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ABSTRACT

The Norwegian healthcare coordination reform (Samhandlingsreformen) was implemented from January 1, 2012. In addition to providing municipalities with funding to strengthen their health infrastructure, it required municipalities to pay hospitals a daily fee for patients who, having been declared ready for discharge and in need of municipal health services, were not received by the municipalities on time. This study examines the effects of the reform on the rate of death and readmissions occurring within 60 days of hospitalization. We use aggregated municipal data for years 2009, 2010, 2012-2014 (N=1646) for Norwegian patients (age 18+) hospitalized in the same years for COPD/asthma, heart failure, hip fracture, and stroke. We stratify our analyses of the municipal data by these patient groups. Our linear regression models test for moderated (interaction) effects whereby associations between the reform and the rate of death and readmissions vary by whether or not patients were classified as ready for discharge and in need of follow-up care in the municipality. The models adjust for municipal sociodemographic and health characteristics. We found no statistically significant moderated effects of the reform across the patient groups, except for patients with stroke (b=.027, SE=.109, p<.05). Specifically, compared to the pre-reform period (2009-2010), the post-reform period (2012-2014) was associated with a higher rate of readmissions at high predicted values of needing follow-up care. Although our analyses of municipal data suggest that patients with stroke are vulnerable to the reform and its incentive scheme, there is no strong evidence overall to suggest that the Norwegian healthcare coordination reform is functioning in a manner that exacerbates the risk of death and readmissions.

Keywords

Healthcare reform; financial incentives; inpatient overstay; post-discharge care; death; readmissions; adverse events; Norway

INTRODUCTION

Increasing efficiency and reducing costs whilst maintaining good quality of care and patient outcomes is a priority for many countries, including Norway. The Norwegian healthcare coordination reform (henceforth reform) was implemented from January 1, 2012 (Norwegian Ministry of Health and Care Services [NMHCS], 2009). Among other features, it included incentives in the form of fees for in-patient overstays. Our aim in this study is to test whether the effect of the reform on the rate of death and readmissions is contingent upon whether patients were classified as ready for discharge and in need of follow-up care in the municipality.

Background

Hospital length of stay (LOS) have been comprehensively debated in several countries, and financial incentives have been used as a tool to reduce LOS. In Sweden, the 1992 Ädel reform required municipalities to pay a fee for inpatient overstays in acute care hospitals (Johansson, 1997). Denmark followed with a similar scheme in 2007 (Sundhedsloven, 2007) as did Helsinki, Finland from 2007 (Häkkinen et al., unpublished results). A 2011 Swiss policy also targeted LOS in psychiatric hospitals where, after an initial lump sum payment, hospitals were reimbursed at a progressively lower daily rate (Warnke et al., 2014). In their evaluation, Warnke and colleagues found that this policy had no notable effect on LOS but was associated with a slight reduction in 30-day readmissions.

Other measures have included that of England where, starting in 2012, the government stopped reimbursing hospitals for avoidable emergency readmissions occurring within 30-days post-discharge (Burgess and Hockenberry, 2014). Additionally, in Germany as of 2004, hospital admissions followed by readmissions for the same conditions within the same DRG were counted as single episodes and reimbursed once (Kristensen et al., 2015).

Although not consistent, research suggests that short LOS can lead to unfavorable outcomes. Studies have reported a negative association between LOS and both readmissions (Carey, 2015; Martin et al., 2016) and mortality (Southern and Arnsten, 2015; Schneider et al., 2012). In a quasi-experimental study from the US, patients treated by physicians with a tendency of discharging patients after short LOS faced a higher risk of 30-day mortality compared to patients treated by physicians with the opposite inclination (Southern and Arnsten, 2015). Evidence from England also suggests that premature discharge may have contributed to the situation whereby a 1-day average reduction in LOS between 2001 and 2005 was accompanied by a 0.7 million increase in admissions over the same period, (Bryan, 2010).

Evidence from Norway found that elderly patients discharged from hospitals with short average LOS faced a higher risk of unplanned 30-day readmissions compared to patients discharged with longer average LOS (Heggestad, 2002). Bjorvatn (2010) also found that elderly patients reported declines in average LOS and increases in rates of unplanned readmissions between 1999 and 2006; and longer LOS was associated with a lower risk of unplanned 30 or 90 day readmissions. Finally, results from a multi-country double-blinded placebo-controlled trial indicated that longer LOS was associated with a lower risk of 30-day readmissions among heart failure patients (Eapen et al., 2013).

The twin challenge of containing costs whilst safeguarding patient outcomes is a central concern that motivated the design and implementation of the healthcare reform in Norway. The reform can be seen as part of a broader reform movement towards improving coordination and shifting tasks and responsibilities from specialist to primary health care. A motivation for the international reform movement is a worry that health care systems are not sustainable as currently organized. Reforms are expected to result both in improved care for patients and overall reduced cost compared to realistic alternatives. Beales and Smith (2012) reviewed the evidence on whether or not high quality primary care reduces use of specialist care with associated cost savings and improved quality of life for patients. Three broad forms of primary care interventions were evaluated: reducing or delaying the onset of disease, reducing use of specialist care after identifying a clinical condition, and reducing the intensity of specialist care when the need for such care has arisen. The authors concluded that there is little persuasive evidence on the macro benefits of primary care spending and, with a few exceptions, the micro evidence is small scale and inconclusive. Evaluations of larger scale schemes with carefully chosen controls are therefore much needed.

The Norwegian Context

The Norwegian coordination reform was implemented in a publically funded healthcare system where multipurpose municipalities are responsible for primary care (e.g., GP services), institutional and home nursing care, and rehabilitation services among other duties like primary education (Ringard et al., 2013). Of particular interest in the reform was the introduction of a financial penalty, paid by municipalities to hospitals, and aimed at reducing inpatient overstays. In the context of the reform, inpatient overstayers are patients who are classified in the hospital registers as “ready for discharge and in need of follow-up care in the municipality”. Municipalities that did not receive these patients in time originally paid hospitals a fee of 4,000 Norwegian crowns per day, a figure that was increased to 4,505 crowns (approximately $557) per day in 2016. In addition to the penalty for overstayers described above, the reform included a) municipal co-financing of patients treated in the state owned specialist health care services and b) the implementation of a system of local acute services aimed at reducing hospitals admissions. Municipal co-financing of patient treatment was restricted to internal medicine services (e.g., inpatients, day stays and outpatients). This element of the reform was terminated after two years because the effects were negligible (Askildsen et al., 2016).

