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Family Matters? The Importance of Relatives for Frail Elders' Mortality and Hospital Readmission

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Abstract We investigate the relationship between availability of relatives and mortality and hospital readmission within 30 days for patients aged 70 and above. The analysis contributes to the existing literature by applying a rich, high-quality data set and by its focus on frail elderly. Using Norwegian register data of 97,920 patients who have had an emergency hospital admission in the period 2009–2013, we employ a linear probability model where we account for a wide range of patient, municipality, and time characteristics. Our results show that having a spouse and at least one child is associated negatively with mortality and positively with readmission. A potential mechanism is that a spouse/child monitors the elder's health status and acts as an advocate for the elderly, making a readmission more likely, while also reducing the mortality risk. Furthermore, we find that the availability of children is more important for female patients than for male patients, while for male patients the availability of the spouse appears to be more important, at least for readmission.

Keywords Norway · Mortality · Hospital readmission · Elderly · Informal care

Introduction

In cases where the elder's own resources are insufficient, because of poor health and often weakened cognitive ability, the availability of relatives are potentially important for improving the elder's health outcome and use of health care services. As is known

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from the literature, the spouse is an important care provider for elderly couples (for example, Lakdawalla and Philipson 2002, find that spouses are willing and able to take care of each other, except in the most severely disabled cases), and adult children play an important role in informal care as well (Bonsang 2009; Charles and Sevak 2005). Indeed, for frail elderly who are married, the primary caregiver is usually the spouse (OECD 2005; Kalwij et al. 2014). In an international, even European perspective, Nordic countries are characterized by a large formal health care sector. Scandinavian countries have been referred to as 'weak-family-ties countries' compared to Southern European countries (see references in Bolin et al. 2008a). Still, analyses indicate that adult children are indeed engaged in caring for their parents. The costs of such care in terms of foregone labor-market opportunities vary between European countries (Bolin et al. 2008b). Analyses based on Norwegian administrative registry data show that care for elderly parents affect the labor supply of adult children in general (Løken et al. 2014) and particularly when the parents are in the terminal phase (Fevang et al. 2012). Jacobs et al. (2017) find that women who provided intensive care have 1 to 3 percentage points higher odds of retirement. A review article by Bauer and Sousa-Poza (2015) concludes, on the other hand, that even though most studies report negative associations between caregiving and employment, the estimated labour force effects are rather small. Caregiving was also found to have a negative impact on caregiver's psychological health (Bauer and Sousa-Poza 2015), self-reported health and sickness absence among full-time working adult children (Ugreninov 2013). Several analyses have concluded that excess mortality of non-married or never-married individuals has increased over time (Berntsen 2011; Kravdal and Syse 2011). One suggested mechanism behind this trend is the introduction of more complex treatments which makes having a spouse more important (Kravdal and Syse 2011).

Institutional factors are likely to impact on informal care-giving (see for instance Bolin et al. 2008a). The Norwegian health care and social care system is tax-financed and covers all inhabitants. Primary health care (GP services, public health nurses, nursing homes and home care) is provided under the responsibility of Norway's 428 municipalities, while specialist health care is provided under the responsibility of four regional, state-owned health enterprises. Services for the elderly include professional home help for domestic tasks, professional home nursing care, institutional day and night care, and daytime services as a relief for informal carers. Municipalities are free to organize the services as they find appropriate in order to fulfil their obligations according to medical and social rights determined by law. Eligibility for long term care and home care is assessed by municipalities' agencies (typically, qualified staff will assess the need for care), but there is no absolute criterion that makes people eligible. Co-payments are required for home help and nursing homes, while for home nursing and short-time stay in nursing homes no co-payments are required.

In this analysis, we study how the availability and characteristics of a spouse and off-spring (hereafter "family resources") are related to the individual patients' health (mortality) and use of health care services (hospital readmission). The analysis focuses on fragile patients – elderly who have been discharged from hospital with specific primary diagnoses (heart attack, heart failure, pneumonia, hip fracture), which are often used in the literature (see for instance Laudicella et al. 2013). Patient health (all-

cause mortality) and probability of readmission is investigated within a time frame of 30 days after hospital discharge. We account for a wide range of patient, municipality, and time characteristics, and do the analysis for both genders.

Lower mortality of adults with relatives is a well-established empirical finding (see the references in Manzoli et al. 2007; Rendall et al. 2011). However, it is not clear that an estimated negative association between mortality and the elder's family resources can be given a causal interpretation. The concern is to what extent this stylized fact is because of health-related selection in the marriage market and fertility, as opposed to a causal, protective effect of the relative. The selection can, for example, occur because healthier individuals might be more likely to be married and have children, or because married individuals are absent from the stress of bereavement or marital dissolution (see Manzoli et al. 2007). On the other hand, a protective effect of the relative could arise through the provision of quality informal care-giving services, provision of social/economic support, or help in improving health behavior. Spouse and adult children may in addition be a source of knowledge about the disease and treatment and may be good advocates for the elder, securing him/her more or better quality formal care than would be offered otherwise (Van Houtven and Norton 2004; Bonsang 2009).

