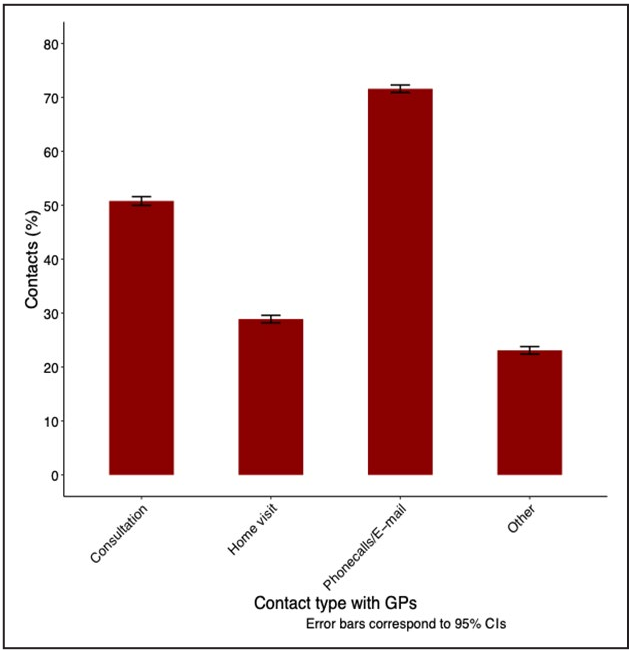

Figure 4. Types of GP contacts within 2 weeks before OHCA. The types of GP contacts within 2 weeks before OHCA. "Other" includes laboratory exams, other examinations such as blood pressure measurements and ECGs or vaccination. The total exceeds 100% because patients could have >1 contact within the 2 weeks before OHCA. Number of patients=15 671. GP indicates general practitioner; and OHCA, out-of-hospital cardiac arrest.

results, but with more contacts in higher levels of CCI and older age groups (Figure S4). Younger patients with OHCA (40–49, 50–59) had also an increase in contacts with GPs and hospitals before the event. However, percentages were overall lower compared with higher age groups.

When examining the weekly percentages of health care contacts according to CCI levels and in age groups of ≤65 and >65 years, a similar pattern to the main results was observed for patients with OHCA with hospital contacts (Figure S5). In relation to GP contacts, patients with OHCA ≤65 years with low and medium levels of CCI had a larger increase in GP contacts in the last week before OHCA compared with patients with a high level of CCI. Additionally, the patients with a medium level of CCI had the highest weekly percentages of GP contacts throughout the year (Figure S6).

Other Analyses

To look for any seasonal change in health care contacts, we investigated contacts that patients had specifically within the 2 weeks before OHCA according to seasonality. As shown in Figure S7, patients had more contacts with GPs during the winter compared with other seasons, while contacts with the hospital were constant throughout the whole year.

Additionally, we investigated for temporal trends in the calendar year of the health care contacts within 2 weeks before the arrest together with the OHCA incidence during the study period (2002–2014) (Figure S8). Percentages of hospital contacts were stable from 2002 to 2008 (P=0.2) but increased in the period of 2008 to 2014 (0.8%–1.5%; P=0.002). While GP contacts had a tendency toward a decline (5.5%–4.5%; P=0.02) throughout the first years (2002–2008) and an increase (4.5%–5.8%; P=0.04) throughout the last study years (2008–2014). The OHCA incidence increased over the last study years from 34 OHCAs per 100 000 people in 2008 to 44 OHCAs per 100 000 people in 2014.

DISCUSSION

This nationwide study aimed to explore health care contacts among patients with OHCA before their cardiac arrest. The study had 3 major findings: (1) The number of health care contacts within the year before OHCA nearly doubled in the 2 weeks up to the OHCA event; (2) more than half of the patients with OHCA were in contact with the health care system within 2 weeks before their OHCA, especially with the GP in the week preceding OHCA; and (3) the patients with health care contact within 2 weeks before OHCA often had >1 contact, higher comorbidity burden, and medicine use compared with patients with OHCA without contact. Early identification and risk stratification of patients before their arrest remains difficult. However, these data with the observed high number of contacts to the health care system up to the arrest is an important finding, indicating a potential for improving prediction and prevention of cardiac arrests in the future with a likely impact on survival. Hence, our data show that more than half of the OHCA population was in contact, especially with GPs, and often more than once within 2 weeks before arrest. This suggests the crucial role that GP could play in future studies in (1) identifying the distribution of specific symptoms leading to a health care contact before arrest; and (2) more detailed knowledge about the clinical circumstances related to the health care contact to better understand the nature of the symptoms that patients present before the arrest. Such data could help improve the early identification of patients at risk of OHCA.

Our findings contradict the general belief that cardiac arrests are sudden and unexpected events without health care contacts before the arrest.[3] Previous literature supports our findings: A Danish study[8] showed that the majority of patients with OHCA had more hospital admissions 1 month before their event, and a Swedish study[5] showed that patients with OHCA, without previously known ischemic heart disease, contacted the health care system and presented symptoms more often in the week before OHCA than in a corresponding week 1 year earlier. Furthermore,