Specialist care including hospitals is owned and funded by the central state. Since the central state also affects municipal revenues through a comprehensive grant system, transfer of resources is possible. Given the expected increase in the demand for municipal health services, the reform also transferred funds from hospitals to municipalities to aid the latter in strengthening their healthcare services. As a consequence, municipalities faced a price shift where using hospital services and not their own, for patients ready for discharge became more expensive. The price shift had the expected effect on hospital LOS, which was reduced by three to five days for patients hospitalized for hip fracture, stroke, heart failure, and COPD/asthma (Melberg and Hagen, 2016).

The reform represents a comprehensive policy package involving several measures to ensure successful implementation and commitment of the involved parties (NMHCS, 2009). Two new laws that complement the reform have also been adopted: The Norwegian Public Health Act or Folkehelseloven in 2012 and the Act of Municipal Health and Care Services or Helse- og omsorgstjenesteloven in 2011. These laws are aimed at reinforcing the municipalities' responsibility for public health. The reform can be characterized as a natural experiment conducive of a full scale assessment of the effects of its fees for inpatient overstays. In the face of an increasing aging population and rising healthcare costs, designing funding schemes and incentive structures that promote efficiency in service delivery and good patient outcomes is important, also for Norway.

The Current Study

The current study builds on the work of Melberg and Hagen (2016). Using Norwegian register data for patients that has been aggregated at the municipality level, we specifically examine the extent to which the effects of the reform on the rate of death and readmissions vary by the classification of patients as ready for discharge and in need of follow-up care in the municipality. Our findings will add to the evidence base on the impact of financial incentives on patient outcomes in tax based systems such as Norway's social democratic welfare state; and specifically on the impact of financial measures used to reduce inpatient overstays.

METHODS

Data and Sample

Nationwide data for Norwegian municipalities are derived from individual-level data from the Norwegian Patient Registry and the Norwegian Cause of Death Registry. We begin by first describing the individual-level data. The sample consists of patients age 18 and older who were hospitalized between January 1^{st} and October 31^{st} 2009-2014 for COPD/asthma (ICD 10: J44, J45 and J46), heart failure (ICD 10: I50), hip fracture (ICD 10: S72), and stroke (ICD 10: I63). As defined in this study, an *index admission* is a hospital admission for any of the four conditions and is part of an *index hospital episode*—defined as the first inpatient treatment during the calendar year for the given condition. Hospital episodes include between-hospital transfers where no more than one day has elapsed from the point of discharge until admission into the next hospital. To be included in the study, a patient had to have not been diagnosed with any of the conditions at any point during the 365 days preceding the index admission for the same condition. The individual-level analytic samples (hospital episodes) are as follows: COPD/asthma (28,455), heart failure (29,041), hip fracture (46,476) and stroke (44,756). These samples exclude between 180 (.4%) and 2,034 (6.6%) hospital episodes across the groups for which there is missing data on study measures.

The municipality outcomes under investigation are yearly rates of death and readmissions. They are described further below. To reduce heterogeneity and thus get a clearer understanding of the impact of the reform on our outcomes, we stratify our municipal analyses by subgroups that correspond to the patient groups from which the municipal data are derived: group 1 (COPD/asthma), group 2 (heart failure), group 3 (hip fracture), and group 4 (stroke). These diseases were chosen because they are associated with a high likelihood of readmissions (Desai and Stevenson, 2012; Yin et al., 2016). We lack data for January and February 2015 and therefore cannot determine if patients admitted in November or December 2014 experienced the outcomes in question. Consequently, we excluded patients hospitalized during these months across our study years to avoid bias.

Hospitals and municipalities likely anticipated the reform such that their behavior may have been influenced by it. We have erred on the side of this possibility and expect that some of the impact of the reform manifested early—in 2011 prior to the implementation of the reform in 2012. To reduce the attendant bias that this scenario could introduce in our results, we have excluded 2011 data from the analyses, leaving us with municipality data for a maximum of five study years: 2009, 2010, 2012-2014. The municipalities are represented as follows across the analysis subgroups: group 1 (N=382 municipalities), group 2 (N=409), group 3 (N=428) and group 4 (N=427). Across these groups, 85.6% of municipalities have observations for all five years, 8.9% have observations for four years, and 5.5% have observations for three years or less.

Measures

In this section, we first describe the individual-level variables from which our municipal measures are derived, after which we present the latter. The dependent variables are *death* (1=yes, 0=no) or the first acute *readmission* (1=yes, 0=no) for any illness, both occurring within 60-days of the index admission. The independent variable is the Coordination *reform* (1=post-reform years 2012-2014, 0=pre-reform years 2009 and 2010) which encompasses fees for inpatient overstays. The post-reform years represent the period during which the fee for inpatient overstays was in effect. The moderator, *FollowupCare1*

(1=yes, 0=no), captures whether or not a patient was classified as ready for discharge and in need of municipal health services (e.g., home nursing, rehabilitation). We are particularly interested in investigating whether the effect of the reform on death and readmissions varies by whether or not patients were classified as in need of post-discharge follow-up care. Our exploratory analyses showed that the proportion of observations with the label "*FollowupCare1=yes*" was significantly larger ($p \leq .000$) in the post-reform period (0.29) compared to the pre-reform period (0.16)—a difference that remained statistically significant net of yearly trends in this classification. This finding was not surprising considering that the reform incentivized hospitals to more diligently classify patients as in need of follow-up.

