Health Policy 122 (2018) 737–745

Contents lists available at ScienceDirect

Health Policy

journal homepage: www.elsevier.com/locate/healthpol

Continuity of care and its effect on readmissions for COPD patients: A comparative study of Norway and Germany

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ARTICLE INFO

Article history:
Received 4 January 2018
Received in revised form 2 May 2018
Accepted 21 May 2018

Keywords:
Patient readmission
General practitioners
Continuity of patient care
Pulmonary Disease, Chronic Obstructive
Germany
Norway

ABSTRACT

Background: This study compares continuity of care between Germany – a social health insurance country, and Norway – a national health service country with gatekeeping and patient lists for COPD patients before and after initial hospitalization. We also investigate how subsequent readmissions are affected.

Methods: Continuity of Care Index (COCI), Usual Provider Index (UPC) and Sequential Continuity Index (SECON) were calculated using insurance claims and national register data (2009–14). These indices were used in negative binomial and logistic regressions to estimate incident rate ratios (IRR) and odds ratios (OR) for comparing readmissions.

Results: All continuity indices were significantly lower in Norway. One year readmissions were significantly higher in Germany, whereas 30-day rates were not. All indices measured one year after discharge were negatively associated with one-year readmissions for both countries. Significant associations between indices measured before hospitalization and readmissions were only observed in Norway – all indices for one-year readmissions and SECON for 30-day readmissions.

Conclusion: Our findings indicate higher continuity is associated with reductions in readmissions following initial COPD admission. This is observed both before and after hospitalization in a system with gatekeeping and patient lists, yet only after for a system lacking such arrangements. These results emphasize the need for policy strategies to further investigate and promote care continuity in order to reduce hospital readmission burden for COPD patients.

1. Introduction

Hospitalizations for chronic conditions and subsequent readmissions are affected by continuity of care (COC) and pose burdens on healthcare systems globally. 210 million individuals characterize the global burden of chronic obstructive pulmonary disease (COPD), and it is projected to be the third leading cause of mortality by 2030 [1,2]. Ambulatory care sensitive conditions (ACSC) or potentially preventable hospitalizations are recognized in Germany for quality management purposes, and it has been estimated that 76% of COPD hospital admissions are avoidable [3]. Norway does not have a recognized list or associated statistics. COC is a complex, multifaceted concept concerned with care quality over time involving information exchange, disease management and interpersonal relationships [4,5]. An ongoing continuous relationship between a patient and care provider, referred to as relational or provider continuity, is considered an important element of primary care for ensuring optimal patient management, particularly for those with chronic conditions [4,6]. In relation to cost-effectiveness and care quality, previous studies have shown hospital admissions for patients diagnosed with chronic conditions are affected by continuity of care, including a limited number specifically focusing on COPD [6–17]. Although research on avoidable hospital admissions and those sensitive to COC exists, the impact of COC on readmissions is not well researched, particularly using continuity indices. Furthermore, studies focusing on hospital readmissions typically, with limited exceptions, measure time to first event or analyze a general dichotomous indicator of occurrence rather than counting instances.

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https://doi.org/10.1016/j.healthpol.2018.05.013

When analyzing healthcare utilization and relationships between primary and secondary care, such as COC, readmission is a suitable alternative to all-cause admission as an outcome measure. Readmissions can be advantageous for researchers particularly when focusing on specific conditions or diagnoses. Study subjects can be identified by acute diagnoses determined by specialists in inpatient settings directly preceding relevant readmissions, rather than by primary care providers preceding potentially unrelated admissions. Primary and secondary care supply-side dependent variation in service availability is greater when generally considering all admissions with inclusion criteria based on primary care diagnoses than for readmissions following acute episodes with diagnoses determined by a specialist. Controlling for hospitalizations with the diagnosis of interest, occurring before the baseline hospital admission that forms the basis of a readmission, further strengthens the suitability of using readmissions in addition to or instead of admissions for COC analyses.

Cross-country comparisons often rely on previously completed independent studies that differ in time frames analyzed, as well as in definitions of information and variables. Rather than relying on previously completed studies, employing two independent datasets covering parallel time periods allows for direct comparison with identically defined information and variables.

With recognized ACSC, health services research focusing on these conditions, as well as COC, is more common in the German context providing a base for comparison with Norway, where such research is sparser. To our knowledge, only one previous study uses indices to document the effect of COC on service utilization in Norway [18]. In addition to demographic differences among countries, differences in health care system characteristics, such as the gatekeeping role of general practitioners (GPs), physician reimbursement schemes, overall system financing and the extent of integration between care levels, may lead to differences in continuity of care, thereby affecting associated hospitalizations for specific patient groups, particularly those with chronic conditions. To our knowledge, no studies have compared countries based on continuity of care measures or their effect on hospital readmissions. Identification of these differences and their influence is important for international health care policy modification and development.