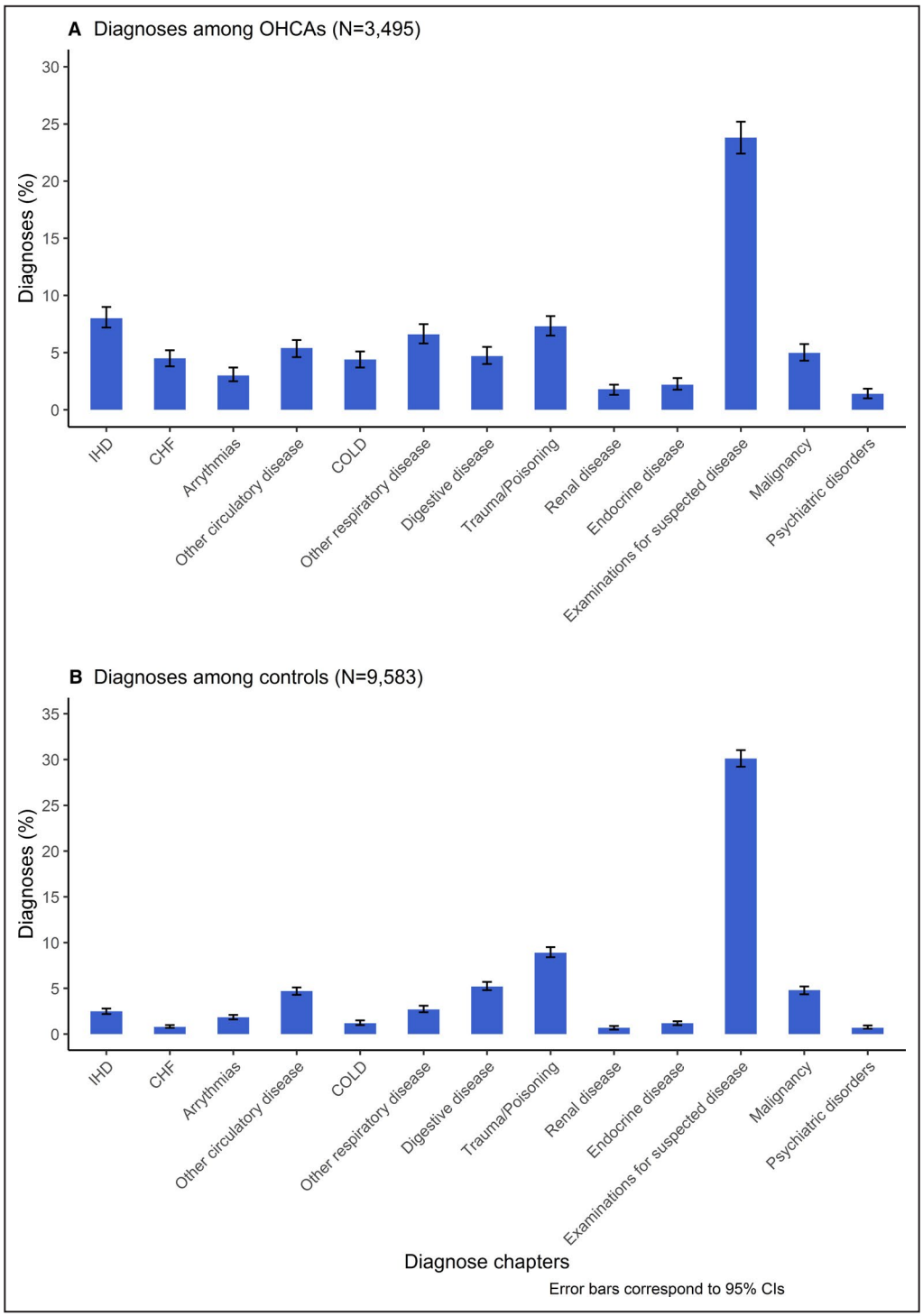

Figure 5. The main discharge diagnosis within 2 weeks before OHCA.
The main discharge diagnosis following a hospital contact within 2 weeks before OHCA compared with an age-, sex-, and index date–matched control population. **A**, Number of cases=3495. **B**, Number of controls=9583. Arrythmias indicates cardiac arrhythmia; CHF, congestive heart failure; COLD, chronic obstructive lung disease; and IHD, ischemic heart disease.

a Canadian study[10] showed that one-fourth had an emergency department assessment and hospital admission 90 days before OHCA. However, in our study, the increase in GP contacts was remarkable in comparison with the hospital contacts, highlighting the key role of the GP in the interaction with patients with OHCA. The nearly doubled number of contacts was observed not only in the total OHCA population

but also in stratified groups of CCI and age ≤65 and >65 years, with mainly more contacts in older patients and patients with more comorbidities.

The observed increase in health care contacts shortly before OHCA could be a result of different factors but is likely attributable to either a worsening of a chronic condition/comorbidity or experience of new or ongoing symptoms.[31]

Nearly half of patients with OHCA who were in contact within 2 weeks before the event were older and had more comorbidities and medicine use than the patients with OHCA without contact. Additionally, the likelihood of return of spontaneous circulation and 30-day survival was notably lower for patients with OHCA with health care contacts than without. Probably together suggesting that morbidity and worsening of a chronic condition could be associated with worse short-term outcomes after OHCA compared with those without health care contact before OHCA.

Patients with comorbidities have previously been found to be associated with greater health care use,[9,31–33] and overall this supports the hypothesis that the increase in health care contacts could be attributable to a worsening of the patients' chronic condition close to their OHCA. Also, when looking for the seasonality differences into health care contacts within 2 weeks before the OHCA, patients had the highest contacts with GP during the winter season, which probably reflects on the possible infection trigger for a worsening of an underlining condition. However, hospital contacts in the 2 weeks were mainly constant throughout the seasons.

While, as expected, we also saw more weekly contacts for patients aged >65 years and with higher levels of comorbidities compared with the other patients with OHCA, overall indicating that the patients with OHCA are an unhealthy population. An interesting finding was the decrease in hospital contacts in the last week before OHCA for primary patients with CCI ≥2 and age >65 years. This is hard to explain but could perhaps be attributable to more GP contacts in the last week before OHCA where we observed a marked increase in GP contacts for all patients.