Due to the foregoing inconsistency, results based on observed values for *FollowupCare1* may be biased. To mitigate this problem, we sought consistency across our study years (2009-2014) in the predicted probability of being classified as in need of follow-up. Specifically, for each of the patient groups: Step 1) we used year 2014 data to estimate the probability of having the "*FollowupCare1=yes*" label net of gender, age, distance to local hospital, comorbidities and length of hospital stay within 365 days preceding the index admission, and month to control for any trends in the follow-up classification. Hospitals in Norway are organized under hospital trusts that serve different districts (catchment areas). We also included in the models fixed-effects for Norway's 19 districts to control for unmeasured variation across the districts in factors such as the supply of health services. We further describe some of these variables below. Step 2) Based on estimates from step 1, we generated predicted values for the follow-up classification for all observations across our study years. The variable that captures these predicted values is *FollowupCare2*. We chose year 2014 data as the basis for calculating predicted values because we expected hospitals and municipalities to have acclimated to some extent to the conditions of the reform; and we did not have access to more recent data. Step 3) Then we created an indicator variable, *FollowupCare3* (1=yes, 0=no), where we classified patients as in need of follow-up if they had a minimum predicted value (from step 2) of 0.340 (COPD/asthma), 0.431 (heart failure), 0.573 (hip fracture) and 0.442 (stroke). With year 2014 data as the reference, we chose these cut-off points because they allowed us to classify patients as in need of follow-up such that the percentage of observations characterized by this label in 2009-2013 was approximately the same as in 2014.

The reform encouraged more diligent classification of patients as ready for discharge and in need of follow-up care in the municipalities. However, we cannot rule out the possibility that it did not motivate other unintended actions from healthcare providers (Jürges and Köberlein, 2015). For example, the reform may have incentivized hospitals to pre-maturely classify patients as ready for discharge and in need of follow-up care. This could then have led to readmissions if the pre-maturely discharged patients were exposed to limited or unsuitable care in the municipality. In light of these considerations, it is not sufficient to only use post-reform/2014 data to address the inconsistency between the pre- and post-reform periods in the "*FollowupCare1=yes*" classification. We have therefore also used 2009 data (pre-reform) to generate predicted probabilities of the follow-up classification across our study years. That is, we have repeated Steps 1 to 3 in the previous section using 2009 data, and specifically in Step 3, we classified patients as in need of follow-up if they had a minimum predicted value (from step 2) of 0.223 (COPD/asthma), 0.262 (heart failure), 0.394 (hip fracture) and 0.301 (stroke).

To summarize, we now have five follow-up variables at the individual-level from which we will derive municipal measures for examining our research question: *FollowupCare1* (1=yes, 0=no; observed in the data; inconsistent classification), *FollowupCare2_b9* and *FollowupCare2_b14* (predicted probabilities of *FollowupCare1* based on 2009 and 2014 data, respectively), *FollowupCare3_b9* and *FollowupCare3_b14*

(1=yes, 0=no; follow-up classification based on predicted values from *FollowupCare2_b9* and *FollowupCare2_b14* respectively).

At the individual-level, the sociodemographic and health controls included to reduce confounding of the focal relationship between the *reform* and each of death and readmissions are *age* in years at index admission (range: 18-107), *gender* (1=male, 0=female), *distance to the nearest hospital* in kilometers (range: 2-522.7), *length of hospital stay* within 365 days preceding the index admission(range: 0-252 days), and *comorbidities* diagnosed during inpatient and outpatient treatment occurring within 365 days preceding the index admission. Comorbidities are operationalized as a Charlson Comorbidity Index (Charlson et al., 1987) based on 17 conditions: acute myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular diseases, dementia, COPD, rheumatic diseases, peptic ulcer disease, mild liver disease, diabetes without complications, diabetes with chronic complications, hemiplegia or paraplegia, renal disease, malignancy (except neoplasm on skin), moderate/severe liver disease, metastatic solid tumor, and HIV/AIDS. With a range of 0-17, higher scores on the comorbidity index reflect poorer health.

In this study, we perform all our analyses on data at the municipal level. <u>Municipal variables</u> are derived from the individual-level data for each municipality by the four subgroups and the study years. The municipal variables include 1) the average: *age* in years, number of *comorbidities*, *length of hospital stay* in days during 365 days preceding the index admission, *distance* in kilometers to the nearest hospital, *FollowupCare2_b9* and *FollowupCare2_b14*; and 2) the rate (per 1,000 population) of: *death*, *readmissions*, *men*, *FollowupCare1*, *FollowupCare3_b9* and *FollowupCare3_b14*. For each municipality—by groups 1-4 and year, the rates are calculated as: the total number of cases (e.g., deaths, patients in need of follow-up care) *divided by* the total population aged 18 years and older (for each municipality per year), after which the result is *multiplied by* 1,000.

The *rate of death* and *readmissions* are the dependent variables, the *reform* (1=post-reform 2012-2014, 0=pre-reform 2009 and 2010) is the independent variable, and the *FollowupCare* measures are the moderators. All the other measures serve as control variables.

Analysis Plan

Our analyses are performed using Stata/SE 15.0 on municipal data derived from patients aged 18 years and older. We call these *analyses A*, and they are stratified by groups 1-4. Descriptive statistics are presented in Table 1. For the rate of death and the rate of readmissions, and for all groups, we first examined the sociodemographic and health correlates of the outcome measures (results are described but not shown, available upon request). Next, we assessed the main effects of the reform on variation in the rate of death and readmissions across municipalities (results are described but not shown, available upon request). Thereafter, we examined the extent to which the effect of the reform on our outcomes varied by the follow-up variables. We describe these moderated (interaction) effects, however, we only show the significant interactions in Table 2 for brevity. We also assessed the interaction effects on municipal data derived from the vulnerable subgroup of patients aged 80 years and older who scored three or higher on the comorbidity index, and who also had been hospitalized previously for five days or more. We will call these *analyses B.* Here too, we describe the findings but do not show the tables for brevity.

All estimates in our regression models adjust for the sociodemographic and health characteristics of the municipalities. We used Stata's xtreg command to fit linear regression models to our panel data where the units/panels (*i*) are municipalities and time (*t*) are our study years. Our data are likely characterized by serial correlation given that our panels are observed repeatedly across time. Serial correlation can affect the efficiency of the ordinary least squares (OLS) estimates of the standard errors (SEs) in our models (Williams, 2015). For example, in the case of positive serial correlation, the estimated SEs will be smaller than the true SEs, leading to type I error where we reject a true null hypothesis. We address serial correlation by fitting our models with robust standard errors (StataCorp, 2017).

We performed an xtoverid test (Schaffer and Stillman, 2010) for each of our models to determine if a random-effects model was more appropriate than a fixed-effects model. The xtoverid test is similar to the Hausman test but unlike the latter, it is appropriate for models fitted with robust standard errors. We employed Stata's margins, marginsplot and contrast commands to explore and visualize significant interactions. Shown below are two examples of linear regression models that test our research question.