Unlike in the case of mortality, it is less obvious how readmission should be viewed from the perspective of the patient's welfare. Readmissions can be an indication of poor hospital treatment (for example, too early discharge) or of poor post-hospitalization treatment (whether care is formal or informal). On the other hand, readmissions are often used as an indicator of hospital quality (Laudicella et al. 2013). They may be viewed as an indication that the health care system is responsive to changes in the medical needs of the patient, especially for fragile patients with an inherent high risk of complications. With the caveat that some readmissions are unavoidable, the Norwegian Directorate of Health defines low rates of readmission as an indicator of good cooperation for specific primary diagnoses, including heart failure, fractures, and pneumonia (www.helsedirektoratet.no).

The health economics literature on the impact of informal care on formal health-care use is limited. Our analysis is closest to the body of literature that studies how the availability of family resources is correlated with health care use (see Weaver and Weaver 2014), and where availability is proxied by living arrangements (typically marital status). In our analysis, availablility is proxied by distance and characteristics of children, as well (education, income, age, number of own children). Another body of literature emerged as survey data on time input from informal care was released. The literature focuses on informal care provided by adult children, and is in most cases restricted to single elderly. Regarding services that require relatively low levels of formal qualifications (labelled "formal home care", "paid domestic help", "home health care" by the authors cited), informal care are found to be substitutes for formal care (Bolin et al. 2008a; Bonsang 2009; Van Houtven and Norton 2004). Van Houtven and Norton (2004) found the same result for use of nursing home and doctor visits, while informal care was found to be complementary to outpatient clinic visits. Regarding the probability of hospitalization, results are more mixed: Bolin et al. (2008a, on SHARE data) found that informal care is a complement to hospital visits, while van Houtven and Norton (2004, on US data), and Weaver and Weaver (2014, on Swiss data) did not detect any statistically significant association between informal care and hospitalization. Weaver and Weaver defined the key explanatory variable as availability

of potential caregivers, proxied by the spouse or any other adult co-residing with the elderly. Regarding length of stay (conditional on hospitalization), van Houtven and Norton (2004) and Weaver and Weaver (2014) found informal care to be a substitute to hospital nights, whereas the relationship between informal care and length of stay was insignificant in Bolin et al. (2008a). A study by Iwashyna and Christakis (2003), who similar to us use register data, find that "marital status has a substantial impact on the health care obtained by the elderly." They suggest that spouses function as higher-order decision-makers rather than home health assistants.

Our analysis diverts from the studies mentioned above in several ways. It addresses both health outcome (mortality) and use of health care services conditional on survival (hospital readmission). While the surveys in question intend to be representative of the general population of elderly, this analysis focuses on frail elderly and their outcomes shortly after hospitalization. Having access to individual-level registry data of the whole population, we avoid the potential problems of health-related non-response inherent in survey data, which are likely to be particularly relevant for frail patient populations. Moreover, a beneficial aspect of our data set is that it contains many variables and covers five years, thus capture trends and institutional changes.

We find that having both a spouse and a child is negatively associated with patient's mortality, but positively associated with readmission. That means that the positive selection into marriage and parenthood with respect to unobserved health, and the health-improving caregiving services of the relatives, which would imply negative association with readmission, cannot be the only underlying factors. There must be some other factors which override this type of selection and causal impact to such a degree that the association with readmission turns positive. One potential mechanism can be that spouses and children do actively engage in monitoring the elder's post-hospitalization health as well and secure them hospital readmission if necessary.

We further find that having a spouse appears to be more important for male patients, while children appear to be more important for female patients. Spouse and children characteristics like age, income, education in health care sector, and living in the same municipality as the parent influence the relationship, although not always in an expected manner.

Data

Data Sources

Several datasets are used in this analysis. First, the Norwegian Patient Register (NPR) gives information on each visit at a hospital or an outpatient clinic. The data provide the patient's date of admission and discharge from the hospital or the outpatient clinic, gender, municipality of residence, main and secondary diagnoses, the place where the patient was admitted from and discharged to (for example private home, institution, etc.), type of admission (emergency or planned), health trust, etc. Through the patients' unique identification number the patients can be linked to other Norwegian registry data from Statistics Norway, which provide more patient characteristics, such as date of birth and possibly date of death,

education, and income, as well characteristics of the patient's spouse and children, including their age, gender, education, municipality of residence and income. Finally, we use the Norwegian municipality-state reporting from Statistics Norway (KOSTRA), which provides information on a wide range of municipality characteristics, such as health care expenditure and personnel resources.

Sample Selection Criteria

Our sample covers the period 2009–2013. We perform the analysis based on patients aged 70 and above, and focus on four main primary diagnoses: heart attack, heart failure, pneumonia, and hip fracture (the ICD-10 codes for the diagnoses used in the analysis agree with the codes used by Norwegian Directorate of Health and are available from the authors upon request). We focus on these four major diagnoses in order to reduce the heterogeneity in patient health status but at the same time to keep the external validity. These diagnoses are very common reasons for hospital admission among elderly patients; together they represent about 29% of all emergency hospital admissions of patients aged 70 and above. Our descriptive data show that they are also among the most severe in terms of high in-hospital as well as post-hospitalization mortality (not reported here). These conditions cause a significant change in the patient‘s health status, but at the same time, many patients can be discharged to their own homes, and because they are unpredictable, hospitalization for these conditions is a good proxy for a health shock. They are also commonly used in various quality indicators in the literature (see www.helsenorge.no), and heart attack and hip fracture are among the health conditions used to capture the health status of the respondent in the SHARE survey (Bolin et al. 2008a).