The increased number of health care contacts was also observed among the younger patients (≤65 years) and patients with a low burden of comorbidities, indicating that the health care contacts also could be attributable to new symptoms or ongoing symptoms. Previous studies have shown that patients with OHCA experience symptoms like chest pain and dyspnea before OHCA,[4–7] and these symptoms can often be nonspecific, thus considered "unharmful."[5] To explore this further, we examined discharge diagnoses for the patients with OHCA with hospital contacts in the 2 weeks before OHCA. Here, we saw that the patients most often had cardiac- (ischemic heart disease, congestive heart failure, arrhythmia) and pulmonary-related diagnoses, but a high number of patients were also assigned with more nonspecific diagnoses.

Taken together, this study indicates that there exists a potential to identify patients before they deteriorate with cardiac arrest as more than half of the patients had a health care contact shortly before their OHCA. However, patients with OHCA are a diverse group with different characteristics, and more data are needed to explore this potential further. In addition, more knowledge is needed regarding the subgroup of patients with no health care contact 2 weeks before arrest and a low burden of comorbidities, which remains a difficult challenge.

Limitations

This study is observational whereby the relations represent associations and cannot be interpreted as causal effects. Regarding the observational data, we were limited by the National Health Insurance Service Registry only providing the week number of the GP contacts and not the exact date. This could give some inaccuracy, yet several sensitivity analyses testing this limitation did not affect our main findings. Another limitation is the lack of clinical information such as symptoms and diagnosis codes from the GP contacts. This missing information could have given a better insight into the symptoms and contact patterns of the patients with OHCA before cardiac arrest and warrants further investigation.

Implications

Our observation that GP visits increased before OHCA may have great clinical relevance in view of previous findings that the majority of OHCA victims had never visited a cardiologist before OHCA struck.[34] Therefore, to discover predictors of OHCA, we should not only focus on cardiologist data (which are nonexistent in most patients with OHCA) but should also include GP data. GP data from the period immediately before OHCA may hold the key. Here, the electronic health record system of the GP may alert the GP automatically of the possibility of impending OHCA if it detects a significant short-term (over weeks) rise in visits of patients in whom a higher a priori risk of OHCA was previously found, for example, because they have cardiovascular disease, a high cardiovascular disease risk profile or other risk indicators to be discovered in the future. Also, analysis that focuses on the GP notes and diagnoses during this period may uncover telltale signs of OHCA, thereby improving our ability to earlier recognize patients at risk of OHCA and to take timely preventative measures. This is of particular relevance for these patients because their chances of survival after OHCA are lower than those of patients with OHCA without

prior health care visits. Thus, more efforts should be focused in the future in involving more the GP practice in the OHCA research.

CONCLUSIONS

The health care contacts of patients with OHCA nearly doubled up to the OHCA event, with more than half of the patients having health care contacts within 2 weeks before arrest.

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Disclosures

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Supplementary Material

Appendix S1
Table S1
Figures S1–S8

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SUPPLEMENTAL MATERIAL

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Table S1. Characteristics of the OHCA population (cases) and the age- and sex-matched background population (controls).

Abbreviations: AFib/AFlut, Atrial fibrillation /Atrial flutter; ¶¶ Cardiac dysrhythmias excluding AFib/AFlut; IQR, 1st and 3rd interquartile range; OHCA, out-of-hospital cardiac arrest.

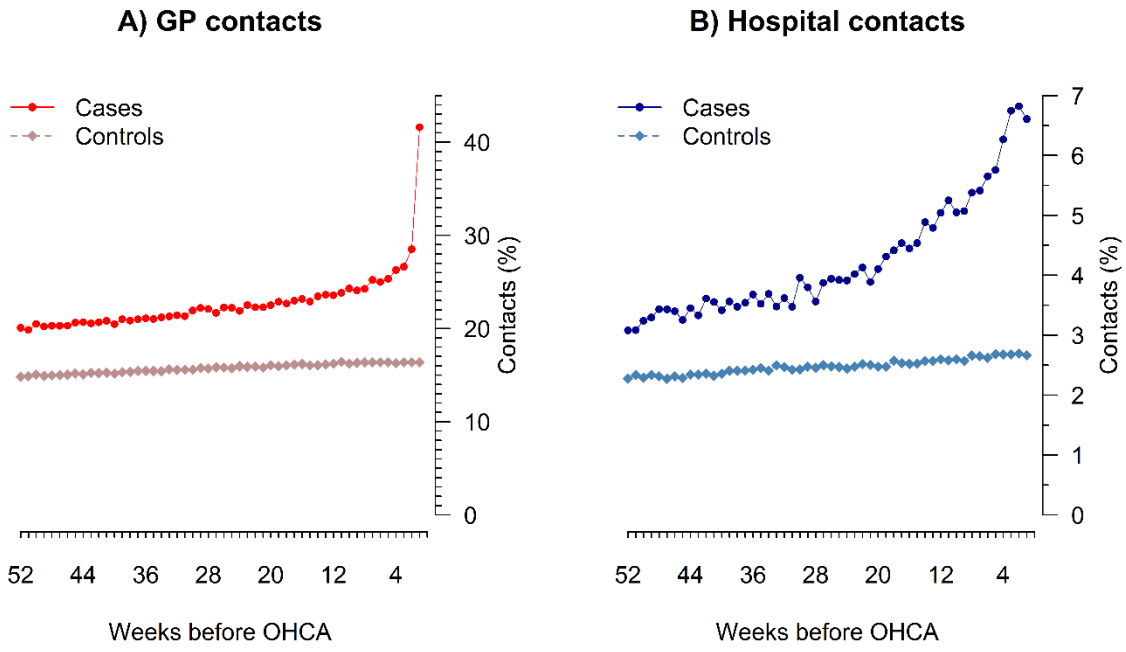
	OHCA population (cases)	**Background population (age- and sex-matched control population)**	**Total**
Number of people	28,955	260,595	289,550
Patient characteristics			
Median Age, years (IQR)	72 (62-81)	72 (62-81)	72 (62-81)
Males, n (%)	19,449 (67.2)	175,041 (67.2)	194,490 (67.2)
Educational level			
Basic education, n (%)	16,210 (55.9)	139,458 (53.2)	155,668 (53.8)
High school and short secondary education, n (%)	9,442 (37.0)	81,075 (38.7)	90,517 (38.5)
Bachelor, Master or Doctoral degree, n (%)	3,303 (12.9)	40,062 (19.1)	43,365 (18.4)
Charlson Comorbidity Index (CCI)			
CCI=0 (low severity), n (%)	10,199 (35.2)	179,019 (68.7)	189,218 (65.3)
CCI=1 (medium severity), n (%)	11,795 (40.7)	62,497 (24.0)	74,292 (25.7)
CCI >=2 (high severity), n (%)	6,961 (24.0)	19,079 (7.3)	26,040 (9.0)