Fixed-effects model [eq. 1]:

$$\text{Death rate}_{i,t} = b_1(\text{avg\_age}_{i,t}) + b_2(\text{rate\_men}_{i,t}) + b_3(\text{avg\_comorbidities}_{i,t}) + b_4(\text{avg\_length of hospital stay}_{i,t}) + b_5(\text{FollowupCare}_{i,t}) + b_6(\text{reform}_t) + b_7(\text{FollowupCare}_{i,t} * \text{reform}_t) + c_i + u_{i,t}$$

Random-effects model [eq. 2]:

$$\text{Death rate}_{i,t} = \alpha + b_1(\text{avg\_age}_{i,t}) + b_2(\text{rate\_men}_{i,t}) + b_3(\text{avg\_comorbidities}_{i,t}) + b_4(\text{avg\_length of hospital stay}_{i,t}) + b_5(\text{avg\_distance to hospital}_i) + b_6(\text{FollowupCare}_{i,t}) + b_7(\text{reform}_t) + b_8(\text{FollowupCare}_{i,t} * \text{reform}_t) + c_i + u_{i,t}$$

In both equations, the subscript *i* represents municipalities and *t* represents the study years. The coefficient b_7 in eq.1 and b_8 in eq.2 answers our research question as to whether the effect of the reform on the rate of death varies by the follow-up measures. $u_{i,t}$ is the error term. In the fixed-effects model, c_i is the unobserved time-invariant/fixed effect for municipality *i*. The average distance to the nearest hospital is constant within municipality and is thus excluded from eq. 1. In the random effects model, α is the intercept that captures the average rate of death across the municipalities. c_i is the municipality-specific random effect that measures the difference between the average rate of death in municipality i and the average rate of death across all municipalities.

RESULTS

Sample characteristics

Table 1 shows the average values, by subgroups 1-4, for the study measures in analyses A. Group 1 has the lowest values for age, comorbidities, and all the follow-up measures except for *FollowupCare3_2009*. On the other hand, group 3 has the highest values for age and for all the follow-up measures. Similarly, the values for comorbidities and length of hospital stay are largest in group 2. The average rate of death is lowest in group 1 and highest in group 4; and the rate of readmissions is highest in group 2 and lowest in group 4. The pattern across the groups does not indicate that the average rate of death or readmissions is consistently higher in either the pre-reform or the post-reform period. Also for the other measures, there are no large differences, overall, between the pre- and post-reform values across the groups; and the differences that are present are not consistently observed in a given period across the groups. Even so, length of stay is consistently larger in the pre-reform versus the post-reform period for all groups; and a similar pattern is present for comorbidities in all but group 1.

As evident in Table 1 across the groups, the average values for *FollowupCare1* is smaller before compared to after the reform. As discussed in the methods section, we addressed this inconsistency by generating the variables *FollowupCare2_2009* and *FollowupCare2_2014*. As seen in Table 1, we now have consistent classifications before and after the reform in the follow-up measures.

<TABLE 1 HERE>

The rate of death and readmissions across the groups are shown in Figures 1 and 2. Consistent with expectations, the rates are lower among patients age 18+ (analyses A) compared to patients age 80+ (analyses B); and the changes in the rates over time are less dramatic in the former group. In both groups, the overall death and readmissions rates increase from 2011 to 2012, and then decline from 2013 to 2014 especially for the elderly group—but not among elderly heart failure patients.

<FIGURES 1 AND 2 HERE>

Associations between municipal characteristics and the rate of death and readmissions

The associations between the municipal sociodemographic and health characteristics and the rate of death was estimated using random effects models for group 1 (intraclass correlation coefficient=.28), group 2 (ICC=.15), and group 3 (ICC=.45); and using fixed effects models for group 4 (ICC=.22). The ICCs indicate that between 15% and 45% of the variation in the rate of death could be explained by differences across the municipalities.

The relationship between the municipal sociodemographic and health characteristics and the rate of readmissions was estimated using random effects for group 1 (ICC=.29) and group 4 (ICC=.03), and via fixed effects for group 2 (ICC=.34) and group 3 (ICC=.24). The ICCs show that between 3% and 34% of the variation in the rate of death could be explained by differences across the municipalities.

For all the groups, the rate of men was positive and significantly associated with the rate of death and readmissions. The average age was similarly associated with death across the groups, and also with readmissions for group 1. Except for a positive and significant effect of average comorbidities on death in group 3, this measure was not significantly linked to death or readmissions across the groups. The average length of hospital stay had a positive and significant effect on death but only in groups 1and 2; and a similar effect on readmissions only in group 3. The effect of average distance to the nearest hospital was only estimated in the random effects models because this variable is constant within municipalities. Across those models, average distance was positive and significantly associated with the rate of death but only in group 2; and it was not significantly linked to the rate of readmissions.

Moderated effects of the coordination reform on the rate of death and readmissions

We estimated random and fixed effects models to test our research question as to whether the effect of the reform on the rate of death varies by each of the follow-up measures (*FollowupCare1*, *FollowupCare2_b9*, *FollowupCare2_b14 FollowupCare3_b9,* and *FollowupCare3_b14*). We fitted the models for municipal analyses A and B, and found one significant interaction in analyses B. It involved the *reform* and *FollowupCare1* (b=-0.427, SE=0.156, p<0.01, random effects, ICC=.68) for the rate of readmissions in group 4 (stroke). We believe that this finding is biased given the inconsistency in the follow-up classification across the study years (see the methods section). Therefore, we will not pursue this result further. In analyses A, we found two significant interactions involving the *reform* and each of *FollowupCare2_2014* and *FollowupCare3_2014* for readmissions in group 4/stroke (Table 2 Models 3 and 5).