1.1. Organization of healthcare in Norway and Germany

Germany and Norway share a number of important similarities and differences in their organization of healthcare. Germany predominantly operates a statutory health insurance (SHI) scheme rooted in what is often referred to as the Bismarck model [19]. This scheme covers about 86% of the population, and as of 2015, 124 “sickness funds” (SHI insurers) compete freely in a national exchange market [20]. SHI membership is compulsory, but special exceptions exist for state workers, high-income individuals and self-employed individuals [19,20]. SHI coverage is primarily funded by employer/employee contributions, where, in theory, employees may choose among various insurance providers. Some individuals also choose to purchase supplementary and complimentary private insurance to augment their SHI policies. This typically serves to provide access to better/additional amenities [19,20]. The Norwegian government runs a semi-decentralized national healthcare system based on what is often called the Beveridge model [21]. This system theoretically covers the entire population and is funded primarily by taxation at several bureaucratic levels. A small percentage (~5–10%) of the population also has supplemental coverage through voluntary, for-profit insurance often provided as an employment benefit granting access to quicker treatment and greater patient choice [20,21].

In addition to the general organizational differences, demographics, as well as healthcare provision and utilization patterns in each country, vary to differing degrees. Germany's population is about 16 times larger than Norway and has about a 4% greater proportion above 65 years of age [22]. Overall, Germany spends a slightly greater percentage of GDP on healthcare, yet Norway spends about 17% more per capita [22]. Both countries have caps on cost-sharing, exemptions for youth and protections for low-income individuals. Both had equal average annual growth rates of real health care spending per capita between 2009 and 2015. Per capita, out-of-pocket health care and hospital spending are lower in Germany, but spending on pharmaceuticals is higher. In terms of population measured per 1000 persons, Germany has slightly fewer practicing physicians and slightly less than one quarter fewer practicing nurses, but over double the number of acute care hospital beds than Norway [22]. On average, Norwegians visit the doctor less than half as often per capita annually. Germany has just over 50% more hospital discharges per 1000 persons and longer average lengths of stay, but average hospital spending per discharge is less than half that of Norway [20,22].

Primary care in both countries is predominantly privately owned. The main form of primary care in Germany is solo practice, whereas Norway predominately has group practices [22]. In general, reimbursement of primary care in Germany is based on a mixture of (budgeted) periodic lump-sum payments and fee-for-service and in Norway by a mix of fee-for-service, capitated payments and user charges. In Norway, specialist care is primarily hospital-based, whereas in Germany many specialists operate private ambulatory practices. Hospital treatment is reimbursed via a mix of diagnosis-related group (DRG) case-based payments and globally budgeted block grants in Norway and based on DRGs per admission in Germany [19,21].

The two countries differ in the extent of implementation of integrated care for chronic care patients. Among a number of reforms and policies implemented since the early 2000 s in Germany, disease-specific integrated care models, known as disease management programs (DMPs), were introduced in 2002 [23,24]. These national, primary care based, patient-centered programs focusing on patient self-management with shared decision making to improve quality and care coordination for chronically ill patients through evidence based treatment have included COPD since 2005 [25–29]. However, only 10–15% of the German COPD population participates in the programs. Unlike Germany, integrated care programs that directly affect chronic care patients and physicians do not exist in Norway, nor do explicit incentives that would affect primary care utilization or further hospitalizations by these patients. Although non-existent in Norway, the topic has been debated. The debate has centered on whether diagnosis specific pathways or generic pathways is the best approach to not only integrating care, but also treating chronic care patients [30]. The idea that multimorbidity is not uncommon among chronically ill patients is a paramount concern, one also acknowledged in Germany. The Norwegian conclusion is that a generic approach is superior to those that are disease specific.

In Germany, patients have free choice of physicians, registration with a GP is not required and except for in select SHI policies, GPs do not hold a gatekeeping role [19]. GPs in Norway, on the other hand, have a gatekeeping role for referrals to specialist care. Although registration with a GP is also not mandatory in Norway, patient lists exist allowing patients to freely register and change GPs up to two times per year (given the selected GP has space on his or her list) and there is very high, nearly complete registration participation [21].

Both countries have national diagnosis and treatment guidelines for COPD that incorporate recommendations from the Global Initiative for Chronic Obstructive Lung Disease (GOLD), National Institute for Health and Clinical Excellence (NICE, UK) as well as other sources [31,32]. Indicators necessitating hospitalization outlined in the guidelines are similar, both including features such as suspected severe/life-threatening exacerbations, lack of response to initial treatment, significant comorbidity complications and inadequate homecare [31,32]. Patients with long distances to hospital are also uniquely included in the Norwegian guidelines as an indication for inpatient treatment. Both sets of guidelines detail GPs' roles in diagnosing and monitoring COPD, assessing disease severity and referrals to other care levels. They also explicitly suggest post-discharge follow-up provided by GPs; within 4–6 weeks in Germany and 4 weeks in Norway with added details of yearly visits for patients with mild to moderate conditions and at least twice a year for those with severe COPD. According to both guidelines, spirometry is the standard used to diagnose and stage COPD severity. Its use in primary care has been shown to both increase diagnosis rates and improve disease management, but the organization and accessibility in primary care differs between the two countries. Norway has high availability (>90% of practices) and use of spirometry is facilitated by being required for pharmaceutical reimbursement, whereas a lack of financial incentives for GPs arranging these tests as well as quotas for the number of tests used in diagnostic evaluation of patients exist in Germany.[33] Severity is often graded into four stages (increasing from I to IV) based on spirometry according to values outlined in the GOLD strategy. GOLD grade distribution from population-based studies is limited, but a large representative sample from Norway reported prevalence rates of 28% in GOLD I, 57% in GOLD II, 13% in GOLD III and 2% in GOLD IV [34]. The DACCORD study, an ongoing German population-based study, reported a distribution of 17% in GOLD I, 49% in GOLD II, 28% in GOLD III, 6% in GOLD IV [35]. This difference indicates severe COPD is more common in Germany.