Comorbidities			
Ischemic heart disease, n (%)	8,189 (28.3)	30,233 (11.6)	38,422 (13.3)
AFib/AFlut, n (%)	5,363 (18.5)	18,949 (7.3)	24,312 (8.4)
Other cardiac dysrhythmias¶¶, n (%)	3,122 (10.8)	8,993 (5.1)	12,115 (4.2)
Congestive heart failure, n (%)	6,543 (22.6)	13,223 (4.2)	19,766 (6.8)
Cerebrovascular disease, n (%)	4,334 (15.0)	20,256 (7.8)	24,590 (8.5)
Chronic obstructive pulmonary disease, n (%)	4,566 (15.8)	13,727 (5.3)	18,293 (6.3)
Psychiatric disease, n (%)	4,638 (16.0)	16,274 (6.2)	20,912 (7.2)
Renal disease, n (%)	1,307 (4.5)	3,004 (1.2)	4,311 (1.5)
Malignancy, n (%)	3,033 (10.5)	20,051 (7.7)	23,084 (8.0)
Pharmacotherapy:			
Antithrombotic treatment, n (%)	11,851 (40.9)	50,658 (19.4)	62,509 (21.6)
Beta-blocker, n (%)	7,234 (25.0)	27,581 (10.6)	34,815 (12.0)
Calcium antagonist, n (%)	4,467 (15.4)	21,955 (8.4)	26,422 (9.1)
Renin-Angiotensin-Aldosteron-inhibitor, n (%)	8,858 (30.6)	34,483 (13.2)	43,341 (15.0)
Diuretics, n (%)	11,869 (41.0)	42,969 (16.5)	54,838 (18.9)
Antiarrhythmic medication, Vaughan-Williams class I or III, n (%)	527 (1.8)	1,251 (0.5)	1,778 (0.6)
Digoxin, n (%)	3,571 (12.3)	7,904 (3.0)	11,475 (4.0)
Antidepressant medication, n (%)	4,438 (15.3)	16,455 (6.3)	20,893 (7.2)

Antipsychotic medication, n (%)	1,792 (6.2)	4,321 (1.7)	6,113 (2.1)
Antidiabetic medication, n (%)	399 (1.4)	1,351 (0.5)	1,750 (0.6)
Antibiotics n (%)	8,064 (27.9)	29,901 (11.5)	37,965 (13.1)

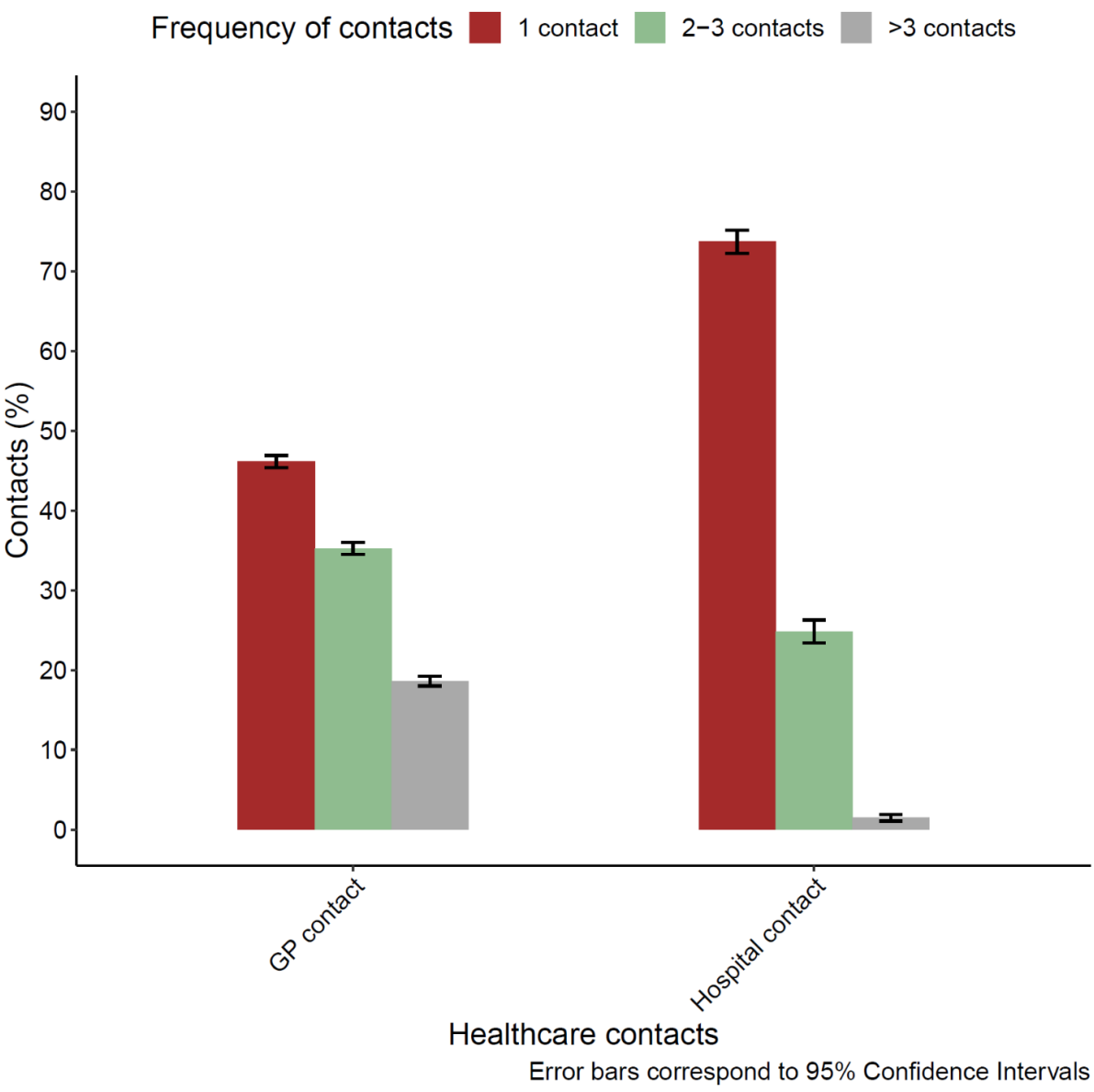
AFib/AFlut, Atrial fibrillation /Atrial flutter; ¶¶ Cardiac dysrhythmias without including AFib/AFlut; IQR, 1st and 3rd interquartile range; OHCA, out-of-hospital cardiac arrest.