<TABLE 2>

The interaction shown in Table 2 Model 3 is depicted in Figure 3 Part A. As shown in the figure, during the pre-reform period, the rate of readmissions was .274, .259, and .245 at low, average, and high values of *FollowupCare2_2014* respectively—where the average value of *FollowupCare2_2014* is 0 because this variable was centered at its mean to avoid multicollinearity in the interaction model. Low and high levels of *FollowupCare2_2014* were respectively defined as one standard deviation (SD) below and above the mean. Specifically, in the pre-reform period, there was no significant difference in the rate of readmissions at low compared to average, low compared to high, or at average compared to high values of *FollowupCare2_2014.* In the post-reform period, the rate of readmissions was .232, .259, and .284 at low, average, and high values of *FollowupCare2_2014.* There were significant differences (p<.05) in the rate of readmissions at low compared to average, low compared to high, and at average compared to high values of *FollowupCare2_2014*. However, the Bonferroni adjusted p-values did not find statistically significant (p=.062) differences in any of the comparisons. Figure 3 Part A shows that, compared to the pre-reform period, the post-reform period is associated with a higher rate of readmissions at high values of *FollowupCare2_2014,* and with lower rates of readmissions at low values of *FollowupCare2_2014* in group 3.

<FIGURE 3 HERE>

The interaction in Table 2 Model 5 is depicted in Figure 3 Part B. As shown in the figure, during the pre-reform period, the rate of readmissions was .261, .260, and .259 at low, average, and high values of *FollowupCare3_2014* respectively—where the average value of *FollowupCare3_2014* is around 0 because this variable was centered at its mean. Low and high levels of *FollowupCare3_2014* were respectively defined as one SD below and above the mean. In the pre-reform period, there was no significant difference in the rate of readmissions at low compared to average, low compared to high, or at average compared to high values of *FollowupCare3_2014.* In the post-reform period, the rate of readmissions was .214, .259, and .304 at low, average, and high values of *FollowupCare3_2014.* There was a significant difference (p<.001; including with Bonferroni correction for multiple comparisons) in the rate of readmissions at low versus average, low versus high, and at average versus high values of *FollowupCare3_2014*. The figure shows that, compared to the pre-reform period, the post-reform period is associated with a higher rate of readmissions at high values of *FollowupCare3_2014,* and with lower rates of readmissions at low values of *FollowupCare3_2014*.

Main effects of the reform on the rate of death and readmissions

In the absence of significant moderated effects of the reform on deaths and readmissions, we report findings on the main effects of the reform on deaths and readmissions across the groups. Aside from the previously described interaction effects, the reform was not significantly associated with the rate of death or readmissions across the groups in both analyses A and B.

DISCUSSION

This study examined the effects of the Norwegian healthcare coordination reform (encompassing the fee for inpatient overstays) on the rate of death and readmissions using municipal data derived from four patient groups (1=COPD/asthma, 2=heart failure, 3=hip fracture, and 4=stroke). Overall, our findings showed that the effect of the reform on the rate of death and readmissions did not vary significantly by patients' need for post-discharge follow-up care as operationalized through five municipal measures. A possible explanation is that municipalities in Norway used the extra resources allocated to them (as part of the reform) to build up their local healthcare services, which in turn may have safeguarded patient outcomes. Consistent with this possibility, work by Olsen and Hagen (2015) showed that municipal services such as GP services, home healthcare services, and use of short term nursing home stays were expanded in the same year (2012) that the reform was implemented. Our models indicated that sizeable proportions of the variation in the rate of death and readmissions could be explained by differences across the municipalities. One study of Norwegian patients hospitalized for acute myocardial infarction (AMI) in 2009 (prior to the reform) found, however, that municipal variation in all-cause mortality among these patients was fully accounted for by the patients' characteristics and not by the features of the municipal health services (Ambugo and Hagen, 2015). Even so, the municipal context of care may differ in important ways for patients with AMI compared to some of the groups considered in this study (e.g., patients with hip fracture who often require prolonged rehabilitation post-discharge).

Our findings here and those of Melberg and Hagen (2016) suggest that hospitals are discharging patients promptly, but perhaps not prematurely—which would imply that the reform is functioning as intended. These findings run counter to much of the existing research described in the background section, and which show that short LOS is associated with poor outcomes like readmissions and mortality (Bjorvatn, 2010; Heggestad, 2002; Southern and Arnsten, 2015). The expansion and strengthening of municipal health services (Olsen and Hagen, 2015) might explain this discrepancy. Patients who are discharged from hospital on time may also benefit considering that longer LOS can increase one's risk of acquiring infections in hospital (Leffler and Lamont, 2015). It is also very likely that family members stepped in with their support and supplemented municipal healthcare services, thereby promoting the health and well-being of their loved ones after discharge.

Our main significant finding suggests that patients with stroke who are in need of follow-up are more vulnerable to the reform. The post-reform period was associated with a higher rate of readmissions for this group compared to the pre-reform period. The healthcare reform targeted in-patient overstays. For patients with stroke, like other vulnerable groups, the early period immediately following discharge from hospital carries particularly high risk of poor clinical outcomes (Desai and Stevenson, 2012). Attention has been given to transitions of care as well as early post-discharge clinic visits and monitoring (Desai and Stevenson, 2012). The question pertinent to our finding here is whether Norwegian municipalities, including GPs, are adequately prepared for the challenges and extra care burden posed by the transition from inpatient care to municipal follow-up care for heart failure patients?

Our findings are partly in line with other findings in the literature. A British study by Smith et. al. (2016) evaluated the associations between LOS and hospital quality, as measured by 28-day emergency readmissions. They found reductions in LOS over time whereas changes in crude readmission rates varied by diagnoses. Conditional upon survival, the probability of readmission was greater for stroke patients who originally had a shorter LOS, and for hernia patients who had an overnight stay. However, there was no relationship between LOS and readmission for patients with hip replacement. Their findings added to the research evidence which, although inconclusive, generally suggests that reductions in LOS are not associated with an increased probability of emergency readmission.

In the US, there has been a lot of interest in the Hospital Readmissions Reduction Program (HRRP), which was established under the Affordable Care Act (ACA) in 2010. HRRP imposed financial penalties on hospitals with higher-than-expected 30-day readmission rates for patients with heart failure, AMI, and pneumonia beginning in 2012. After HRRP went into effect, readmission rates among Medicare beneficiaries declined for target conditions nationwide (Wasfy et al., 2017; Zuckerman et al., 2016). A recent study did however indicate that the introduction of HRRP was significantly associated with an increase in 30-day post-discharge mortality for patients with heart failure and pneumonia, but not AMI. Other studies also indicate that the associations between LOS and readmission rates/mortality are contingent upon diagnoses. Given this mixed landscape, financial incentives that target in-patient overstays across the board, such as that of Norway, may not be especially helpful—even though in the Norwegian context, the reform also allocated resources to municipalities which may have buffered against unfavorable outcomes. Future research could concentrate on identifying specific diagnoses that could benefit from targeted incentive schemes, both in terms of reduced LOS and good patient outcomes. Future research should concentrate on which diagnoses that are the most vulnerable.