1.2. Objective

The highlighted differences, the importance of COPD and the lack of studies evaluating readmissions related to COC indices provide the basis for this study.The aim was to compare a social health insurance country (Germany) and a national health service country with gatekeeping and patient lists (Norway) on continuity of primary care for patients in terms of GP visits before and after their first hospitalization with a COPD diagnosis. Additionally, we investigated and compared the effect of care continuity on 30-day and one-year hospital readmission rates following hospital discharge for COPD. We accomplished this by counting the number of readmissions within each period, rather than measuring the time to first event or by a binomial indicator of occurrence. Based on initial analyses, COPD patients had relatively high readmission rates. By analyzing counts, we provide additional detail beyond what the traditional time to event or general occurrence within a defined timeframe analyses provide. Both countries' guidelines state that GPs should provide follow-up for stable COPD patients, thus making a comparison of COC based on GP visits and its effects on readmissions important. The high compliance with patient list registration and the gatekeeping role of physicians in Norway compared to the absence of either in Germany could lead to differences in overall continuity of care. This, together with a higher number of GP contacts per capita in Germany and shorter lengths of hospital stay in Norway, may also result in differences in hospital readmission rates and the relationship between continuity of care and readmissions between the countries.

2. Methods

This study utilized routinely collected data from two sources: pseudonymized German insurance claims data and linked Norwegian national register data from 2009 to 2014. Both datasets contain administrative records including individual patient demographic information, inpatient admissions, ambulatory visits and diagnoses. The German data is a random sample of all insured patients, supplied by WIdO – The Scientific Research Institute of the regional health insurance funds, 'Allgemeine Ortskrankenkassen' (AOKs). This sample, limited to half a million patients due to data restrictions, includes diagnoses based on International Classification of Diseases 10th revision (ICD-10) coding as well as data on hospital stays, physician visits and medication. The AOKs insure ~25.5 million individuals throughout Germany [36]. The linked Norwegian data is complete data on all patients hospitalized during the period compiled from multiple national registries including: the national in-patient registry (NPR), the database for control and payment of reimbursements to health service providers (KUHR), the cause of death register (DÅR) and the GP database (Fastlegedatabasen). The Norwegian data includes diagnoses based on ICD-10 codes for inpatient care. Due to data sharing restrictions, it was not possible to pool the two data sets and conduct a full comparative analysis.

The German ambulatory physician visit data is based on billing records. Basic services, including personal doctor-patient contacts, are generally covered by a per capita payment that is only billed at the first visit per yearly quarter, so not every visit is visible in the German data. The Norwegian physician visit data, on the other hand, contains all all-cause ambulatory visits from 2009 to 2014 for all patients who were hospitalized during that period. Due to the potentially limiting nature of the quarterly billing basis of the German ambulatory data, we modified the Norwegian ambulatory visit data in order to mimic the German data as closely as possible for optimal comparability. First, we classified the data quarterly by year. Then, all visits by the same patient, to the same physician for the same diagnosis during a given quarter were identified and aggregated into a single visit or record per quarter. For example, if patient X visited physician Y six times during a given quarter in the raw data and one visit had diagnosis J, two visits had diagnosis O, and the remaining three visits had diagnosis S, after identification and modification it would appear as three records (visits) in total: one with diagnosis J, one with diagnosis O, and one with diagnosis S, rather than the original six visits for that particular quarter. This modification solely affected the number of ambulatory visits in the Norwegian data.

We identified hospital spells by combining individual episodes. A hospital spell is the entire period of continuous time that a patient spends hospitalized from initial admit to final discharge which can include multiple episodes. An episode is a patient record with an admit date and discharge date. Episodes were stitched into spells when the previous discharge date was less than one day from the current admission date. This typically occurs when a patient is transferred between institutions or departments which appear as a new stay or observation in the raw data. This was followed by identification of index admission and index discharge dates which comprise an index stay. The index stay was identified and defined as the index admission and discharge dates for patients who were admitted to hospital from 2011 to 2013 for the first time with COPD (ICD-10: J44.x) as their main discharge diagnosis, controlling for all prior admissions in the previous two years (730 days).The identification of index admissions – by excluding COPD admissions in the previous two years – was done to set a baseline of severity and identify only new incident cases, rather than cases that are in the middle of an ongoing or series of previous COPD hospital treatments.

