

Access to primary health care and health outcomes: The relationships between GP characteristics and mortality rates

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Abstract

This paper analyses the impact of economic conditions and access to primary health care on health outcomes in Norway. Total mortality rates, grouped into four causes of death, were used as proxies for health, and the number of general practitioners (GPs) at the municipality level was used as the proxy for access to primary health care. Dynamic panel data models that allow for time persistence in mortality rates, incorporate municipal fixed effects, and treat both the number and types of GPs in a district as endogenous were estimated using municipality data from 1986 to 2001. We reject the significant relationship between mortality and the number of GPs per capita found in most previous studies. However, there is a significant effect of the composition of GPs, where an increase in the number of contracted GPs reduces mortality rates when compared with GPs employed directly by the municipality.

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1. Introduction

The health sector has grown rapidly in most developed countries over the last few decades. Government decisions affect the allocation of resources both to and within the sector. To evaluate the effectiveness of medical intervention without market prices, it is necessary to know the cost

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and returns to resource use and interventions in the sector. The key outcome of most health interventions is reduced mortality and morbidity, and better quality of life.

Three different lines of research on mortality can be identified in the economic literature. Some studies have analysed the relationship between economic resources and health outcomes. Most of these papers focus on the effects of economic conditions such as unemployment rates or aggregate measures of income on mortality (e.g., Auster et al., 1969; Forbes and McGregor, 1984; Gravelle, 1984; Leu, 1986; Hitiris and Posnett, 1992; Grubaugh and Santerre, 1994; Joyce and Mocan, 1993; Ruhm, 2000, 2003; Cutler et al., 2002). Other studies have focused on mortality rates at the hospital level, where resource use, policy changes relating to reimbursement rates, doctor and nurse staffing, managed care, and technological change are important explanatory factors for mortality rates (e.g., Cutler, 1995; McClellan and Noguchi, 1998; Hartz et al., 1989; Manheim et al., 1992; Kessler and McClellan, 2000; Geweke et al., 2003; Mark et al., 2004). A third line of research has focused on the effect of the number of physicians or general practitioners (GPs) in a district (usually US state level or national level) on mortality (e.g., Auster et al., 1969; Grubaugh and Santerre, 1994; Robst and Graham, 1997; Robst, 2001; Or, 2000; Or et al., 2005).

In our study, we analyse the relationship between access to primary care (proxied by the number of GPs at the municipality level) and health outcomes (proxied by mortality rates divided into four groups of causes of death) within a health production function framework (see Auster et al., 1969). Mortality rates change over time and vary substantially across municipalities, largely because of age and gender differences, but also due to other factors.¹ The number of GPs may affect mortality, but mortality may also affect the future number of GPs in a district. This creates a simultaneity problem, not previously handled in a panel data framework for this line of research, which may seriously bias the results from previous studies. In addition, there is a high degree of persistence in mortality rates over time. We estimate an econometric panel data model that accounts for the simultaneity problem between GPs (both the number and type) and mortality rates, incorporates municipality fixed effects, and allows for the influence of past mortality rates of current rates, using longitudinal data for all the 435 Norwegian municipalities over a 16-year period from 1986 to 2001.

Using standard econometric techniques previously used in the literature (i.e., static fixed-effects models) we find a negative effect of the per capita number of GPs on mortality rates. However, we do not find any significant effect of GPs on mortality rates once we allow for simultaneity between number of GPs and mortality rates in our dynamic regression model. This contradicts several studies that have found significant and negative effects of the number of GPs on mortality (Grubaugh and Santerre, 1994; Robst and Graham, 1997; Robst, 2001; Or et al., 2005).² However, we find a significant effect of the composition of GPs, where more contracted GPs reduce mortality rates compared with GPs employed directly by the municipality.

The paper proceeds in Section 2 with a description of the institutional settings for the primary health care sector relevant for this study. Section 3 presents data used in the analysis, with descrip-

¹ Mortality is only one measure of health status. Morbidity and other subjective indicators of well-being are also likely to be affected by economic factors. There is a huge literature on the relationship between socio-economic condition and self-reported measures of health. We use mortality rates because this measure of health is easily quantifiable and has been precisely measured over time. A closely related alternative to mortality rates would be the expected average length of life at birth. The correlation between mortality rates and life expectancy is very high, around 0.9. However, the expected average length of life varies for different causes of death. This is not the case for mortality rates. Thus, the mortality rate is a consistent measure of health between different causes of death, and makes our study comparable with studies from other countries.

² These studies use country-level or state-level data (US).

tive statistics. A discussion of the econometric model used in analysing the relationship between mortality and access to health care follows in Section 4. The paper discusses the empirical results of the regression analysis in Section 5, and gives concluding remarks in Section 6.

2. Institutional settings in the primary health care sector

Responsibility for health services in Norway is rooted in the public sector.³ The public health system is under the jurisdiction of the Ministry of Health and Social Affairs, which is responsible for devising and monitoring national health policy. Responsibility for provision of services is decentralized to municipal and regional (county) administrative levels.⁴

Counties provide specialized medical services, including general and psychiatric services and others such as laboratory, radiography, and ambulance services. Primary health care, including both preventive and curative treatments, is in the hands of municipalities. Municipalities are required by law to offer services for disease prevention and health promotion, diagnosis and treatment of illness, rehabilitation, and long-term care. There are no defined minimum standards regarding level or quality of health services.