Figure S1. Healthcare contacts within one year before OHCA.



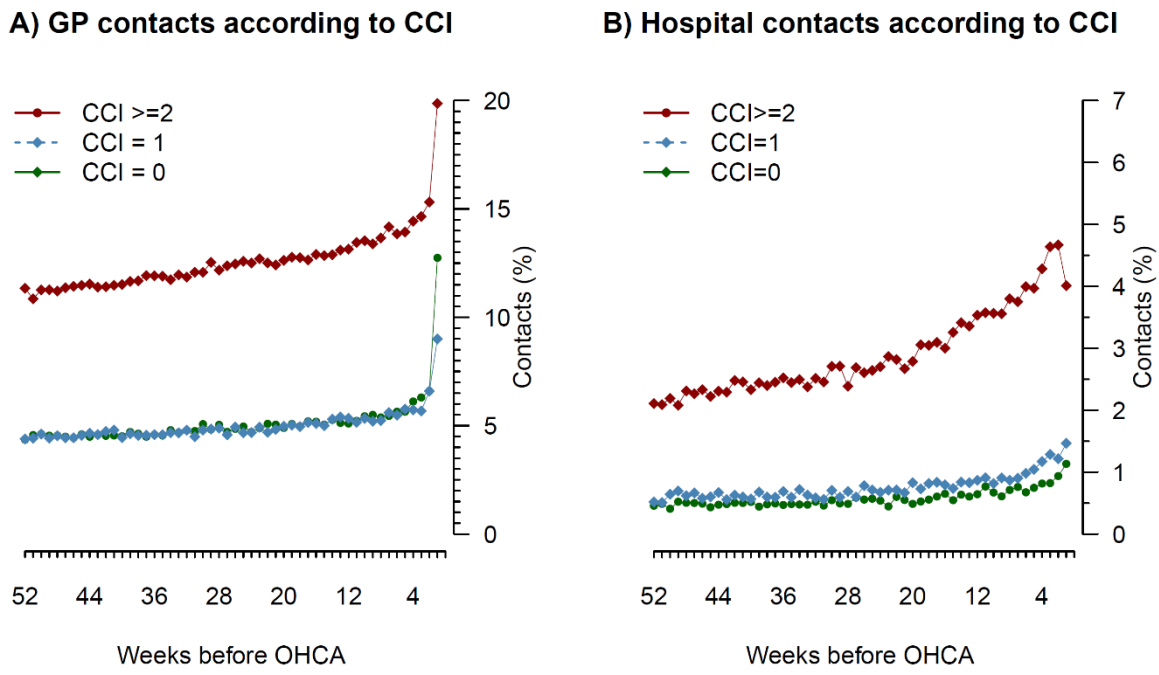
The weekly percentages of healthcare contacts within one year before OHCA compared to an age-, sex-, some comorbidities (prior ischemic heart disease, congestive heart failure, arrythmias, obstructive lung disease, hypertension and diabetes) and index date-matched control population divided by (A) Contacts to GP; (B) Contacts to hospital. Number of cases=28,955; Number of controls=256,959. GP, General practitioner.

Figure S2. The frequency of healthcare contacts within 2 weeks before OHCA.