In order to study post-hospitalization outcomes, we need to define the index hospitalization. It is defined as the first acute hospital admission for a given diagnosis in a given year, lasting more than one day, under the restriction that the patient could not be hospitalized for the same diagnosis in the previous twelve-month period (a robustness check on this criterion is included in "Robustness Checks" section). Samples are first generated for each year and each diagnosis separately and then pooled across years and diagnoses (thus, the same patient can emerge in the dataset multiple times. We will treat such observations as independent). The sample is restricted to patients coming from private homes or from emergency primary health care, since spouse/adult children are hypothesized to have a lower impact on patients who stay at institutions. Since we study post-hospitalization outcomes, patients who are not alive at the time of discharge are excluded. Patients discharged after December 1st 2013 (for whom the outcome within 30 days after hospital discharge is not observable) are excluded. With these restrictions, our sample for analysis includes 97,920 observations of inpatients.

Variables

Dependent Variables Our two dependent variables are mortality and readmission within 30 days after hospital discharge. Readmission is defined as acute, all-cause hospitalization that takes place between 1 and 30 days after hospital discharge.

Following The Norwegian Directorate of Health, we exclude hospitalization due to some specific diagnoses, such as accidents, cancer, and poisoning (the complete list of ICD-10 diagnoses excluded from the definition of readmission is available from the authors upon request). When estimating readmission, we restrict the sample to patients who were at risk of readmission the whole post-hospitalization period; therefore, patients who died within 30 days after discharge are excluded. Thus, the sample used for estimating readmission includes 91,446 observations.

Explanatory Variables As proxies for quantity of informal care, we use the elder's family resources. Our variables of prime interest are the following indicator variables: (1) *Spouse only*, 1 if a patient has a spouse (or a cohabitant) who is alive at the time the outcome is measured but has no children; (2) *Child only*, 1 if a patient has at least one child but no spouse; and (3) *Both*, 1 if a patient has both a spouse and at least one child. Unfortunately, because of data limitations we cannot be certain that the spouse lives in the same household as the patient. This limitation may result in underestimated coefficients on *Spouse only* and *Both* since a spouse who does not live in the same household as the patient (but, for example, lives at an institution) is believed to have a lower impact. The dummy for whether the elder person is married or not is based on yearly data from 2007 onwards. We are not able to distinguish among widow(er)s, divorced, and never-married.

Other explanatory variables include patient characteristics, such as age (level and squared), gender, education (in three levels: compulsory, intermediate and tertiary), income (sum of employment income, capital income, taxable and tax-free transfers received during the calendar year), and the main diagnosis. Family resources might be positively correlated with patient's unobserved health, irrespective of whether the patient receives home care and assistance from their relatives or not. Hence, it is important to control for patient's general health status, both before and during index hospitalization. We, therefore, generate a set of control variables in order to capture patient's health status one year before the index hospitalization, such as number of elective/emergency visits at outpatient clinic, and length of elective/emergency stay at hospitals. Characteristics of the index hospitalization itself include the length of stay, whether the patient was discharged to home or to an institution, dummies for number of co-morbidities, and health trust. We also include controls for the year and day of week the patient was admitted to hospital. The day of week serves as a proxy for *days at hospital before treated*, since weekends might be less convenient days for admissions. In addition, we include a range of municipality characteristics, which are described in Appendix Table 6.

To be able to analyse whether patient's health outcome varies by spouse characteristics, we include the following information: the spouse's age (level and squared), education (three categories), income, and whether the spouse has education related to the health care sector. Spouse's characteristics can have an impact on their role both as a caregiver and advocate. For example, if the spouse's education is related to the health care sector, he or she might be more likely to take a role as a caregiver. Higher socioeconomic status might be beneficial for the

advocacy role but at the same time it might constitute larger time or opportunity costs.

For analogous reasons we include children characteristics. Since one patient can have more than one child, we have to decide which child's characteristics to include, as including all children's characteristics would be overwhelming, and including averages might not be representative. We believe the most representative would be to include the characteristics of the child who has the greatest probability of being the main care provider. To maximize this probability, our first criterion is geographical proximity (on municipality level). If several adult children live equally close, we choose the oldest daughter. In case of no daughter, we choose the oldest son, and if more than one child fits the criteria, for example, in case of twins, we choose the first one in the data. The reason for this selection criterion follows the findings in empirical studies; for example, Horowitz (1985) finds that sons provide less care to their parents than daughters do, and that sons tend to become a caregiver only in the absence of an available female sibling. A more recent study confirms that women are more likely to be main caregivers than men (Carmichael and Charles 2003). Children characteristics are number of siblings, whether any of the children have education from the health care sector, the reference child's gender, age, education, income, and whether the reference child resides in the same municipality (about 78% do). The latter variables are proxies for the opportunity cost of providing care.

The existence of family resources is in itself not a perfect measure for the quantity and/or quality of informal care. However, empirical literature shows that spouse and off-spring are important care-givers, as shown above. In this analysis, we have included controls for a number of characteristics which may be related to actual input of care-giving (distance, the age, education, and income of spouse and adult child, and gender and number of own children of adult child).