The primary health care sector is financed through grants from municipalities, retrospective reimbursement by the National Insurance Scheme (NIS) for services supplied, and out-of-pocket payments by patients. Major responsibilities of the Norwegian primary health care sector can be grouped as follows. Firstly, municipalities have responsibility for the promotion of health and prevention of illness and injuries, including organizing and running school health services, health centres, and child health care by health visitors, midwives, and physicians. Secondly, municipalities have responsibility for diagnosis, treatment, and rehabilitation, including general medical treatment, physiotherapy, and nursing. Thirdly, municipalities have responsibility for nursing and care within and outside institutions, including running nursing homes, home nursing, and several other activities.

The total number of GPs per 1000 capita increased from 0.9 in 1986 to 1.1 in 2001.⁵ Two groups of GPs provide primary health services: GPs employed by the municipality (employed GPs), and self-employed GPs contracted to the municipality (contracted GPs). Both employed and contracted GPs work separately from hospital services and provide the first contact between patients and health services. Employed GPs typically work at health centres, often in group practice with other GPs. They are on a fixed salary, and the municipality generally determines their working hours and tasks. Contracted GPs have a contract with the municipality to cover some expenses (about 30% of physicians' gross income). As well, they obtain income from patient fees and a fixed fee reimbursement scheme from the National Insurance Administration. Contracted GPs can, largely, make their own decisions about the number of hours worked. The proportion of contracted GPs has increased from 0.39 in 1986 to 0.56 in 2001.

Municipalities have a legal obligation to employ physicians to carry out certain administrative, emergency, and clinical functions. Beyond this, there is no legislation regarding minimum requirements for physician–patient ratios. However, in order to secure a geographically balanced

³ For a more thorough description of the Norwegian health sector, see Van der Noord et al. (1998).

⁴ The national authorities have retained some delivery mandates as well, including the control of several national councils, research institutions, the National Hospital of Norway (Rikshospitalet), the National Cancer Hospital (Radiumhospitalet), and a few other highly specialized hospitals.

⁵ The number of GPs per 1000 capita varies in different countries: France (1.6), Germany (1.1), Italy (0.9), Sweden (0.5), UK (0.6), and US (0.8).

distribution of doctors, a commission comprising members from the central government and the Norwegian Medical Association (NMA) regulates the establishment of new positions for both GPs and hospital specialists. This means that municipalities need approval from the commission to establish new physician positions. Municipalities have an average gross expenditure of NOK 700 per inhabitant (€84) for each GP. Expenses vary from around NOK 500 (€60) per inhabitant for the largest municipalities to around NOK 2300 (€277) per inhabitant for the smallest municipalities; see [Kjelvik \(2004\)](#).

3. Data and descriptive statistics

We use data from all the Norwegian municipalities for the 16-year period from 1986 to 2001. Data were gathered from Statistics Norway and from the Norwegian Social Science Data Services (NSD). The health outcomes reported here are total mortality rates and deaths due to four groups of causes. The classification of causes of deaths follows the ICD-10 system classification system. The four main groups are: C, malignant neoplasm (cancer); I, diseases of the circulatory system (cerebrovascular disease, ischaemic heart disease, and other heart diseases); J, diseases of the respiratory system (for example, pneumonia, bronchitis, emphysema, and asthma); and O, other causes (for example, accidents, suicide, diseases in the digestive system, and mental disorders).⁶

A possible problem with our dataset is the lack of information on patient mobility. If individuals frequently visit GPs outside their own municipality, municipality access to primary care might be a poor proxy for actual access to primary care. Register data on actual patient mobility are unfortunately not available in Norway. However, in a study based on survey data [Grimsmo \(1995\)](#) points out that it is uncommon to use a GP in a neighbouring municipality for people living in rural parts of Norway, mainly due to long travel distances. We have not found any information on patient mobility in central municipalities, but mobility is probably higher here. In central areas more individuals are crossing municipality borders on their way to work and some of them probably choose to have their GP located closer to the work place.

[Table 1](#) explains the variables and [Table 2](#) gives descriptive statistics for different measures of mortality and explanatory variables we use in the empirical analyses. Total mortality and most specific mortality rates have declined over time, although the changes over the 16-year period in this analysis were small (see [Table 2](#)).⁷ Total mortality rates have decreased from 11.1 per 1000 inhabitants in 1986 to 10.8 in 2001. Mortality group C (cancer, etc.) has increased from 2.3 per 1000 inhabitants in 1986 to 2.7 per 1000 inhabitants in 2001. Diseases in the circulatory system (group I in the ICD-10 classification system) are the most common causes of death in the statistics. The numbers in this group decreased from 5.6 deaths per 1000 inhabitants in 1986 to 4.6 in 2001. As a percentage of all deaths, this group decreased from 50% in 1986 to 42% in 1992. The numbers for group J (respiratory diseases) vary from year to year, with a peak in 1993. [Fig. 1](#)

⁶ We do not focus on infant mortality because deaths among the youngest do not contribute significantly to the improvement of life expectancy in Norway as they did during the first half of the 20th century. Each year, of the total of around 56,000 births, fewer than 200 children die before the age of one year. In the US, more than two-thirds of life expectancy improvements resulted from reductions in mortality for those over the age of 45 years ([Cutler and Meara, 2001](#)).

⁷ Mortality rates also vary substantially across municipalities. The 10-percentile mortality rate in 2001 was 7 per 1000 inhabitants, and the 90-percentile mortality rate at the municipality level was around 16 per 1000 inhabitants. Some of the variation in mortality is obviously due to the fact that many municipalities are small in terms of population. In these small municipalities one or two deaths will have a large influence on mortality rates, and we have therefore dropped observation with mortality rates lower than the 5% percentile and higher than the 95% percentile.