Readmissions following initial admission with COPD as the discharge diagnosis were identified at two different time intervals (30 days, one year) based on the index discharge date. This served to capture the short and long-term effects of COC. The total numbers of re-hospitalizations occurring within each period from the index discharge date were aggregated.

To account for different aspects of patient-provider continuity, we calculated three different indices commonly utilized when evaluating chronological continuity of care. These indices include the Bice–Boxerman Continuity of Care Index (COCI) [37], the Breslau-Reeb Usual Provider Index (UPC) [38] and Steinwachs' Sequential Continuity Index (SECON) [39]. These indices capture care density, dispersion and consecutiveness and were calculated for each individual [37–43].

The degree to which care is distributed amid providers is captured by the COCI. UPC characterizes the share of total physician visits that are made to a patient's usual provider, calculated as a fraction of usual provider visits over total visits. In line with previous literature, as suggested by Eriksson et al. [42], we defined the usual provider as the physician that was seen most often during the calculation period. SECON is a ratio of the number of pairs of sequential visits to the same provider and the total number of visits. All indices range from 0, fully discontinuous, to 1, fully continuous. Values increase as more visits are made to the usual provider (UPC), as more visits are made to fewer unique providers (COCI) and as visits to the same provider are more consecutive (SECON).

For optimal comparability, due to the difference in organization and definition of specialists in the ambulatory sector (many in Germany and few in Norway with most employed by hospitals), each of the three indices was individually calculated based solely on GP visits at different time points with respect to the index hospital stay for each patient. The two time periods utilized in the analyses were two years before and one year after the index stay. Due to the nature of the quarterly billing for ambulatory visits in Germany and associated modification of the Norwegian data, continuity scores could not be accurately calculated for a 30-day period after discharge. Therefore, for 30-day readmissions, we sought to capture the broadest possible calculable period for COC indices before index admission – two years. For one year readmissions, in addition to the two before index admission, we were able to calculate COC indices for the one year readmission period after discharge. Any patients with less than two ambulatory visits recorded during the relevant continuity period were excluded upon index calculation.

To further compare the samples on demographics, prior health care use and health status and control for morbidity, a number of additional variables that have been associated with higher risk of readmissions were included [44–50]. Gender and age at index admission were incorporated as demographic characteristics [45,46,49]. Age was calculated based on birth month and year and index admit date. The index stay length was computed for each patient [47–50]. The total number of non-COPD hospital days and ambulatory physician visits in the period two years prior to and one year after the index stay were aggregated [45,50]. Dichotomous indicators for individuals retaining the same physician as their usual provider (visited most often) before (two years) and after (one year) the index stay were developed. Comorbidities, by ICD-10 codes for any primary or secondary inpatient diagnoses recorded in the dataset two years before and including an index admission, were identified for each patient using 17 unweighted conditions outlined by the Charlson comorbidity index [51].

2.1. Statistical analysis

In the descriptive analyses, results are presented as means and standard deviations for continuous variables and percentages for categorical variables. We conducted independent-samples *t*-tests to compare differences between countries for all continuous variables due to large samples and chi-square tests for categorical variables. We used negative binomial (365-day readmissions) and logistic (30-day readmission) models to analyze correlations between readmission and continuity of care measured before and after initial hospitalization for COPD. Due to overdispersion in the 365-day readmission counts, a negative binomial model was preferred over a Poisson model from a likelihood ratio test. Results are presented as incident rate ratios (IRR) and odds ratios (OR) with 95% confidence intervals.

To adjust the effect of continuity of care for possible confounders, the models included gender, age, comorbidities (using individual Charlson Index condition dummy variables), number of non-COPD hospital days two years before admission, time to first follow-up after discharge and since last physician visit before index admit, index length of stay and if the usual provider was the same before and after the index stay. Age was categorized from 0 to 49 years and 10 years segments beyond age 50, with 90 years and above as the reference group. Quartiles for the total number of non-COPD hospital days and the number of days between physician visits/billing dates and hospitalization before and after the index admit and discharge dates were calculated and included in the regressions as dummy variables with the first quartile as reference groups. Categorization was done to avoid the assumption of a log-linear effect of the variables. Additionally, quartile categories remove any skewness observed among the variables. The number of ambulatory physician visits in the period two years prior to and one year after the index stay were compared descriptively, but not included in the regressions since these measures are indirectly captured by the continuity indices.

All regression analyses excluded patients dying during the readmission period. This was done to standardize the follow-up periods for all patients, and due to the fact that end-of-life care utilization could be different from usual care utilization, thus influencing the estimates for the continuity of care indices. Due to the exact day of the month of death being unknown for the German data, only patients alive through the last month of the readmission period were included from both datasets.