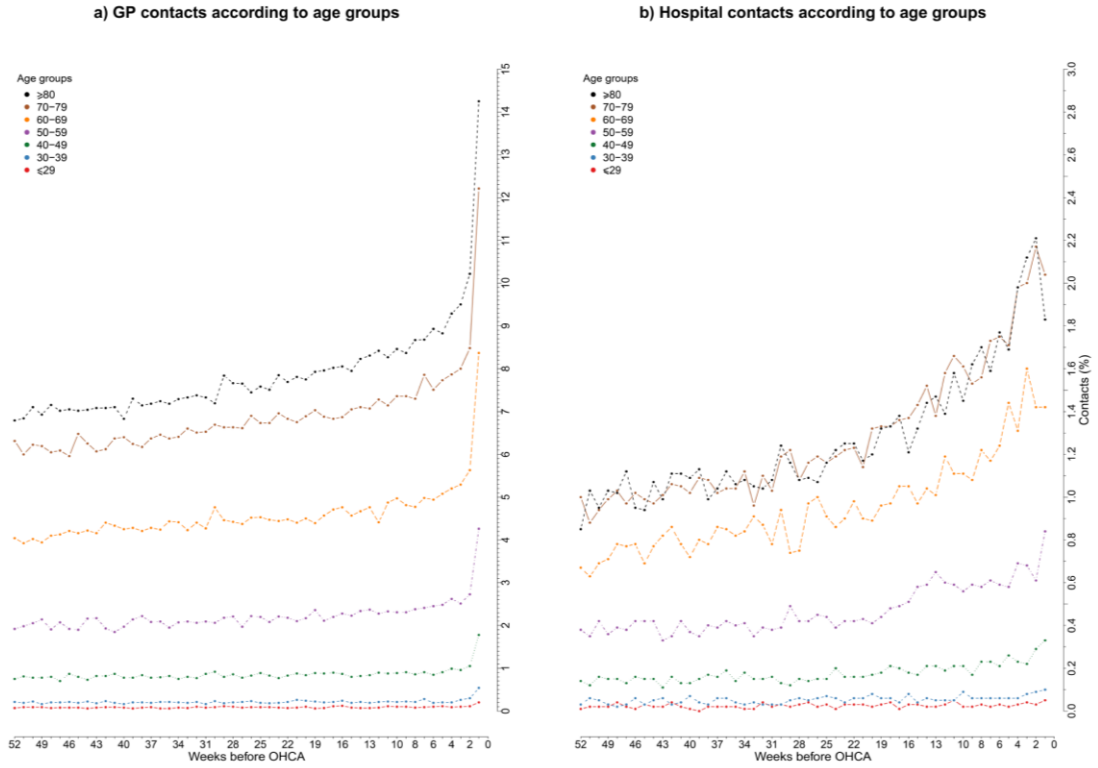
The frequency of contacts to the GP and hospital within 2 weeks prior to OHCA. GP, General practitioner.

Figure S3. Healthcare contacts within one year before OHCA according to Charlson Comorbidity Index.



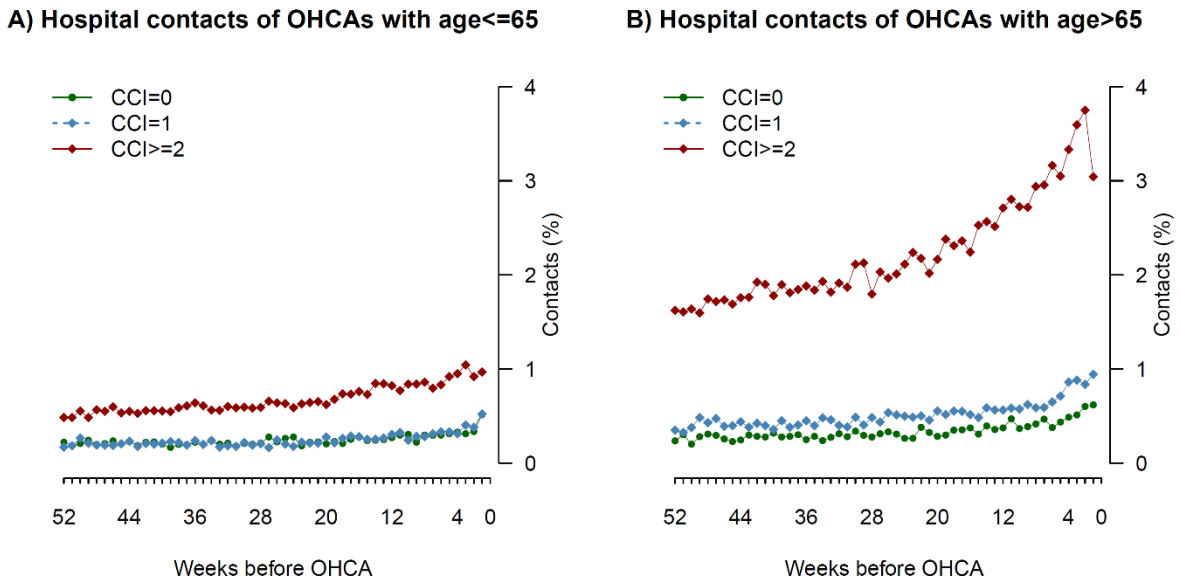
The weekly healthcare contacts within one year before OHCA according to Charlson Comorbidity Index score divided by (A) Contacts to GP; and (B) Contacts to hospital. (A) Number of patients with GP contacts according to CCI; CCI (0) =8,909; CCI (1) =6,358; CCI (CCI >=2) = 12,127. (B) Number of patients with hospital contacts according to CCI; CCI (0) =3,962; CCI (1) =3,993; CCI (CCI >=2) =9,921. CCI, Charlson Comorbidity Index score; GP, General practitioner.

Figure S4. Healthcare contacts within one year before OHCA according to patients age groups.