Table 1
Variable descriptions

Mortality ratio	Number of deaths per 1000 inhabitants
Mortality ratio C	Number of deaths due to malignant neoplasm (cancer) per 1000 inhabitants
Mortality ratio I	Number of deaths due to diseases of the circulatory system per 1000 inhabitants
Mortality ratio J	Number of deaths due to diseases of the respiratory system per 1000 inhabitants
Mortality ratio O	Number of deaths due to other causes per 1000 inhabitants
GPs	Number of GPs per 1000 inhabitants
Vacant GPs	Number of vacant GPs per 1000 inhabitants
Contracted GPs	Number of employed GPs/number of contract GPs
Age 67–79 years	Proportion of inhabitants older than 66 years and younger than 80 years
Age >80 years	Proportion of inhabitants older than 80 years
High education	Proportion with high school level or higher in the municipality, inhabitants older than 20 years
Disability	Proportion of disabled in the municipality, inhabitants older than 20 years
Unemployment	Proportion of unemployed in the municipality, inhabitants older than 20 years
Divorce rate	Number of divorces per 1000 inhabitants, older than 20 years
Population	Number of inhabitants in the municipality

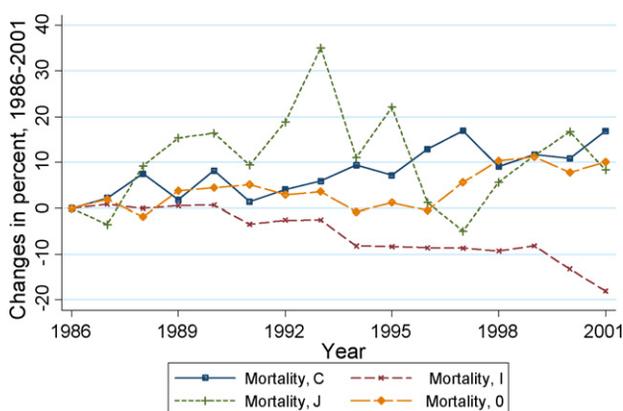


Fig. 1. Changes in mortality rates over time.

measures the percentage change in mortality rates using 1986 as a reference point, and depicts the fluctuations in specific mortality rates over time.

There has been an increase from 0.90 physicians engaged in primary health care per 1000 inhabitants in 1986 (around 3200 GPs) to 1.10 physicians per inhabitant in 2001 (around 4100 GPs) (see Table 2 for details). Most of these GPs are engaged in diagnosis, treatment, and rehabilitation (3375 person-labour years in 2001).⁸ The corresponding figures for physicians working in the school health services/child health care and nursing homes/other institutions were 231 and 249, respectively. There has been a steady increase in the number of GPs at the municipality level over time. The increase in the number of GPs was 20% from 1986 to 2001 (see Fig. 2 for more details).

The number of GPs per 1000 inhabitants varies significantly across municipalities. Contrary to most OECD countries, Norway has a relatively high per 1000 capita supply of GPs in rural

⁸ These data are only available from 2001.