As GP utilization patterns and referral to hospital may differ depending on age, rural/urban residence and COPD severity, the following sensitivity and subgroup analyses were also conducted: Norwegian COC indices calculated using the modified quarterly data were compared to the raw data. COC regression coefficients were estimated both without adjusting for comorbidities as well as adding additional comorbidities prevalent among COPD patients (e.g., depression, lung cancer, cachexia, osteoporosis, primary hypertension) not covered among the Charlson conditions [52–54]. Regression analyses were run excluding patients with COPD (ICD-10: J44.x) as a secondary diagnosis for any admission in the two years prior to the index admission. Risk adjustment and subgroup analyses for GOLD grade COPD severity, made possible by the German ICD-10 coding modification, were conducted on the German data. Rural and urban area subgroup analyses were performed based on classifications from The Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) ascertained using postal codes and information published by The Federal Statistical Office (Das Statistische Bundesamt) and BBSR for the German data, and using an urban settlement classification grouping cut off (>20000 inhabitants) defined by Statistics Norway based on municipality numbers in the Norwegian data. Potential age trends were also analyzed for both countries via age interval subgroups (0–64, 65–74, 75–84 and 85+ years). All analyses were conducted using STATA (version 14.2).

3. Results

The demographics and characteristics of the two study populations are displayed in Table 1. The average patient was slightly older in Germany compared to Norway. The share of women in the German sample was approximately 9 percentage points lower than that of the Norwegian sample. Compared to Norwe-

Table 1
Descriptive statistics of covariates by country.

		Germany			Norway		
		Mean	SD	N	Mean	SD	N
Age		73.3	11.3	6373	71.8	12.0	13507
Gender (Female), %		43.2		6373	52.5		13507
Patients with previous hospital visit,[a] %		71.0		6373	61.0		13507
Number of non-COPD hospital days[a]		32.2	40.7	4524	16.9	21.7	8246
Average Charlson comorbidity count[a]		3.3	2.0	6373	1.8	1.1	13507
Index length of stay		10.8	12.5	6373	7.6	9.2	13507
Same usual provider 2 years before and 1 year after index stay, %		69.7		6305	64.4		13465
30-day post-discharge mortality, %		8.9		6373	5.1		13507
365-day post-discharge mortality, %		25.1		6373	20.4		13507
Physician visits	2 years before index stay	31.6	25.5	6158	19.0	12.2	13292
	1 year after index stay	18.2	15.1	5769	10.5	7.5	12619
COCI	2 years before index stay[b]	0.71	0.25	5681	0.49	0.26	12690
	1 year after index stay[c]	0.73	0.25	4500	0.52	0.29	10019
UPC	2 years before index stay[b]	0.81	0.19	5782	0.67	0.21	12968
	1 year after index stay[c]	0.82	0.19	4565	0.70	0.22	10369
SECON	2 years before index stay[b]	0.76	0.23	5681	0.55	0.25	12690
	1 year after index stay[c]	0.76	0.25	4500	0.55	0.29	10019
Readmissions 30 day[d]		0.23	0.49	5807	0.23	0.52	12816
Readmission 365 day[c]		1.70	2.00	4776	1.56	2.27	10748

[a] 2 years before index admission.
[b] Only those discharged alive.
[c] Only those surviving at least one-year follow-up.
[d] Only those surviving at least 30-days follow-up.

gian patients, the share of German patients with at least one non-COPD hospitalization in the two years before index admission was about 10 percentage points higher, with an average of 15.3 more total hospital days. The average number of comorbidities per patient in Germany, classified by categories used to calculate the Charlson comorbidity index, was just under double that compared to Norway. The average length of stay for index admissions was approximately three days longer for German than Norwegian patients. On average, the share of patients in Norway that had the same most frequent usual provider before and after his or her index admission was about 5 percentage points fewer compared to Germany. German COPD patients had an average of just over 12.5 more ambulatory physician visits during the two years leading up to an index hospital stay and an average of about 7.5 more visits in the year following discharge compared to Norwegians. The mean values for all continuity indices two years before index admission and one year following index discharge were considerably higher for Germany than for Norway. The average number of readmissions within 30 days and one year after discharge were relatively similar for both countries with 0.23 and 1.70 in Germany and 0.23 and 1.56 in Norway. All tests indicated statically significant differences in values between the two countries with p-values <0.0001 except for the readmission variables. The difference in average 30-day readmission counts between Norway and Germany was not statistically significant ($p = 0.75$), but the difference in one-year readmissions was ($p < 0.001$).

In the multivariate regression analyses, there were no associations between continuity, by any continuity measure two years before an index stay, and 30-day or one-year readmissions for German COPD patients. There were statistically significant reductions of 4.2%, 4.9% and 2.4% in associated incidence rates of one-year readmission for each 0.1 increase in COCI, UPC and SECON values one year after discharge, respectively. There were no associations between COCI or UPC continuity two years before admission and 30-day readmissions for Norwegian COPD admissions. There was a significant reduction of 3.0% in odds of 30-day readmissions associated with each 0.1 increase in SECON two years before index admissions for Norwegian patients. Likewise, each 0.1 increase in COCI, UPC and SECON two years before the index was associated with significant reductions of 3.3%, 3.9% and 3.8%, respectively, in one-year readmission incidence rates. Similarly, each 0.1 increase in COCI, UPC and SECON one year after discharge was associated with significant reductions of 14.5%, 19.2% and 13.5% in respective one-year readmission rates. (Table 2)