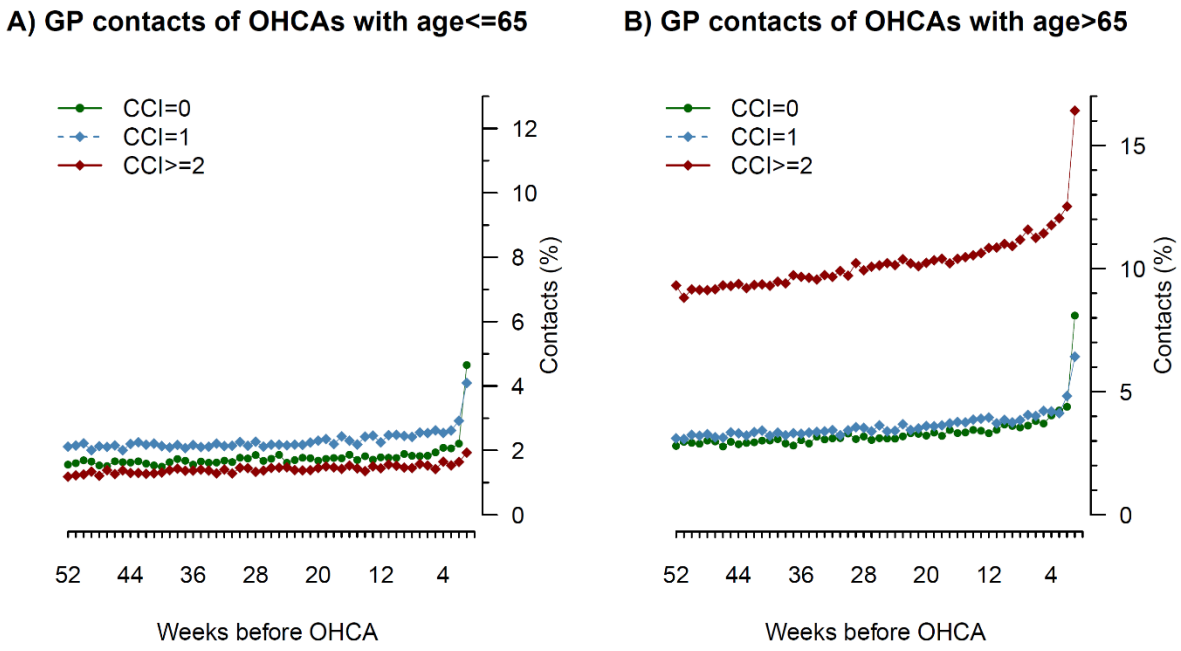
The weekly percentages of GP and hospital contacts within one year before OHCA among the OHCA patients divided by age groups from <=29, 30-39, 40-49, 50-59, 60-69, 70-79, >=80). The number of patients with GP contacts among age groups was accordingly: 168; 390; 1,369; 3,276; 6,063; 7,854 and 8,274 (a). The number of patients with hospital contacts among age groups was accordingly:117; 235; 797; 1,983; 3,820; 5,160 and 5,764 (b). GP, General practitioner; OHCA, out-of-hospital cardiac arrest.

Figure S5. Hospital contacts within one year before OHCA according to Charlson Comorbidity Index and patient age.



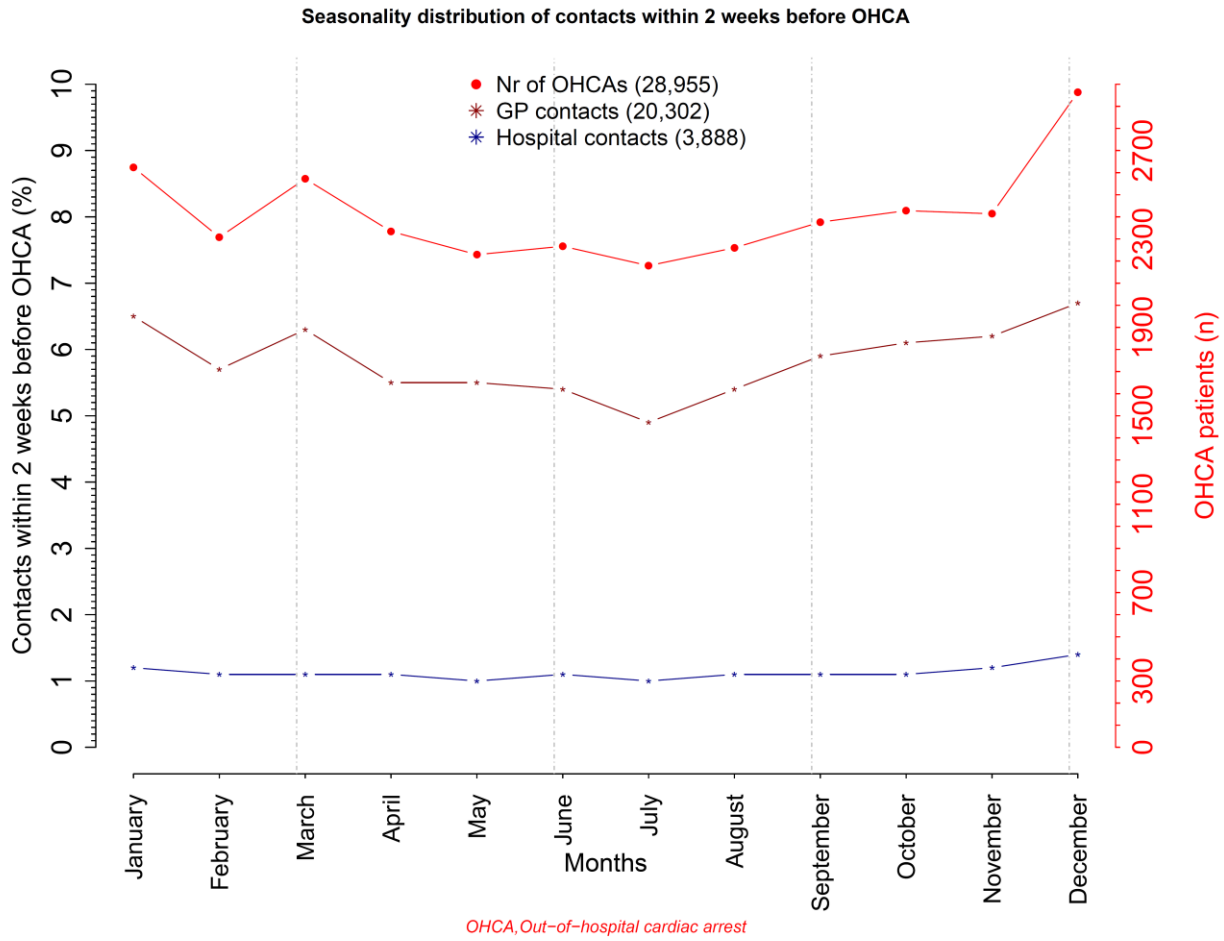
The weekly percentages of hospital contacts within one year before OHCA among the OHCA patients divided by levels of Charlson Comorbidity Index and age ≤65 years and age >65 years. (A) The number of patients with hospital contacts and age ≤65 years =4,931. (B) Number of patients with hospital contacts and in age >65 years = 12,945. CCI, Charlson Comorbidity Index score; OHCA, out-of-hospital cardiac arrest.