Table 2
Descriptive statistics (mean and standard deviation) by year

	1986	1987	1988	1989	1990	1991	1992	1993
Mortality ratio	11.151 (2.875)	11.261 (2.883)	11.371 (2.974)	11.461 (2.960)	11.636 (2.942)	11.200 (3.004)	11.352 (2.950)	11.569 (2.893)
Mortality ratio C	2.283 (0.947)	2.333 (1.005)	2.455 (1.021)	2.324 (0.898)	2.470 (1.050)	2.315 (0.977)	2.376 (0.972)	2.418 (0.996)
Mortality ratio I	5.583 (1.869)	5.631 (1.859)	5.583 (1.876)	5.614 (1.968)	5.621 (1.784)	5.389 (1.882)	5.439 (1.817)	5.442 (1.852)
Mortality ratio J	0.969 (0.733)	0.935 (0.592)	1.058 (0.756)	1.118 (0.782)	1.128 (0.736)	1.060 (0.730)	1.152 (0.795)	1.309 (0.830)
Mortality ratio O	2.317 (1.078)	2.362 (1.101)	2.275 (0.998)	2.405 (1.066)	2.420 (1.066)	2.436 (1.061)	2.385 (1.128)	2.400 (1.072)
GPs	0.898 (0.290)	0.894 (0.280)	0.968 (0.365)	0.948 (0.321)	0.961 (0.335)	0.980 (0.355)	0.985 (0.348)	0.960 (0.324)
Vacant GPs	0.066 (0.168)	0.077 (0.190)	0.059 (0.150)	0.057 (0.159)	0.058 (0.170)	0.064 (0.164)	0.075 (0.160)	0.068 (0.158)
Contracted GPs	0.389 (0.403)	0.385 (0.404)	0.389 (0.393)	0.367 (0.390)	0.364 (0.385)	0.374 (0.389)	0.387 (0.386)	0.391 (0.387)
Age 67–79 years	0.112 (0.025)	0.112 (0.026)	0.113 (0.026)	0.114 (0.025)	0.114 (0.025)	0.114 (0.024)	0.114 (0.025)	0.113 (0.023)
Age >80 years	0.039 (0.012)	0.040 (0.012)	0.040 (0.012)	0.041 (0.012)	0.042 (0.013)	0.043 (0.013)	0.044 (0.014)	0.045 (0.014)
High education	0.473 (0.079)	0.494 (0.081)	0.510 (0.083)	0.524 (0.078)	0.540 (0.079)	0.556 (0.077)	0.569 (0.076)	0.586 (0.074)
Disability	0.076 (0.026)	0.080 (0.028)	0.083 (0.029)	0.088 (0.029)	0.090 (0.031)	0.091 (0.030)	0.091 (0.037)	0.089 (0.030)
Unemployment	0.017 (0.010)	0.015 (0.009)	0.021 (0.011)	0.031 (0.012)	0.033 (0.012)	0.035 (0.011)	0.038 (0.013)	0.040 (0.013)
Divorce rate	1.769 (1.129)	2.075 (1.121)	2.138 (1.152)	2.245 (1.130)	2.467 (1.244)	2.535 (1.204)	2.477 (1.246)	2.805 (1.275)
Population	7.895 (25.55)	8.471 (26.00)	9.207 (26.27)	9.543 (26.27)	9.498 (27.69)	9.661 (28.14)	10.015 (28.51)	10.305 (29.79)
Municipalities	339	333	346	363	373	366	391	365
	1994	1995	1996	1997	1998	1999	2000	2001
Mortality ratio	10.997 (2.851)	11.094 (2.794)	10.967 (2.880)	11.138 (2.760)	11.134 (2.880)	11.330 (2.920)	11.003 (2.841)	10.845 (2.955)
Mortality ratio C	2.498 (1.023)	2.447 (0.973)	2.577 (0.956)	2.670 (1.020)	2.491 (0.961)	2.550 (0.933)	2.531 (0.968)	2.669 (1.099)
Mortality ratio I	5.124 (1.763)	5.119 (1.720)	5.103 (1.762)	5.098 (1.707)	5.064 (1.844)	5.127 (1.939)	4.844 (1.827)	4.575 (1.779)
Mortality ratio J	1.076 (0.767)	1.183 (0.725)	1.183 (0.650)	0.921 (0.587)	1.024 (0.731)	1.080 (0.694)	1.131 (0.720)	1.050 (0.736)
Mortality ratio O	2.299 (1.027)	2.345 (1.054)	2.306 (1.064)	2.449 (1.051)	2.556 (1.078)	2.576 (1.177)	2.497 (1.109)	2.550 (1.071)
GPs	1.012 (0.350)	1.016 (0.342)	0.994 (0.337)	0.999 (0.333)	1.025 (0.344)	1.026 (0.335)	1.052 (0.353)	1.094 (0.368)
Vacant GPs	0.052 (0.144)	0.083 (0.183)	0.093 (0.201)	0.092 (0.184)	0.093 (0.205)	0.088 (0.197)	0.098 (0.214)	0.064 (0.169)
Contracted GPs	0.408 (0.394)	0.430 (0.395)	0.466 (0.405)	0.492 (0.405)	0.520 (0.397)	0.527 (0.392)	0.527 (0.385)	0.564 (0.369)
Age 67–79 years	0.112 (0.023)	0.111 (0.023)	0.110 (0.022)	0.109 (0.022)	0.107 (0.021)	0.106 (0.021)	0.104 (0.021)	0.101 (0.020)
Age >80 years	0.045 (0.014)	0.046 (0.014)	0.047 (0.014)	0.048 (0.014)	0.049 (0.015)	0.050 (0.014)	0.050 (0.014)	0.051 (0.015)
High education	0.597 (0.074)	0.617 (0.074)	0.636 (0.076)	0.647 (0.076)	0.658 (0.074)	0.678 (0.075)	0.780 (0.074)	0.786 (0.073)
Disability	0.087 (0.026)	0.089 (0.026)	0.090 (0.026)	0.093 (0.026)	0.095 (0.026)	0.100 (0.028)	0.102 (0.028)	0.104 (0.028)
Unemployment	0.037 (0.013)	0.035 (0.013)	0.031 (0.014)	0.025 (0.012)	0.019 (0.009)	0.020 (0.010)	0.021 (0.010)	0.021 (0.010)
Divorce rate	2.625 (1.325)	2.396 (1.173)	2.406 (1.161)	2.226 (1.137)	2.319 (1.060)	2.357 (1.057)	2.515 (1.187)	2.647 (1.353)
Population	10.469 (29.52)	10.445 (29.55)	10.573 (29.55)	10.550 (29.55)	10.735 (29.55)	10.682 (30.41)	10.698 (30.46)	10.878 (30.46)
Municipalities	384	392	398	400	393	401	407	406

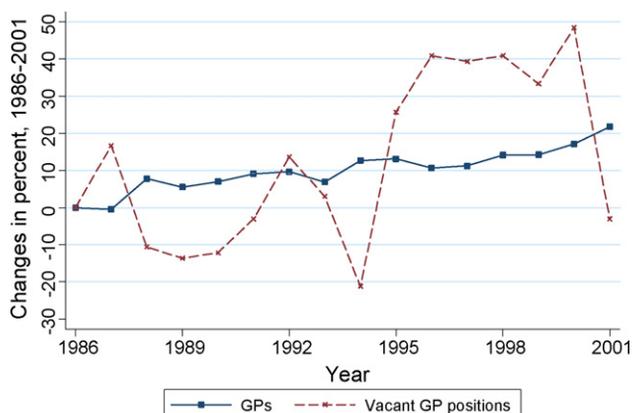


Fig. 2. Changes in GPs and vacant GP positions.