Study strengths include analysis of nation-wide registry data yielding results that are relevant to the Norwegian population of adults hospitalized for COPD/asthma, heart failure, hip fracture and stroke. We replicated our analyses for the full sample (age 18+) on the advanced elderly (age 80+), thereby contributing to an understanding of the impact of the reform on this group who, faced with a heightened risk of death and readmissions given their stage in the life course, may be especially vulnerable to the reform. This study also has some limitations. The reform comprised other measures besides the fee for inpatient overstays. Our results capture overall associations between the reform and each of death and readmissions. With appropriate data, future studies could help isolate the effects of specific elements of the reform on these outcomes. Our findings may be confounded by patient characteristics like living alone or lack of companionship and adequate support, which we do not control for in our models. Additionally, due to a small sample size, our estimates of the moderated effects of the reform on death and readmissions among elderly COPD/asthma patients should be viewed with caution.

Conclusion: Overall, we found little evidence to suggest that the Norwegian healthcare coordination reform is operating in a way that heightens the rate of death or readmissions across the groups considered in this study. Even so, patients with stroke appear vulnerable. It may be appropriate to differentiate the (reform's) fee for inpatient overstays across diagnoses. Future research should also address the cost effects of the reform. Analyses by Häkkinen and colleagues (unpublished) covering hip fracture patients indicated that the observed shorter hospital stays among these patients were more than compensated for by longer stays in municipal long-term-care institutions. Furthermore, the costs associated with the expansion of municipal services (including health services) was approximately comparable to the reduced costs in hospitals due to shorter LOS. Although we found little evidence of adverse outcomes linked to the reform, a more comprehensive study of adverse events—including mental illness and psychosocial health and well-being—is needed.

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ACCEPTED MANUSCRIPT

Table 1. Sample characteristics: Municipality-level data for patients age 18+ hospitalized in 2009, 2010, and 2012-2014 in Norway.

	Group 1 (COPD/Asthma)		**Group 2**		**Group 3 (Heart Failure)**		**Group 3 (Stroke)**	
	Pre-reform	Post-reform	Pre-reform	Post-reform	Pre-reform	Post-reform	Pre-reform	Post-reform
Characteristic	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Men (rate)	0.77 (0.66)	0.81 (0.66)	0.92 (0.69)	0.93 (0.68)	0.78 (0.66)	0.75 (0.63)	1.32 (0.89)	1.26 (0.79)
Age (avg.)	68.68 (7.87)	69.71 (6.98)	78.75 (6.04)	78.81 (6.26)	80.25 (5.99)	80.35 (5.91)	75.08 (5.82)	74.65 (6.01)
Comorbidity index (avg.)	0.23 (0.47)	0.22 (0.48)	1.49 (1.01)	1.53 (1.05)	0.68 (0.63)	0.70 (0.63)	0.66 (0.57)	0.71 (0.67)
Length of stay (avg.)	6.08 (6.18)	6.04 (6.72)	9.13 (8.37)	8.17 (7.22)	4.64 (5.01)	4.06 (4.87)	4.00 (3.91)	3.87 (4.29)
Distance to hospital (km, avg.)	65.58 (65.49)	66.57 (66.96)	64.87 (62.96)	65.00 (63.76)	67.75 (67.83)	67.28 (66.76)	67.91 (67.54)	67.11 (66.58)
FollowupCare1 (rate)	0.06 (0.16)	0.21 (0.33)	0.09 (0.19)	0.28 (0.40)	0.50 (0.59)	0.83 (0.81)	0.31 (0.43)	0.48 (0.52)
FollowupCare2_2009 (avg.)	0.05 (0.06)	0.05 (0.06)	0.06 (0.06)	0.06 (0.06)	0.22 (0.13)	0.22 (0.13)	0.15 (0.09)	0.15 (0.08)
FollowupCare2_2014 (avg.)	0.18 (0.11)	0.18 (0.11)	0.26 (0.16)	0.25 (0.16)	0.49 (0.22)	0.49 (0.22)	0.31 (0.15)	0.30 (0.15)
FollowupCare3_2009 (rate)	0.06 (0.21)	0.06 (0.22)	0.04 (0.17)	0.04 (0.19)	0.33 (0.64)	0.33 (0.65)	0.23 (0.42)	0.19 (0.35)
FollowupCare3_2014 (rate)	0.26 (0.43)	0.27 (0.38)	0.37 (0.52)	0.35 (0.47)	0.99 (1.13)	0.98 (1.10)	0.60 (0.72)	0.55 (0.66)
Death (rate)	0.09 (0.22)	0.10 (0.21)	0.23 (0.33)	0.25 (0.36)	0.27 (0.35)	0.27 (0.40)	0.36 (0.43)	0.35 (0.39)
Readmissions (rate)	0.31 (0.38)	0.34 (0.38)	0.40 (0.45)	0.40 (0.44)	0.35 (0.41)	0.36 (0.44)	0.27 (0.35)	0.26 (0.33)
N	1071	1088	1142	1141	1242	1249	1249	1240

Table 2. Moderated effects—on rate of readmissions—of the Norwegian healthcare coordination reform encompassing fees for inpatient overstays: Municipality-level data for patients (age 18+) hospitalized in 2009, 2010, and 2012-2014 for STROKE (N=2,075).

	Model 1		Model 2		Model 3		Model 4		Model 5	
Independent variables	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Reform (/pre-reform)	-0.012	(0.016)	0.003	(0.016)	0.004	(0.016)	0.005	(0.016)	0.005	(0.016)
FollowupCare1	0.076	(0.040)								
FollowupCare2_2009			-0.124	(0.127)						
FollowupCare2_2014					-0.095	(0.091)				
FollowupCare3_2009							0.043	(0.030)		
FollowupCare3_2014									-0.001	(0.018)
Reform X FollowupCare1	0.033	(0.050)								
Reform X FollowupCare2_2009			0.097	(0.174)						
Reform X FollowupCare2_2014					0.272*	(0.109)				
Reform X FollowupCare3_2009							0.046	(0.047)		
Reform X FollowupCare3_2014									0.067**	(0.022)
Constant	0.207	(0.124)	0.111	(0.124)	0.154	(0.132)	0.157	(0.125)	0.187	(0.131)
Intraclass correlation coefficient	0.030		0.029		0.030		0.030		0.025	
Model	re		re		re		re		re	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1.