Descriptive Statistics

Table 1 describes the outcome variables and patient characteristics by the availability of family resources. In the raw data, the general picture for mortality is that patients with more family resources have on average lower mortality. For readmission, on the other hand, patients with more family resources have higher average readmission rate. When we look at the composition of the subsamples, men are more likely to have a spouse. By construction, patients whose spouse and child are alive are themselves on average younger, and they are somewhat more educated and with higher income. The same holds for patients with spouse only. However, these younger subsamples ("only spouse" and "both") score unfavourably on use of specialist health services the year before the current hospitalization. This may reflect that patients who have survived till high ages are positively selected. Younger subsamples have on average a shorter index hospitalization stay, and they are more likely to be discharged to their home, which is either an indication of a better post-hospitalization health status or the fact that the hospital takes into account the patient's access to family resources when deciding length of stay and discharge destination. These composition differences will be taken into account in the regression analysis.

Table 1 Descriptive statistics of outcome variables and patient characteristics, by family resources

	Mean (s.d.)							
	No relatives		Only children		Only spouse		Both	
Mortality	0.084	(0.28)	0.071	(0.26)	0.065	(0.25)	0.052	(0.22)
Readmission	0.188	(0.39)	0.196	(0.4)	0.234	(0.42)	0.243	(0.43)
Male	0.37	(0.48)	0.26	(0.44)	0.66	(0.48)	0.67	(0.47)
Age	85.3	(7.18)	84.64	(6.6)	81.5	(6.64)	80.13	(6.18)
Educ. compuls.	0.53	(0.5)	0.52	(0.5)	0.43	(0.5)	0.41	(0.5)
Educ. interm.	0.37	(0.48)	0.39	(0.5)	0.43	(0.5)	0.46	(0.5)
Educ. tertiary	0.1	(0.23)	0.08	(0.28)	0.14	(0.34)	0.14	(0.35)
Log income	12.25	(1.02)	12.33	(0.49)	12.28	(0.85)	12.35	(0.58)
Length of stay (LOS), previous year:								
- Emergency	4.55	(9.49)	4.64	(9.68)	4.82	(10.5)	4.72	(10.54)
- Elective	0.75	(4.14)	0.83	(4.01)	0.96	(4.69)	1.18	(5.)
No. of visits at outpatient clinic, previous year:								
- Emergency	0.32	(1.09)	0.31	(1.05)	0.33	(1.28)	0.38	(1.52)
- Elective	1.52	(2.9)	1.74	(3.01)	2.43	(3.89)	2.6	(3.83)
LOS index hospitalization	7.35	(6.33)	7.08	(6.1)	6.84	(6.04)	6.58	(5.79)
Discharged to home	0.45	(0.5)	0.48	(0.5)	0.61	(0.49)	0.63	(0.48)
No. of co-morb.	2.92	(1.76)	2.97	(1.76)	2.96	(1.76)	2.92	(1.77)
Observations	12,557		47,749		2892		34,722	

The descriptive statistics are calculated for the sample used in the mortality analysis, except for readmission rates

Table 2 provides mean mortality and readmission rates for the whole population and for the subsamples split by gender. The overall mortality is 6.6%, while the readmission rates are in general much higher, 21.3%. Both mortality and the probability of readmission are higher for men.

Table 3 describes our key explanatory variables - family resources. About 38% of the patients have a spouse and most patients (84%) have at least one child. Out of the four possible categories, the largest category is patients without a spouse but with children (49%). About 13% have neither spouse nor children. The shares differ by gender; women are less likely to have a spouse (22% have a spouse as opposed to 60% for men), which is in line with the fact that women live longer. However, both genders are similarly likely to have children.

Table 2 Descriptive statistics of the outcome variables, by gender

(%)	Whole sample	By gender	
		Women	Men
Mortality	6.6	6.1	7.3
Observations	97,920	55,798	42,122
Readmission	21.3	18.9	24.5
Observations	91,446	52,390	39,056

Table 3 Descriptive statistics of family resources: proportion of patients with and without family resources

	(%)	No children	Has children	Total
Whole sample	No spouse	12.8	48.8	61.6
	Has spouse	3.0	35.5	38.4
	Total	15.8	84.2	100
Women	No spouse	14.3	63.4	77.7
	Has spouse	1.8	20.6	22.3
	Total	16.1	83.9	100
Men	No spouse	10.9	29.4	40.3
	Has spouse	4.5	55.2	59.7
	Total	15.4	84.6	100

The descriptive statistics are calculated for the sample used in the mortality analysis

To sum up, the descriptive statistics suggest that family resources are negatively related to mortality, and positively related to readmission. The descriptive statistics also indicate that the characteristics of patients with and without relatives differ. Therefore, the negative relationship with mortality and positive relationship with readmission might be driven by differences in the sample composition. In our regression analysis, we will study whether the main picture for mortality and readmission changes after controlling for background characteristics. We will also look at gender differences and how spouse and children characteristics influence the relationship between family resources and mortality and readmission.

Empirical Specification

Our interest is in *(i)* the effects of family resources on the probability of death and hospital readmission for elderly patients, after controlling for patient, municipality, and time characteristics; and *(ii)* the heterogeneity in these effects with respect to patient gender and relatives' characteristics.