compared with urban areas, and the number of physicians per 1000 inhabitants is higher in rural areas than in urban municipalities. This is partly due to the legal obligation for even the smallest municipalities to employ a GP. In addition, the administrative and emergency components of primary health care require more physicians per inhabitant in small municipalities. The number of physicians per 1000 inhabitants was 1.32 in rural areas in 2001. These municipalities have on average around 3000 inhabitants. In urban municipalities, with an average population of around 14,000 inhabitants, the number of physicians per 1000 inhabitants was 0.92 in 2001.⁹

Most GPs prefer to work in larger cities and municipalities. Thus, many smaller municipalities have difficulty attracting GPs to work for them. The number of vacant GP positions per 1000 inhabitants was around 0.06 in both 1986 and 2001. This is around 6% of all GPs. However, the numbers of vacant positions vary from year to year (see Fig. 2). The number of vacant GP positions per 1000 inhabitants was only 0.05 in 1994 compared with 0.10 per 1000 inhabitants in 2000. As is clear from Fig. 2, the fluctuation in numbers of vacant GP positions does not follow a systematic pattern. However, the new patient list system was introduced in 2001, making it more attractive to hold a GP position compared with other type of positions for medical doctors. This can explain the drop in number of vacant GP positions in 2001.

The number of contracted GPs versus employed GPs also varies considerably between municipalities and over time. The number of contracted GPs increased from 0.39 in 1986 to 0.56 per 1000 inhabitants in 2001 (see Table 2). The ratio of contracted GPs over total number of GPs increased from 39% in 1986 to 51% in 2001. For more details about the change in the number of contracted GPs and total number of GPs over time, see Fig. 3.

Table 2 shows that the population is ageing, which is evident even for the short period 1986–2001. In 1986, 3.9% of the population was above the age of 80 years. By 2001, this

⁹ The percentage of municipalities defined as urban and rural has been constant over time in the dataset we are analysing. Since our fixed-effects model assumes time-varying variables, the rural–urban distinction is not included as a variable in the regression. An alternative estimation strategy would be to run regressions for urban and rural municipalities separately, which we did in an earlier version of the paper. The results from these regressions are not included in this paper. We have included interaction terms between GPs and population size, and also interaction terms between vacant GPs and population size. The effect of these interaction terms on mortality rates was not significantly different from zero, and they are not included in the final regressions.

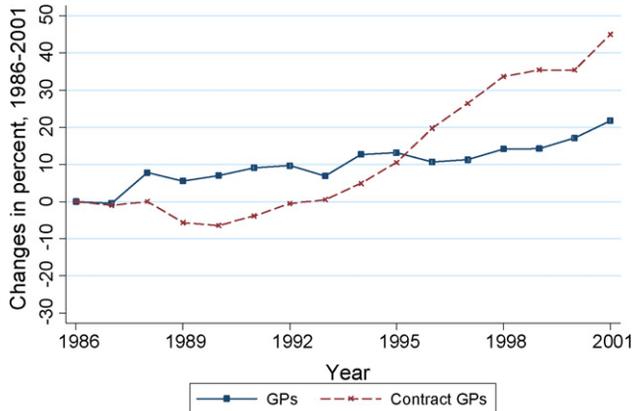


Fig. 3. Changes in GPs and contract GPs.

proportion had increased to 5.1%. This is an increase of 30% over a 15-year period. The population between 67 and 79 years has decreased slightly from 11.2% in 1986 to 10.1% in 2001.

4. Econometric issues

The aim of this paper is to examine the relationship between the availability of physicians and health outcomes in Norwegian municipalities. To investigate factors that determine the health status of a population, an aggregate health production function is a natural starting point. That means that we consider the health status of a municipality's population as the outcome of a production process where medical and non-medical resources or characteristics are used as inputs. As described in the previous section we use mortality per 1000 inhabitants (total mortality and four specific mortality measures) as a measure of health outcomes. Our key explanatory variables are the ones that measure different aspects of each municipality's workforce of GPs: "number of GPs", "number of vacant GP positions", and "number of contracted versus employed GPs". In order to estimate reliably the effects of these variables, we must address several problems. We start by describing what we consider the three main problems to be, and thereafter we present an econometric model that has potential for solving these problems.

First, even though we control for a number of municipal characteristics, municipalities are likely to have unmeasured attributes (lifestyle factors like tobacco and alcohol consumption, number of health care personnel other than physicians, capacity in institutions for elderly, distance to hospitals, etc.) that may affect mortality rates. These unobserved factors are most likely correlated with the explanatory variables, and, unless controlled for in the regressions, this leads to an omitted variable bias. Therefore, incorporating municipal fixed effects seems particularly important in this analysis.

Second, another source of omitted variable bias is an assumption that health status is static, i.e., explained solely by contemporaneous characteristics and circumstances. While contemporary circumstances obviously affect the health status of a population, current health will also depend on previous health. To control for this omitted variable bias, a dynamic panel data model is needed.

Third, as noted in a seminal paper by Auster et al. (1969), the direction of causality between health status and number of physicians is not clear. In municipalities whose populations are

exposed to an increased risk of death, the demand for physician services is probably particularly high. The variables “vacant GP positions” and “contracted GPs” are probably endogenous as well, and not controlling for this will result in biased estimates of the effect of these variables.