Rate of death per 1000 population age 18+; and rate of death per 1000 population age 80+.

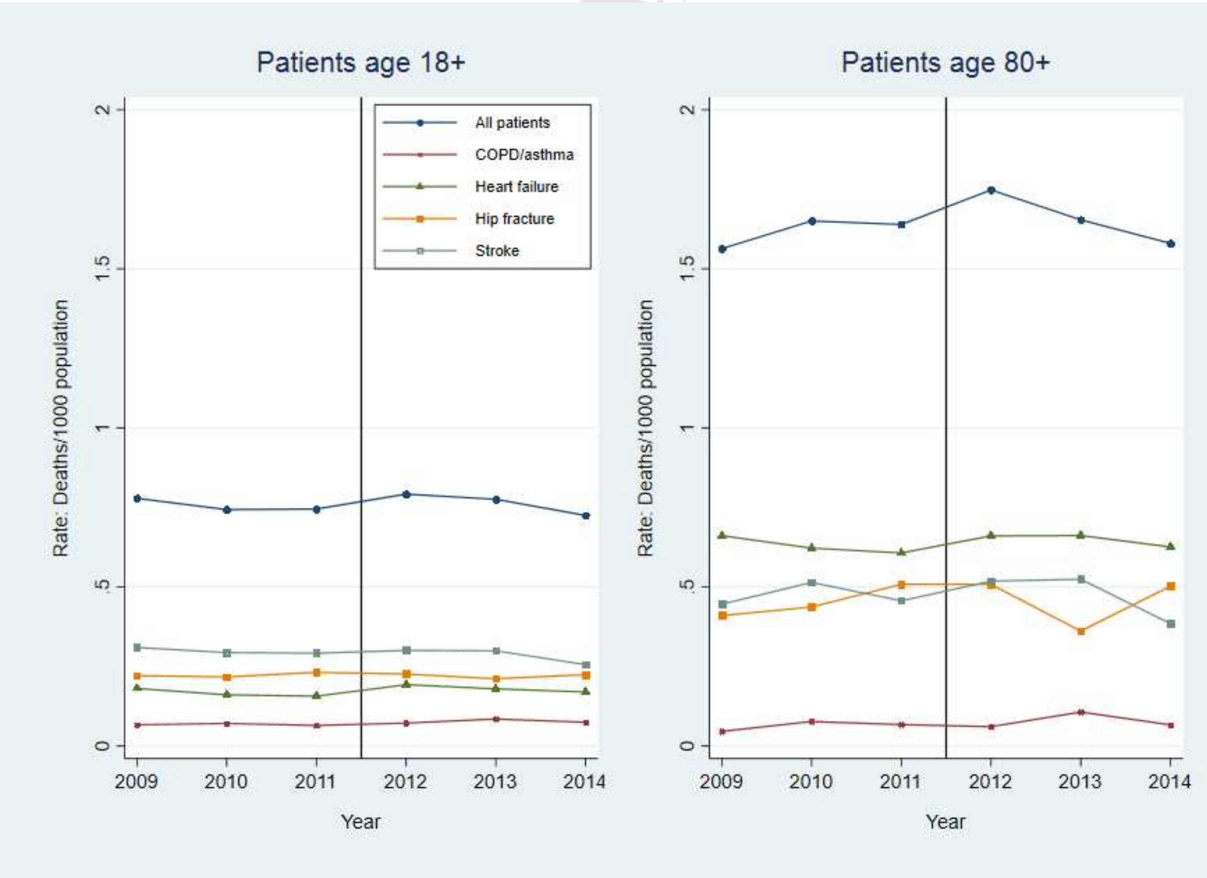
Figure 2.

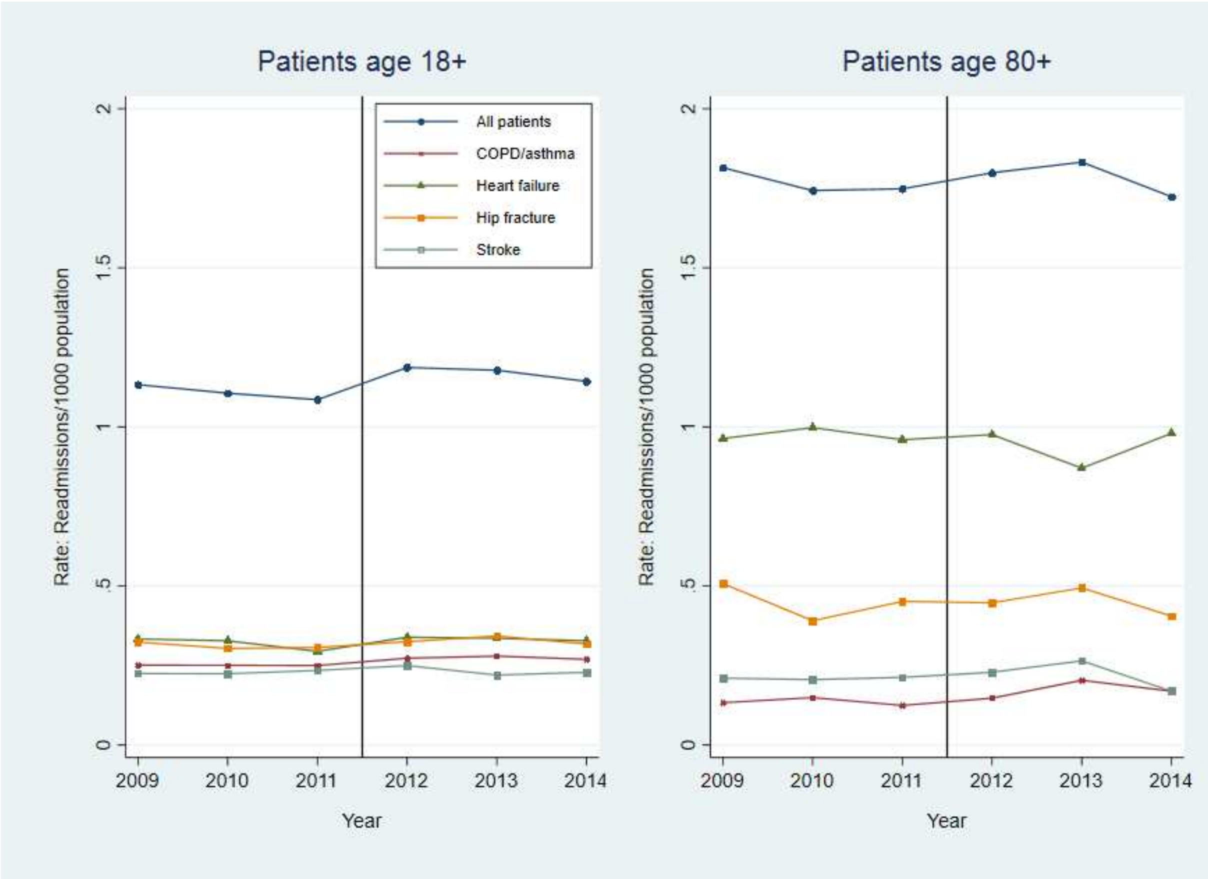
Rate of readmissions per 1000 population age 18+; and rate of readmissions per 1000 population age 80+.