Identifying *effects* is difficult primarily since there might be some unobservable characteristics associated with both the patient's health and the family resources. Marital status and parenthood, as well as the survival of spouse and children until old ages, are likely to correlate positively with the overall health status of the patient. Appendix Table 7 reports the associations between family resources and mortality during the index hospitalization (accounting for a battery of background characteristics). The reported negative associations indicate lower in-hospital mortality among patients with relatives, independent of post-hospitalization care or advocacy. Therefore, we are likely to face an endogeneity (omitted variable) problem. Finding a valid identification strategy appears to be extremely difficult in this setting, because any seemingly exogenous variation in the endogenous variables *Spouse only, Child only or Both* (for instance a war) is likely to have a direct impact on the elderly's health, through his/her own exposure or through bereavement. Since we do not have any instrumental variable or other identification strategy that could solve this endogeneity problem, the estimated parameters below should be considered associations rather than causal effects.

To investigate *(i)* the relationship between family resources and mortality or readmission, we estimate a linear probability model of the following form, using the OLS estimator:

$$Y_i = \alpha_1 + \alpha_2\ Spouse\ only_i + \alpha_3\ Child\ only_i + \alpha_4\ Both_i + X1_i\ \alpha_5 + \tau_i + \mu_i + \varepsilon, \qquad (1)$$

where *i* indexes the elderly patient, *Y* is an indicator variable for whether the patient died or was readmitted to hospital within 30 days from hospital discharge, *Spouse only, Child only,* and *Both* are indicator variables for whether the patient has a spouse but no children, at least one child but no spouse, and both spouse and at leat one child, respectively. The variable vector *X1* contains an extensive set of control variables for patient and municipality characteristics described in "Results" section. The variable vector τ captures year and day-of-week fixed effects, and μ captures municipality fixed effects. We include municipality fixed effects to control for all time-invariant municipality characteristics that may have independent influence on patients' health outcomes and are as well correlated with our variables of interest. This is relevant because in Norway, primary health care and home care services are the responsibility of the municipalities. The supply and quality of formal care is therefore to a large extent captured by municipality-fixed effects.

Since the dependent variable is a probability, the estimated parameters are measured in percentage points.

The parameters α_2-α_4 represent the difference in probability of death/readmission for patients with family resources, compared to the baseline category of patients without a spouse or children. If these estimates were to be given a causal interpretation, the identifying assumption would be that patients with and without relatives are otherwise similar on unobservable characteristics, and thus the patients without relatives constitute a valid comparison group to the patients with relatives. Under this assumption, for the mortality outcome, the estimates of α_2-α_4 will be *negative* if close relatives provide home care that decreases the probability of the elderly patient's death. For readmission, the prediction is less straightforward. The input of time and effort of a relative as a caregiver or a social/moral/financial supporter might improve the patient's overall health and *decrease* the probability of readmission (i.e., *negative* estimates of α_2-α_4), while the role of the relatives as advocates for patient's needs can, in fact, *increase* the probability of readmission (i.e., *positive* estimates of α_2-α_4).

Regarding the endogeneity of family resources, the estimates of α_2-α_4 are expected to be *downward biased* since healthier individuals (with lower risk for mortality and readmission) tend to have more family resources available (as seen in Appendix Table 7). Note that the readmission is conditional on survival – patients who died within 30 days after index hospitalization are taken out from the sample for readmission, which introduces an endogeneity issue.[1] However, controlling for variables such as patient's background characteristics, patient's health status, and characteristics of the index

[1] We are aware of the selection problem in estimating readmission, addressed by Laudicella et al. (2013) for a different research question. In our case; *unobserved patient health* affects both survival and readmission propensity. However, we are not able to find a good instrument for unobserved patient health in the mortality equation, i.e., one that is correlated with mortality but uncorrelated with our variables of interest (family resources). Therefore, we resort to the approach that is common in the literature, namely to exclude individuals who died during the first 30 days.

hospitalization helps reduce this problem. One potentially important omitted variable is formal home care, since informal care and formal care are possibly endogenously decided (Van Houtven and Norton 2004). If elderly without family were more likely to be assigned formal caregivers who provide higher quality care post-discharge than family members then the estimate of interest would be biased upwards (i.e., those with family would appear to have higher mortality and readmission rates). For our patient group, the formal home care most relevant for the outcomes measured is professional home nursing care. Notably, previous studies indicate that in a European setting, informal care is unlikely to be a substitute for formal care in situations where highly qualified and specialised health care is demanded; informal care is found to be a complement, rather than a substitute for high-skilled nursing care (Bonsang 2009), and also for doctor visits and for having any hospital stay (Bolin et al. 2008a).

To study *(ii)* how the spouse's characteristics influence the relationship between the patient's health outcomes and family resources, we estimate separately for elders who have a spouse and augment model (1) with spouse characteristics, denoted *Spouse char*, see model (2a) below. The influence of children's characteristics, *Child char*, is analysed in a similar way, on the subsample of elders who have children, see model (2b):

$$Y_i = \beta_1 + \beta_2 Spouse\ char_i + \beta_3 Both_i + X1_i\,\beta_4 + \quad \tau_i \quad + \mu_i + \xi_i, \tag{2a}$$

$$Y_i = \lambda_1 + \lambda_2 Child\ char_i + \lambda_3\ Both_i + X1_i\,\lambda_4 + \quad \tau_i + \mu_i + \nu_i, \tag{2b}$$

Spouse's and children's characteristics contain variables described in "Results" section. Vectors *X1,* τ and μ are the same as before in Eq. 1 (patient and municipality characteristics, and year, day-of-week and municipality fixed effects).