To consider these issues, we specify the following dynamic health production function:

$$M_{i,t} = \beta_0 + \gamma M_{i,t-1} + \alpha \text{VGP}_{i,t} + \beta X_{i,t} + f_i + \gamma_t + e_{i,t}, \quad (1)$$

for $i = 1, \dots, N$; $t = 1, \dots, T$, where i is the municipality indicator and t is the time indicator. $M_{i,t}$ is the mortality rate in municipality i at time t , and $M_{i,t-1}$ is the mortality rate in municipality i in the previous period. By including previous values of mortality we allow for the possibility that current health depends on past health status through a partial adjustment mechanism.¹⁰ $\text{VGP}_{i,t}$ is a vector of GP variables including number of GPs, number of vacant GP positions, and number of contracted versus employed GPs, where all three variables are treated as endogenous. $X_{i,t}$ are other explanatory and control variables including age, education, disability, unemployment, divorce rate, and population. f_i is an unobserved municipality-specific time-invariant effect, γ_t are period-specific intercept terms common to all municipalities (captured by year dummies), and $e_{i,t}$ is a disturbance term. To shorten the notation we include the year dummies (γ_t) in the $X_{i,t}$ -vector.

The specification in Eq. (1) is a dynamic panel data model and is estimated by standard GMM methods. First, Eq. (1) is first-differenced to get rid of the municipality fixed effects f_i , which may be correlated with the right-hand side variables of interest. With T time periods, the estimating dynamic health production function becomes

$$\Delta M_{i,t} = \gamma \Delta M_{i,t-1} + \alpha \Delta \text{VGP}_{i,t} + \beta \Delta X_{i,t} + \Delta e_{i,t}, \quad i = 1, \dots, N; \quad t = 2, \dots, T, \quad (2)$$

where Δ is the difference operator ($\Delta M_{i,t} = M_{i,t} - M_{i,t-1}$, etc.). Differencing Eq. (1) eliminates the municipality-specific effect, but introduces a new bias. By construction the new error term, $\Delta e_{i,t} = e_{i,t} - e_{i,t-1}$, is correlated with the lagged dependent variable $\Delta M_{i,t-1} = M_{i,t-1} - M_{i,t-2}$. Notice however that $M_{i,t-s}$ and $\Delta M_{i,t-s}$ are uncorrelated with $\Delta e_{i,t}$ and therefore are valid instruments for $s \geq 2$ (serial correlation has been ruled out by assumption). Arellano and Bond's (1991) GMM estimator exploits all possible moment restrictions in levels for each period $t \geq 3$. The number of available restrictions increases with t :

$$t = 3 : E(\Delta e_{i,3} M_{i,1}) = 0,$$

$$t = 4 : E(\Delta e_{i,4} M_{i,1}) = 0, E(\Delta e_{i,4} M_{i,2}) = 0$$

$$t = 5 : E(\Delta e_{i,5} M_{i,1}) = 0, E(\Delta e_{i,5} M_{i,2}) = 0, E(\Delta e_{i,5} M_{i,3}) = 0, \text{ etc.}$$

In the case where the explanatory variables are assumed to be endogenous they are treated symmetrically with the dependent variable. In our case, we assume the GP variables (the VGP-vector) to be endogenous, and the lagged values $\text{VGP}_{i,t-2}$, $\text{VGP}_{i,t-3}$, etc., are therefore valid instruments for periods $t = 3, 4, \dots, T$. The rest of the explanatory variables (the X -vector) are treated as strictly exogenous, so for each variable in X , the complete time series ($X_{i,1}, X_{i,2}, \dots, X_{i,T}$) will be valid instrumental variables in each of the first-differenced equations.

¹⁰ Health resources both today and early in life may affect adult health and mortality. An alternative specification would estimate the effect of health resources for instance 20 years ago on mortality rates today. Robst (2001) shows that young adult mortality rates are influenced by physician availability during childhood in addition to currently available care. We do not have data to estimate the effect of health resources during childhood on mortality, since our GP variable is available only from 1986. However, future work on the relationship between access to health care and health outcomes should consider the availability of care over the lifetime.

Utilizing these moment conditions, a two-step GMM estimator can be used to estimate the differenced equation. More recently, Arellano and Bover (1995) and Blundell and Bond (1998) show that the efficiency of the Arellano and Bond's (1991) GMM estimator may be dramatically improved by using an extended system GMM estimator that uses lagged differences as instruments for equations in levels, in addition to lagged levels of the instruments for equations in first differences. In this paper, we report both the "ordinary" GMM and "system" GMM results. The validity of the over-identifying restrictions may be tested using a Sargan test. If the $e_{i,t}$ are serially uncorrelated, then the residuals in the first-differenced model are first-order correlated, but should not show any second-order serial correlation (see Arellano and Bond, 1991, or Blundell and Bond, 1998). These restrictions will be tested along the paper.¹¹

5. Empirical results

In Table 3 we report results from static (OLS and fixed effects) and dynamic (GMM and GMM-SYS) health production functions, where the dependent variable is the total mortality rate in the municipalities. In the static panel data specifications, the variable measuring the number of GPs in the municipality is positive, but insignificant.¹² If anything, this indicates that the mortality rate increases with the number of physicians in the municipality. The variable "number vacant GP positions" is positive and significant, indicating that an increased number of vacant positions increases the mortality rate. The last variable measuring contract GPs is negatively significant in the fixed-effects model, but insignificant in the OLS model. However, these variables are probably endogenous. For example, the number of GPs is most likely simultaneously determined and not controlling for this endogeneity problem will lead to an upward-biased estimate of the variable (since municipalities where the mortality rate is high on average tend to have more physicians per inhabitant than elsewhere).