3.1. Sensitivity and subgroup analyses

To check the stability of the results, a number of sensitivity and subgroup analyses were also conducted. Comparison of calculations of Norwegian COC indices using the original unmodified individual visits and the modified quarterly lump-sum billing resulted in negligible differences in COC estimates, both in the descriptive and regression analyses. Two modified analyses, removing Charlson comorbidities and adding additional comorbidities specifically related to COPD, did not affect the main results. Excluding patients with COPD as a secondary diagnosis two years prior to the index admission reduced the number of patients included in the analyses by around 40% for both countries, but resulted in limited changes of statistical significance with interpretation implications. Norwegian 30-day readmission ORs for COCI and UPC measured two years before index admission were each reduced by less than 0.05, but gained statistical significance, thus making all COC coefficients for Norway significant. For Germany, there was a loss of significance and small increase in the IRR (less than 0.02) associated with 365-day readmissions for SECON measured one year after index admission. These results strengthen the conclusion from the primary analysis that the effects of COC are stronger in Norway than in Germany. Risk adjustment for GOLD grade COPD severity (available for ∼45% of the German data) did not alter the main results in the German data.

Subgroup analyses to evaluate potential differences in COC effects by age and rural/urban areas were performed for both countries, and according to GOLD status in the German data. Regressing the data using rural/urban distinctions gave similar COC effects in both groups in the German data with no changes in statistical significance from the main results. Norwegian results for the same analyses were consistent with the main results, with the exception of all COC types having statistical significance in their effects on 30-day readmissions in urban areas. Subgroup analyses based on GOLD grade groups (I/II and III/IV) for the German data did

Table 2
Negative binomial and logistic models for association between COCI, UPC and SECON and hospital readmissions within 30 and 365 days.

	Association between COCI, UPC and SECON and Hospital Readmissions					
	Germany			Norway		
	30 day[b]	365 day[c]		30 day[b]	365 day[c]	
	2 years before Odds Ratio (95% CI) N	2 years before Incidence Rate Ratio (95% CI) N	1 year after Incidence Rate Ratio (95% CI) N	2 years before Odds Ratio (95% CI) N	2 years before Incidence Rate Ratio (95% CI) N	1 year after Incidence Rate Ratio (95% CI) N
COCI[a]	**0.990** (0.960-1.021) 5473	**1.002** (0.987-1.017) 4484	**0.958***** (0.945-0.971) 4488	**0.987** (0.967-1.008) 12221	**0.967***** (0.956-0.978) 10244	**0.855***** (0.847-0.863) 10005
UPC[a]	**0.993** (0.955-1.032) 5563	**1.003** (0.985-1.021) 4562	**0.951***** (0.934-0.969) 4546	**0.986** (0.962-1.010) 12444	**0.961***** (0.948-0.974) 10421	**0.808***** (0.799-0.817) 10342
SECON[a]	**0.987** (0.956-1.018) 5473	**1.003** (0.989-1.018) 4484	**0.976***** (0.962-0.989) 4488	**0.970**** (0.951-0.990) 12221	**0.962***** (0.952-0.973) 10244	**0.865***** (0.857-0.873) 10005

CI = confidence interval, N = number.
*p < 0.05.
**p < 0.01.
***p < 0.001.
All indices range from 0 (complete discontinuity) to 1 (fully continuity). Each continuity index was multiplied by 10 before inclusion in each model; the β coefficient for each IRR can be interpreted as the percent change in associated incidence rate of readmission for each 0.1 increase in index value. For example, IRR = 0.95 equates to 5% lower incidence rate of readmission for each increase in 0.1 associated continuity score.
A 0.1 increase in the continuity score corresponds to 1) a 10 percentage point reduction in the dispersion of the visits per provider distribution for the COCI 2) a 10 percentage point increase in the number of visits to the usual provider for the UPC and 3) a 10 percentage point increase in the number of sequential provider visits for the SECON.
[a] Models controlled for baseline sex, age, comorbidity (using the Charlson Index conditions), number of non-COPD hospital days before admission, time to first follow-up after discharge and last physician visit before index admit (days), index length of stay and if same usual provider before and after the index stay.
[b] Patients who died within the first 30 days or before discharge are excluded.
[c] Patients who died within the first year or before discharge are excluded.

not indicate any changes to the interpretation of the main regression results, although one shift in significance compared to the results of the primary analysis occurred. Both GOLD grade groups were non-significant for SECON one year after discharge, while the undefined group maintained significance. In general, the significant effects were slightly stronger for group I & II than for group III & IV. Dividing the data into age intervals subgroups 0–64 years, 65–74 years, 75–84 years, 85+ years in both countries indicated potential age trends. Two main changes in statistical significance occurred in the Norwegian data. The effect of COC two years before index admission on 365-day readmissions was non-significant for all COC measures for patients 85+ years. Additionally, all COC measures showed either significant (UPC and SECON) or close to significant (COCI, p = 0.055) effects on 30-day readmissions for the age group 0–64 years, while coefficients for all other age groups were non-significant. In the German data, the effect of COC one year after discharge on 365-day readmissions lacked significance for the oldest age group (85+) for all COC measures and the only group to maintain a significant effect of SECON was 75–84 years.