In all specifications the error terms are clustered at the municipality level in order to allow for within-municipality correlation.

Results

Main Results

Family Resources Column 1 in Table 4 shows that having both a spouse and a child is associated with a significant reduction of 0.88 percentage points (pp) in mortality compared to individuals without family. The reduction in mortality for individuals with only a spouse or a child is not statistically significantly different from zero. Since the overall mean mortality is 6.6% in the sample (Table 2), the estimated associations are of considerable relative magnitude.

Whereas mortality is *negatively* associated with family resources, the probability of (all-cause) readmission given survival is *positively* associated (column 4 in Table 4). For elderly who have both a spouse and a child the probability of readmission is 2.06 pp. higher and for elderly who have either a spouse or a child the probability of readmission is 2.2 pp. and 0.81 pp. higher compared to individuals without family. The mean frequency of readmission is 21.3% (see Table 2). Thus, in relative terms, the

Table 4 Main regression results

	Mortality			Readmission		
	All	Women	Men	All	Women	Men
	(1)	(2)	(3)	(4)	(5)	(6)
Spouse only	−0.0035	−0.0040	−0.0014	0.022***	0.0170	0.0263**
Child only	−0.0051*	−0.0093***	0.0007	0.0081**	0.0096*	0.0079
Both	−0.0088***	−0.0109***	−0.0066	0.0206***	0.0224***	0.0218***
Patient char						
Male	0.0223***	–	–	0.0214***	–	–
Age	−0.0226***	−0.0271***	−0.0225***	0.0067	0.0009	0.0137**
Age squared	0.0002***	0.0002***	0.0002***	−0.0001**	−0.0000	−0.0001***
Educ. interm.	−0.0023	−0.0056***	0.0025	−0.0072**	−0.0059*	−0.0117**
Educ. tertiary	−0.0058**	−0.0073*	−0.0043	−0.0105**	−0.0017	−0.0220***
Log income	0.0004	0.0005	0.0010	−0.0003	0.0043	−0.0025
Length of stay (LOS), previous year:						
- Emergency	0.0010***	0.0009***	0.0011***	0.0021***	0.0024***	0.0018***
- Elective	0.0002	0.0004	0.0000	0.0001	0.0005	−0.0002
No. of visits at outpatient clinic, previous year:						
- Emergency	0.0032***	0.0035***	0.0030***	0.0032***	0.0046***	0.0022*
- Elective	0.0000	−0.0003	0.0002	0.0027***	0.0025***	0.0031***
LOS index	0.0002	−0.0001	0.0003	−0.0012***	−0.0012***	−0.0012**
To home	−0.0702***	−0.0625***	−0.0807***	−0.1212***	−0.0805***	−0.1752***
Co-morb. = 1	0.0042	0.0004	0.0096**	−0.0007	−0.0015	0.0012
Co-morb. = 2	0.0133***	0.0090***	0.0209***	0.0053	0.0111	−0.0010
Co-morb. = 3	0.0241***	0.0199***	0.0312***	0.0065	0.0125**	0.0008
Co-morb. = 4	0.0291***	0.0243***	0.0372***	0.0119**	0.0168**	0.0076
Co-morb. = 5	0.0391***	0.0338***	0.0476***	0.0210***	0.0215***	0.0225**
Co-morb. = 6+	0.0529***	0.0515***	0.0576***	0.0320***	0.0317***	0.0341***
Heart attack	0.0187***	0.0319***	−0.0043	0.2521***	0.2283***	0.2804***
Heart failure	0.0371***	0.0490***	0.0147**	0.1037***	0.0849***	0.1305***
Pneumonia	0.0433***	0.0458***	0.0299***	0.0598***	0.0466***	0.0797***
Municip. char						
Municip. size	−0.0742	−0.0819	−0.1047	0.1785	0.3013*	0.0034
Care services	0.0409	0.0475*	0.0347	0.0141	−0.0049	0.0240
Man-labor-yrs	−0.0002	0.0003	−0.0006	0.0012	0.0009	0.0016
Slots in instit.	0.0012	0.0006	0.0018	−0.0008	0.0015	−0.0032*
Slots in rehab.	0.0002	−0.0000	0.0006	0.0003	−0.0002	0.0009*
Physician hrs	−0.0080	−0.0047	−0.0130	−0.0004	−0.0067	0.0106
Physiother. hrs	−0.0036	−0.0122	0.0085	0.0061	0.0120	0.0017
Sick leave	−0.0011	−0.0006	−0.0021	0.0001	−0.0007	0.0017
Constant	1.0998	1.3075	1.4837	−2.0487	−2.9562	−0.5829
Observations	97,920	55,798	42,122	91,446	52,390	39,056
Adjusted R^2	0.044	0.040	0.052	0.094	0.072	0.116

Results from estimating Eq. (1) with time and municipality fixed effects. Indicators for health trust omitted from the table

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

estimated association with family resources is larger in the mortality regression than in the readmission regression.