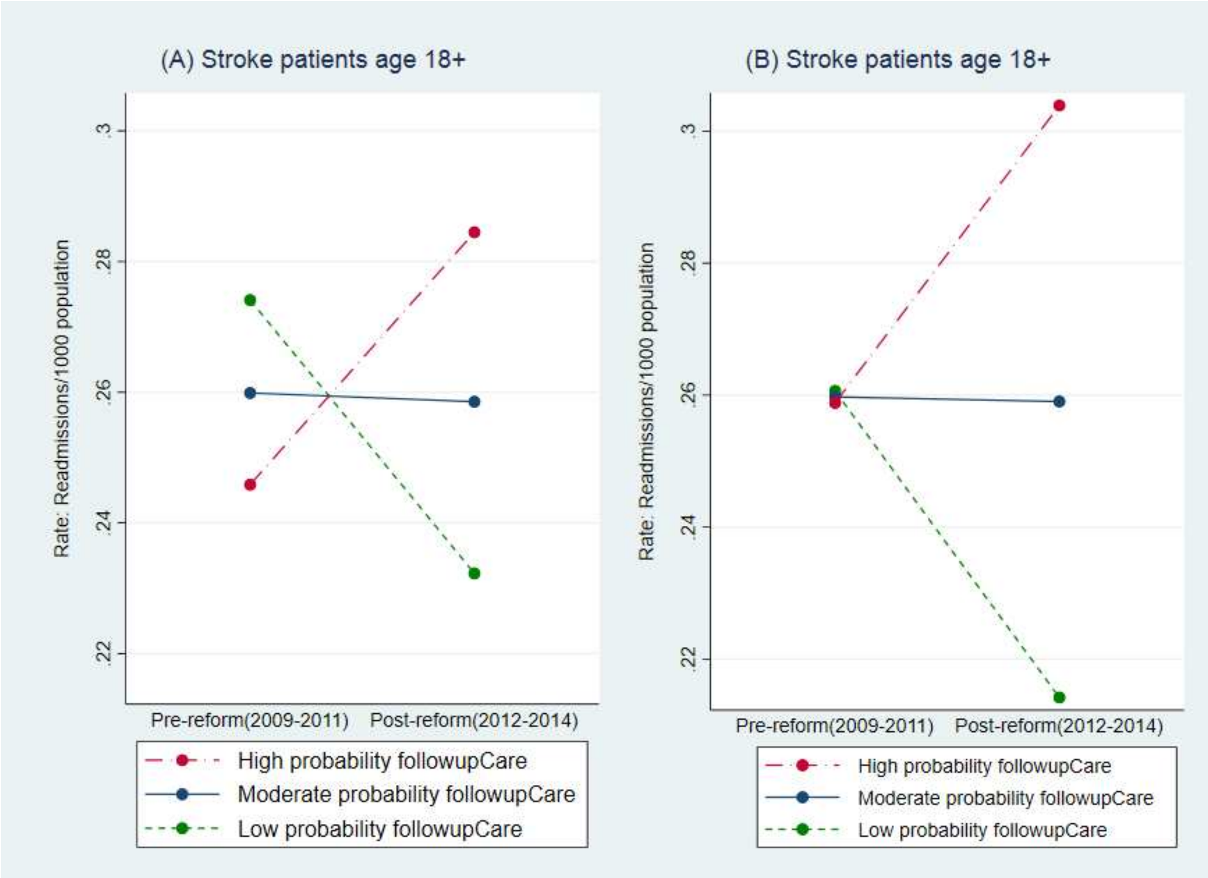
Figure 3.

(A) Rate of readmissions as a function of the Norwegian healthcare reform encompassing fees for inpatient overstays and the average predicted probability of being classified as in need of follow-up care.

(B) Rate of readmissions as a function of the Norwegian healthcare reform encompassing fees for inpatient overstays and the rate of being classified as in need of follow-up care based on predicted probabilities.




Patients age 18+
Patients age 80+
All patients
COPD/asthma
Heart failure
Hip fracture
Stroke
Rate: Readmissions/1000 population
0
.5
1
1.5
2
2009
2010
2011
2012
2013
2014
Year


(A) Stroke patients age 18+
Rate: Readmissions/1000 population
.22
.24
.26
.28
.3
Pre-reform(2009-2011)
Post-reform(2012-2014)
High probability followupCare
Moderate probability followupCare
Low probability followupCare
(B) Stroke patients age 18+
Rate: Readmissions/1000 population
.22
.24
.26
.28
.3
Pre-reform(2009-2011)
Post-reform(2012-2014)
High probability followupCare
Moderate probability followupCare
Low probability followupCare

Research Highlights

- Reform aimed at fewer inpatient overstays and more post-discharge community care.
- The reform is not significantly associated with increased risk of adverse outcomes.
- Patients with stroke appear vulnerable to the reform.