Moving on to the dynamic models, we note that the specification tests are satisfactory.¹³ The Sargan tests do not reject the over-identifying restrictions and the tests regarding serial correlation reject the absence of first-order, but not second-order serial correlation. From the dynamic models we see that the lag of the dependent variable is positive and significant. This certainly rejects a static model, previously used in the literature, in favour of a dynamic and indicates some degree of persistence in the mortality ratio over time. Further, the estimated effect of most explanatory variables differs both between the dynamic and static models and between the GMM and GMM-SYS models. Most important is that the conclusions regarding the three GP variables differ substantially between the models.¹⁴

In the two dynamic models in Table 3 (GMM and GMM-SYS) the number of GPs, vacant GPs, and contract GPs are treated as endogenous. In both the GMM and GMM-SYS models,

¹¹ GMM and GMM-SYS models are estimated by DPD for Ox; see Doornik et al. (2001).

¹² Notice, however, that the number of GPs is negative and significant if we run regressions without the vacant GPs variable. The number of vacant GP positions may be interpreted as measuring unmet demand.

¹³ Results are reported for two-step GMM and GMM-SYS estimators. However, one- and two-step results are very similar.

¹⁴ We have included many different variables for other types of medical personnel in our regressions, such as per capita number of nurses (different types), total number of employed persons in primary care except GPs, etc. We have also included measures for total expenditures on primary care. These variables were not significantly different from zero and did not affect the main variables in our regressions. Thus, we have dropped these variables from the regressions reported in this paper.

Table 3
Explaining municipal mortality

	OLS	Fixed effect	GMM	GMM-SYS
Mortality ratio (−1)				
GPs	0.107 (0.088)	0.035 (0.143)	0.056* (0.033)	0.105*** (0.041)
Vacant GPs	0.622*** (0.148)	0.676*** (0.161)	−0.479 (0.938)	−0.331 (0.478)
Contracted GPs	0.042 (0.075)	−0.285** (0.136)	−0.591 (0.674)	−0.385 (0.518)
Age 67–79 years	39.337*** (1.891)	24.961*** (3.635)	−0.832 (0.686)	−0.623* (0.349)
Age >80 years	81.591*** (3.057)	111.930*** (6.702)	117.11*** (13.330)	29.450*** (4.445)
High education	−3.020*** (0.509)	−3.151** (1.616)	385.50*** (25.654)	88.720*** (6.910)
Disability	14.328*** (1.050)	4.165* (2.445)	−2.194 (3.611)	−3.088** (1.352)
Unemployment	6.658*** (2.536)	−2.506 (3.610)	0.415 (3.597)	12.708*** (2.037)
Divorce rate	0.111*** (0.023)	−2.506 (3.610)	−12.119 (7.087)	4.622 (4.493)
Population	−0.021*** (0.001)	0.019 (0.023)	0.050 (0.036)	0.107*** (0.036)
Constant	−0.021*** (0.001)	−0.021 (0.019)	0.002*** (0.001)	0.002*** (0.001)
Year 1987	3.445*** (0.410)	5.436*** (1.201)	−0.185 (0.182)	4.048*** (1.164)
Year 1988	−0.005 (0.148)	0.029 (0.139)		
Year 1989	−0.018 (0.148)	0.110 (0.149)		0.041 (0.166)
Year 1990	−0.170 (0.153)	0.052 (0.172)	−0.191 (0.257)	−0.143 (0.173)
Year 1991	−0.105 (0.157)	0.182 (0.193)	−0.050 (0.214)	−0.033 (0.179)
Year 1992	−0.518*** (0.162)	−0.212 (0.214)	−0.468** (0.211)	−0.497** (0.196)
Year 1993	−0.528*** (0.167)	0.229 (0.235)	−0.022 (0.204)	−0.419* (0.229)
Year 1994	−0.235 (0.174)	0.052 (0.257)	0.137 (0.247)	−0.242 (0.227)
Year 1995	−0.725*** (0.172)	−0.511** (0.265)	−0.494** (0.215)	−0.655*** (0.241)
Year 1996	−0.607*** (0.175)	−0.425 (0.289)	0.085 (0.216)	−0.479* (0.258)
Year 1997	−0.662*** (0.177)	−0.554* (0.311)	−0.096 (0.229)	−0.563** (0.255)
Year 1998	−0.504*** (0.177)	−0.466 (0.325)	0.039 (0.246)	−0.394 (0.263)
Year 1999	−0.509*** (0.179)	−0.518 (0.339)	−0.069 (0.217)	−0.418 (0.286)
Year 2000	−0.357** (0.187)	−0.328 (0.371)	0.276 (0.223)	−0.273 (0.296)
Year 2001	−0.322 (0.222)	−0.292 (0.524)	0.245 (0.393)	−0.306 (0.406)
Year 2001	−0.470* (0.225)	−0.441 (0.532)	−0.072 (0.212)	−0.393 (0.429)
Observations	6052	6052	5183	5621
AR(1) test (<i>p</i> -value)			−9.769 (0.000)	−9.379 (0.000)
AR(2) test (<i>p</i> -value)			0.686 (0.492)	1.434 (0.152)
Sargan test (<i>p</i> -value)			260.8 (0.677)	329.7 (0.463)

Static and dynamic models. Results from two-step GMM and GMM-SYS estimator.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

the coefficient on the number of GPs has the expected negative sign, but is still insignificant.¹⁵ The coefficient on vacant GPs goes from positive and significant in the fixed-effects model to negative and insignificant in the dynamic models. Thus, given the current level of GPs, neither of them affects total mortality rates. The composition of GPs, on the other hand, seems to have some influence on the mortality rate. More contracted GPs compared with GPs employed by the municipality decreases mortality rates. However, this effect is only significant in the GMM-SYS model, and only at the 10% level.