Patient Characteristics Many of the patient characteristics are highly statistically significant for both mortality and readmission. They all have the expected sign: mortality and readmission are higher among men, and naturally increase in age. We find a negative association between educational level and both mortality and readmission, whereas the estimates for income are statistically insignificant. This might be because pensions do not reflect the economic status of the elderly individuals so well since there is much lower variation in pension income than in labour income. Indicators of patient severity such as use of health care the previous 12 month period and number of co-morbidities show positive associations (if significant).

There is no significant association between the length of stay of index hospitalization and mortality, while for readmission we find a negative, although small association, suggesting that a too short hospital stay can increase the probability of readmission. The indicator variable for being discharged to private home has a very large negative coefficient, which supports the argument that hospitals assess the patient's health status before deciding discharge destination. The estimation results for our variables of interest vary by diagnoses. Hip fracture patients, the base category, have the lowest risk of both mortality and readmission. Hearth attack patients have rather low risk of mortality, but the highest risk of readmission.

Municipality Characteristics None of the municipality estimates are significant at 5% level.

Heterogeneity by Gender

Since our explanatory variables of prime interest are related to life expectancy and gender roles within the family, we estimate our main specification separately by gender.

From columns 2 and 3 in Table 4 it seems that the negative association between family resources and mortality is mostly driven by female patients. Having both a husband and children is associated with 1.09 pp. lower probability of death (mean female mortality is 6.1%, as seen in Table 2) for women, while having a wife and/or children does not seem to be significantly associated with lower mortality risk for men. For females it is the children who appear to drive the negative association with mortality – there is a 0.93 pp. decrease in mortality for females with only children versus statistically insignificant decrease for females with only a spouse.[2]

For readmission (columns 5 and 6), the estimated coefficients on having both a spouse and children are positive and significant for both genders, with a similar size: 2.24 pp. for women and 2.18 pp. for men (mean readmission rates are 18.9% and 24.5%, respectively). Similarly to mortality, children are more important for women – mothers have 0.96 pp. higher chance of readmission (although the estimate is significant at 10% level only), while fathers' chances of readmission are not significantly

[2] The lack of significance for the Spouse coefficient estimate can partly be a result of the small sample – only 1.8% of all women (996 individuals) have a spouse but no children.

related to having children only. For males, however, it is the spouse that appears to drive the positive association – having a wife without children is associated with 2.63 pp. increase in readmission.

The other explanatory variables display no qualitative differences to the main results when split by gender.

Spouse and Children Characteristics

Our analysis benefits from a rich set of spouse and children characteristics (see "Results" section for detailed description). Table 5 reports results from estimating Eqs. 2a and 2b. The bottom line of the first panel reports *p*-values of the joint significance of all spouse (or children) characteristics. It shows that taken together, both spouse and children characteristics are significant for both mortality and readmission (though spouse characteristics are jointly significant for readmission only at 10% level).

Considering each variable separately, we see that tertiary education and education in the health care sector are the only spouse characteristic that are significant for mortality. The negative estimate on the tertiary education is in line with our expectations – having a spouse with higher education is associated with lower mortality. On the other hand, the positive sign of the coefficient on spouse's education in health sector is surprising. We would expect a negative association with mortality since having relevant knowledge from the health care sector might be useful in providing quality health care to the spouse. A possible explanation might be a measurement error - education type might

Table 5 The importance of spouse and children characteristics

	Spouse characteristics		Children characteristics	
	Mortality	Readmission	Mortality	Readmission
	(1)	(2)	(3)	(4)
Educ. secondary	0.0003	−0.0067	−0.0011	0.0031
Educ. tertiary	−0.0073**	−0.0047	−0.0039	−0.0048
Age	0.0036*	0.0069*	0.0034***	0.0010
Age squared	−0.0000	−0.0001*	−0.0000***	−0.0000
Log income	0.0007	−0.0036	−0.0020**	0.0011
Health care educ.	0.0098**	0.0090	−0.0047**	0.0055*
No. of children	–	–	−0.0012	0.0008
Male	–	–	−0.0005	−0.0007
Same municipality	–	–	0.0003	−0.0092**
Joint significance	0.0001	0.0911	0.0044	0.0129
Both	−0.0055	−0.0023	−0.0040**	0.0133***
Observations	37,614	35,608	82,471	77,245
Adjusted R^2	0.049	0.144	0.045	0.089

Results from estimating Eq. (2a) – columns 1 and 2 – and Eq. (2b) – columns 3 and 4. The first two columns are estimated on the subsample of patients with a spouse, and the last two columns, on patients with children. The set of control variables is the same as in Table 4

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

not optimally reflect caring capabilities of the spouse half a decade later. For readmission there are no characteristics significant at 5% level.

Looking at children's characteristics, we see that mortality decreases, the younger and richer the reference child is, and is lower if at least one of the siblings has an education targeted towards the health care sector. From the readmission regression, we learn that if the child lives close to the elderly, the probability of readmission is lower. This association is compatible with the child taking a role as caregiver, improving the patient's overall health status. Note that the child's gender coefficient is not significant. This is in line with Van Houtven and Norton (2008), who found that sons and daughters are equally effective at providing informal care. The reference child's education does not appear to play a significant role.

Robustness Checks

We have performed several analyses to check the robustness of the results reported in Table 4.