Figure S6. GP contacts within one year before OHCA according to Charlson Comorbidity Index and patient age.



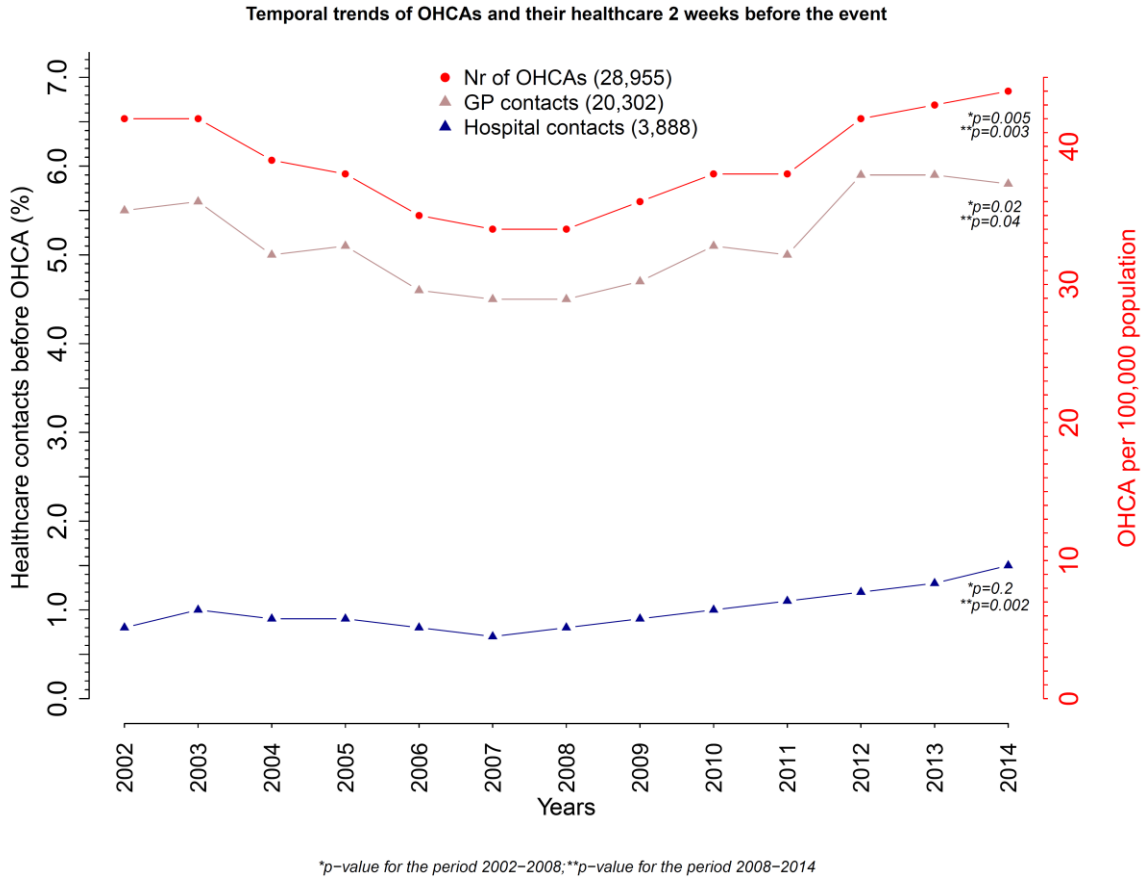
The weekly percentages of GP contacts within one year before OHCA among the OHCA patients divided by levels of Charlson Comorbidity Index (CCI) and age ≤65 years and age >65 years. (A) The number of patients with GP contacts and age ≤65 years =8,142. (B) Number of patients with GP contacts and age >65 years = 19,252. CCI, Charlson Comorbidity Index score; GP, General practitioner; OHCA, out-of-hospital cardiac arrest.

Figure S7. Healthcare contacts within the 2 weeks before OHCA and OHCA incidence according to seasonality.



GP, General practitioner; OHCA, out-of-hospital cardiac arrest.

Figure S8. Temporal trends from 2002 to 2014 of OHCA incidence and healthcare contacts among patients 2 weeks before their event.



GP, General practitioner; OHCA, out-of-hospital cardiac arrest.