4. Discussion

This study demonstrates notable differences in COC between Norway and Germany, with little difference in crude readmission rates. Logistic and negative binomial analyses indicate continuity prior to hospitalization does not affect readmission rates in Germany and has mixed effects in Norway. In Norway, 30-day readmissions were exclusively affected by sequential continuity prior to hospitalization. There were also effects of all continuity measures prior to hospitalization for one-year readmissions in Norway, but none observed in Germany. In both countries, one-year readmissions were affected by all continuity types after discharge. With values slightly less than 1, the magnitude of the effects we observe are similar to what has been reported previously in studies of COC measures and their effects on hospitalization for other conditions reporting per 0.1 changes as we have done [12].

Without a mandated gatekeeping function of physicians in Germany, unlike in Norway, patients may freely seek care by any medical provider without referral. Unlike Germany, in Norway there is high compliance with patient list registration with regular general practitioners. Based on these key organizational differences and the previously documented comparatively higher number of annual GP visits per capita in Germany, one could expect that Norwegian patients have higher overall continuity of care, which, in turn, could result in fewer hospital readmissions despite shorter average hospital lengths of stay in Norway. However, in the data, COC was estimated to be higher in Germany overall. Multiple arguments can be made to validate this finding. The COC estimates for Germany are similair to and derived by the same methods as those found by Vogt et al. for heart failure [16]. The AOK data from Germany only contains health records for one insurance provider in Germany, and AOK is known to ensure a more sickly demographic than the average [55]. Previous studies have suggested that patients with more complications or comorbidities usually require care from more or a wider variety of providers often with more intense treatments and will therefore likely have lower continuity, but this was not consistent with our findings based on the comparatively higher comorbidity count for German patients [15]. An alternative explanation for higher continuity scores for the German patients could be the possibility that patients with more severe, well-managed illnesses exhibit higher levels of continuity due to regular or intense care regimens that require treatment by the same physicians. This would be consistent with the higher comorbidities observed for German patients. Management of those comorbidities likely requires more GP visits, potentially translating to higher continuity if treatment is consistent with the same physician. Additionally, these results could be due, at least in part, to the German DMPs for COPD. However, this is unlikely as it would require relatively high DMP participation rates by patients included in the analysis, and actual DMP enrollment for the German population with COPD is only ~10% [29]. Furthermore, other underlying and uncontrolled factors, such as the way care is organized, could be present in the Norwegian system causing lower levels of continuity. The difference in the predominant type of primary care practice, solo and group, between countries could also influence COC values. Often in Norway when a patient's specific GP is unavailable, they are alternatively given an appointment with another physician within the same group practice. Calculating indices considering group practice visits could result in higher Norwegian COC compared to using individual physician visits. With nurses increasingly providing more extensive services outside of hospitals in primary and home care settings, differing numbers of practicing nurses per population and their specific role within primary care in each country could also have uncaptured effects on ambulatory physician visit numbers and COC values.

The subgroup analyses indicated potential general trends. Although not completely conclusive, overall trends in the results for differences among geographic areas indicate contrasts between the countries, with slightly stronger effects of COC on readmissions for patients in rural areas in the German data and the converse being true in the Norwegian data. Age trend results were slightly inconclusive, but there are indications that COC has less of an effect for the oldest patients based on the only readmission period with significant effects in the German data (one year after discharge) losing significance for those 85+ years and the same occurring for the effect of pre-hospitalization COC on 365-day readmissions in the Norwegian data. The sole Norwegian study that we are aware of to evaluate COC indices only calculated UPC and found a mean value (0.78) inconsistent with the Norwegian COC values we have observed [18]. On the other hand, two recent Swedish studies, focusing on specific counties, that used COC indices to compare continuity and outcomes reported values more consistent with our findings [17,56]. There are few other studies focusing on COPD using COC indices that can be used for direct reference. Two Asian studies and a US Medicare based study focused on COPD patients and reported mean COCI values [10,13,14]. With the exception of the Swedish study, the values recorded by other studies fall in between the two countries we compared.

The majority of the descriptive results of this study concerning COPD patients confirm previous data on general patient populations. German patients had more inpatients days during the two years leading up to the initial COPD related admission and comparatively longer average index lengths of stay. The mean number of days to first follow-up visit after discharge, for those patients who had at least one follow-up visit measured in the first 30 days and one year post-discharge, were both longer in Norway. Although the follow-up times were considerably longer for Norwegian patients, the average time to last ambulatory visit before admission was shorter than in Germany. All readmission counts were relatively similar for both countries. The fact that Norwegian patients had comparatively lower mortality and similar 30-day readmission rates, despite the German data consisting of older patients with greater numbers having pre-index hospitalization, more pre-index hospital days, longer lengths of stay and more comorbidities, is in line with previously documented high rates of readmission and low mortality in Norway [57]. Consistent with previous literature, German patients had a far greater average number of physician visits during both periods studied [22]. However, contrary to our initial assumptions, based on the existence of the patient list system, a smaller percentage of Norwegian patients had the same most frequently visited provider before and after his or her index stay compared to German patients. This is, nevertheless, consistent with the comparatively lower continuity scores observed for Norwegian patients. To our knowledge, there is a lack of literature that analyzes the association of COC and readmissions, particularly for COPD patients, for direct comparison to our regression results.