Length of "*clean period*"*:* We have selected a 12-month "clean period" for an index hospitalization. To check this assumption, we have changed the sample selection criteria by allowing for a shorter (6 months) and longer (18 months) pre-hospitalization period. Although this alters the sample size, these results are very similar to the results presented in Table 4.

Linear probability model: Since mortality and readmission are binary outcomes, a logistic specification might better fit the data. To test this, we have estimated logit models, and our results are robust to this alternative specification.

Repeated observations: Some individuals appear in the data multiple times. To account for repeated observations we have re-estimated all models with standard errors clustered at the individual level instead of at the municipality level. The significance of the estimates did not change.

Better control for individual health differences: In the main specification, we include proxies for health status prior to the index hospitalization (length of hospital stay previous year, visits at outpatient clinic previous year, etc.). To strengthen the control for case mix, we have included indicators for chronic deceases (being hospitalized for cancer, diabetes, dementia, obesity or arthritis at least once in the year prior to the index hospitalization). This did not change our results.

Results from the robustness checks are available upon request.

Comparison with Previous Studies

A novelty of this analysis is that it benefits from administrative registry data when investigating the relationship between availability of relatives and the elder's health and health care use. Compared to survey data, which dominate the existing literature on use of health care services, some problems are avoided, particularly recall bias and non-response, which is likely to be correlated with the respondent's health status. On the other hand, survey data has the advantage of eliciting

information on hours of care provided, and control variables such as self-assessed health, life-style, reported symptoms and limitations (Bolin et al. 2008a; Bonsang 2009). Importantly, administrative data allows us to explore clinically relevant outcomes that cannot be incorporated in surveys; in this case mortality and readmission.

Our results on mortality, showing that elders with family resources (a child or both child and spouse) have lower mortality risk, is in line with existing literature. However, we do not find a statistically significant reduction in mortality among elders who have a spouse but no children, compared to elders with no next-of-kin.

Our health care use outcome, hospital readmission, relates most closely to the literature on hospitalization (the probability of at least one night at hospital). It is worth noting that the populations studied varies profoundly, since we study patients who have been discharged to home from hospital for serious conditions, while the surveys typically target the general population of home-dwellers. Results on hospitalization are mixed, as commented upon in the introduction. Our results are consistent with Bolin et al. (2008a). Using data from ten European countries (Norway not included), they find that for the survey population aged 70 and above, informal care showed a significant and positive relationship with the probability of having any hospital care. Our results illustrate the general point that informal care cannot substitute for formal health care use that requires highly-skilled care.

Conclusion

Our main results show that, accounting for a range of patient, municipality and time characteristics, having a spouse and adult child is *negatively* associated with mortality and *positively* associated with readmission within 30 days. The analysis is made for patients aged 70 and above who have had an emergency hospital admission with specific primary diagnoses (heart attack, heart failure, pneumonia, hip fracture). When interpreting these results, the main challenge is to isolate the potential effect of the relatives' activity or functions from the health-related selection into marriage and parenthood. Such a selection is well documented in the literature and it appears to be present in our data as well. However, even in the presence of this type of selection, which implies a *negative* association with readmission, we observe a *positive* association between family resources and readmission. This means that other factors must play a role as well. One plausible explanation is the causal effect of relatives' activities that increase readmission rates, for example, when a spouse/child monitors the elder's health status and acts as an advocate for the elderly, making a readmission more likely (while also reducing the mortality risk).

We further find that having children is more important for female patients than for male patients for both readmission and mortality and that for readmission, having a spouse appears to be more important for male patients than for female patients. Spouse and children characteristics like age, income, education, and living in the same municipality as the parent influence the relationship, although not always in an expected manner.

This analysis is explorative in nature, and results cannot be given a causal interpretation. Still, the increased mortality risk of patients without family resources indicates that formal in-home support needs to be more targeted following a hospital discharge. More research is needed to fully understand the causal links between family resources, post-discharge mortality and readmission.

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Appendix

Table 6 Definitions and means of municipality characteristics used in the analysis

Variables	Definition	Mean (s.d.)
Municip. size	Number of inhabitants, log	8.6 (1.12)
Care services	Net expenditure care services per inhabitant aged 80+, deflated to year 2009 with CPI, log	12.7 (0.23)
Man-labor-yrs	Percentage of man-labour-years with professional education above upper sec. Level	29.7 (6.17)
Slots in instit.	Slots in institutions per inhabitant 80+, percent	21.13 (8.72)
Slots in rehab.	Slots for (re)habilitation out of all slots in institutions, percent	7.67 (7.8)
Physician hrs	Physician hours per week per patient in nursing home	0.38 (0.19)
Physiother. hrs	Physiotherapist hours per week per patient in nursing home	0.34 (0.26)
Sick leave	Certified sick leave of municipal care-service workers, percentage of man-labour years	8.72 (2.14)
Observations		1780

Table 7 In-hospital mortality

	All admitted (1)	Women (2)	Men (3)
Spouse only	−0.006	−0.0091	−0.008
Child only	−0.0088***	−0.009***	−0.0125***
Both	−0.0126***	−0.0107***	−0.0176***
Observations	105,471	59,567	45,904

Results from estimating Eq. (1) on a sample augmented with those who died in hospital. Otherwise, the same-sample selection criteria as used in Table 4 regression. Control variable are identical to those in Table 4 and are omitted from the table. The variable to home is not included since it is not defined for in-hospital mortality. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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