Overall, the German data indicates that, in a system lacking gatekeeping and patient lists, readmissions are only sensitive to continuity of care after discharge during a one-year post-discharge time frame but not to care continuity leading up to an initial hospital admission. Norwegian data, on the other hand, suggest that in a system with gatekeeping and patient lists readmissions one year post-discharge are sensitive to multiple measures of continuity of care both before and after index hospitalization for COPD. The data further suggests, unlike the German data, that readmissions during the 30-day period following discharge are sensitive to the sequential aspect of continuity of care before admission, but not continuity density or dispersion. This conclusion should be viewed with caution, as COC may influence readmissions and vice versa. Hence, COC and readmissions measured in the same time period could be problematic. For instance, during a relevant study period, readmissions could have occurred prior to all GP visits recorded for a patient, leading to the observed effects of COC being strongest in both countries when measured after discharge. However, only using GP visits for construction of COC indices should decrease reverse causality risk. Readmissions might increase the number of specialist visits, thereby affecting continuity index values if included in COC calculations, yet readmissions should have a lesser influence on changes in GP visit patterns. Additionally, higher COC values measured prior to index admission were still associated with lower one-year readmission rates in the Norwegian data, where reverse causality should not be a problem, as the patients have no COPD hospitalizations during the pre-index stay period.

Additional limitations may affect our findings. Our results may not be generalizable to other populations, specifically German patients with other insurance types or providers. The claims and register based nature of the data sets limited our risk adjustment capacity by lacking clinical, pharmaceutical and disease severity details that are potentially associated with continuity scores and readmission occurrence. Although our evaluation has focused on notable differences with important utilization implications (gatekeeping, patient lists, care approaches for chronic conditions, and system organization and financing), other differences in primary care organization not covered here could further explain the results. Due to lack of information from the two data sources or when only present from one source, there is a multitude of patient characteristics that we were not able to account for which could concurrently or independently influence continuity and/or likelihood of readmission. Yet, among the variables for which it was possible to adjust, the effects of COC maintained stability in several different settings illustrated in multiple sensitivity analyses. Additional aspects and types of continuity such as informational, interpersonal and management were not measured or compared for the two countries. Without this information, we were unable to capture transitional care continuity but instead focused on the potential relationship between continuity in one care level and resource use and utilization outcomes in another level. Transitional care and information continuity have important relevance due to the potential for a patient's vulnerability when discharged being directly affected by the division among the ambulatory and hospital sectors, like that which exists in both countries. These aspects would add an important dynamic to our results. Based on the nature of our analyses, we are unable to draw any comparative conclusions about care quality. In some instances receiving treatment from multiple healthcare providers is advantageous for overall treatment quality, which also results in lower COC measures. Measuring COC based solely on GP visits alleviates this concern as these instances usually involve multiple specialists rather than multiple GPs.

There are numerous strengths to this study despite these limitations. We were able to directly compare two independent datasets from different countries covering parallel time periods with uniformly defined information and variables. Setting a baseline index admission controlling for two years prior added an aspect of homogeneity to the study groups. We analyzed readmissions, an arguably stronger metric than admissions and did so by evaluating counts rather than time to first event or a general indicator of occurrence. Splitting the analysis into 30- and 365-day follow-up periods strengthened the analysis by allowing us to evaluate COC both short- and long-term.

5. Conclusion

For COPD patients, there are notable differences in continuity of care and associated readmissions between Norway and Germany; two countries with healthcare systems that functionally differ in delivery and utilization of care, primarily with regard to gatekeeping, patient lists and integrated care programs for chronic care patients. Comparatively speaking, baseline levels of COC were opposite of what we had expected based on assumptions made about the operation and regulations in place within the healthcare systems. We are not able to conjecture or ascertain what causes higher/lower levels of continuity, but based on routinely collected insurance claims data and national register data and three continuity of care indices, our findings add to the current literature and indicate that higher GP continuity in primary care is associated with reductions in hospital readmissions after initial admit with COPD, regardless of systems' set up and the measured levels of care continuity. These associated reductions are observed both before and after index hospitalizations in a system with gatekeeping and patient lists, and only after index hospitalizations in a system with disease management programs but lacking gatekeeping and patient lists. These results observed for COPD patients may not be applicable for other diagnoses. Our results emphasize the need for policy strategies to further investigate and promote primary care continuity to influence secondary care utilization and post-secondary care outcomes for COPD patients, particularly hospital readmissions.

Conflicts of interest

None.

Acknowledgements

The paper is funded by the Norwegian Research Council through the evaluation program for the Cooperation reform (NFR grant 220764 – "Prosessevaluering av Samhandlingsreformen: Statlige virkemidler, kommunale innovasjoner"). The funding source had no involvement in study design, collection, analysis and interpretation of data, writing of the report or the decision to submit the article for publication. Special thanks to The Scientific Institute of the AOK (WIdO) for providing the German data.

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