In Table 4 we present results from GMM-SYS models where we distinguish between four groups of mortality rates (cancer, circulatory system, respiratory system, and other causes). The

¹⁵ We have estimated several models where we included lags of the GP variable. However, these lags were not significant.

Table 4
Explaining municipal mortality

	Mortality C	Mortality I	Mortality J	Mortality O
Mortality ratio (–1)	0.101** (0.043)	0.112*** (0.042)	0.139*** (0.053)	0.123*** (0.049)
GPs	–0.243 (0.206)	–0.106 (0.396)	–0.136 (0.139)	–0.063 (0.228)
Vacant GPs	0.011 (0.242)	–0.058 (0.389)	–0.027 (0.163)	–0.046 (0.279)
Contracted GPs	–0.400** (0.180)	–0.181 (0.283)	–0.068 (0.154)	–0.392** (0.176)
Age 67–79 years	10.223*** (1.632)	13.547*** (2.576)	1.909 (1.421)	5.714*** (2.114)
Age >80 years	10.005*** (2.840)	46.576*** (4.937)	13.714*** (2.261)	14.163*** (3.572)
High education	0.206 (0.546)	–1.957** (0.944)	–0.295 (0.449)	–0.424 (0.603)
Disability	1.406** (0.665)	7.553*** (1.187)	0.376 (0.548)	3.299*** (1.055)
Unemployment	1.103 (1.845)	6.018* (3.279)	–0.174 (1.554)	–2.661 (2.096)
Divorce rate	0.028 (0.023)	0.042 (0.029)	0.020* (0.012)	0.029 (0.022)
Population	0.001** (0.000)	–0.000 (0.000)	0.001*** (0.000)	0.001*** (0.000)
Constant	0.636 (0.456)	1.996** (0.838)	0.271 (0.341)	1.003*** (0.527)
Year 1988	0.122 (0.084)	–0.110 (0.133)	0.133** (0.055)	–0.107 (0.081)
Year 1989	–0.097 (0.084)	–0.248* (0.131)	0.152** (0.065)	0.022 (0.092)
Year 1990	0.042 (0.093)	–0.216 (0.140)	0.157** (0.065)	0.005 (0.091)
Year 1991	–0.142 (0.098)	–0.480*** (0.145)	0.063 (0.067)	0.039 (0.100)
Year 1992	–0.039 (0.111)	–0.464*** (0.159)	0.167** (0.079)	–0.049 (0.100)
Year 1993	–0.033 (0.110)	–0.519*** (0.173)	0.292*** (0.081)	0.023 (0.111)
Year 1994	0.055 (0.113)	–0.729*** (0.173)	0.089 (0.081)	–0.065 (0.115)
Year 1995	0.023 (0.117)	–0.668*** (0.173)	0.198** (0.081)	–0.028 (0.117)
Year 1996	0.158 (0.120)	–0.646*** (0.177)	–0.027 (0.083)	–0.043 (0.122)
Year 1997	0.264** (0.117)	–0.658*** (0.185)	–0.047 (0.079)	0.069 (0.122)
Year 1998	0.066 (0.125)	–0.673*** (0.196)	0.025 (0.084)	0.145 (0.123)
Year 1999	0.152 (0.125)	–0.649*** (0.201)	0.076 (0.094)	0.179 (0.142)
Year 2000	0.157 (0.175)	–0.732** (0.290)	0.133 (0.131)	0.113 (0.188)
Year 2001	0.298* (0.172)	–0.969*** (0.297)	0.059 (0.131)	0.190 (0.192)
Observations	5621	5621	5621	5621
AR(1) test (<i>p</i> -Value)	–8.845 (0.000)	–9.374 (0.000)	–8.161 (0.000)	–8.277 (0.000)
AR(2) test (<i>p</i> -Value)	1.917 (0.055)	1.569 (0.117)	1.172 (0.190)	0.861 (0.389)
Sargan test (<i>p</i> -Value)	409.6 (0.684)	414.0 (0.776)	406.3 (0.588)	409.0 (0.585)

GMM-SYS models. Results from two-step GMM-SYS estimator.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Sargan test and test for serial correlation are satisfactory. Our conclusions regarding the GP variables remain the same as in Table 3. The effect of number of GPs is negative, but insignificant in all four models. Given the current level of GPs, vacant positions have no effect on mortality rates. Increasing the number of contracted GPs compared with the number of employed GPs reduces mortality rates, but only for mortality groups C (cancer) and O (other causes).

Looking at the other explanatory variables, it is not surprising to find age is an important variable explaining mortality rates at the municipality level. A larger proportion of persons in the age groups 67–79 and above 80 years significantly increase the mortality rate. These effects are found in all models, except for mortality J (respiratory diseases) in the age group 67–79 years. Leu (1986) found that the proportion of the population over 65 years of age was the most important determinant of differences in crude mortality rates among countries.

We find a significant negative effect of education on mortality rates, where we use the proportion of persons with education at high school level or higher as the explanatory variable. Many studies

have found a significant link between schooling and health status (Auster et al., 1969; Grossman, 1972; Kemna, 1987). Fuchs (1998) also pointed to the striking negative correlation between number of years of schooling and mortality, especially for the US. The effect of education on mortality in our data is small in terms of absolute value. We find that a 10 percentage points increase in the proportion having high education reduces the number of deaths per 1000 inhabitants by around 0.3 in the GMM-SYS model; see Table 3. The long-run effect of education is 0.35.

One predicts an increase of around 100 persons in the highest educational group to reduce the number of deaths. However, we do not find the same clear effect of education when we divide mortality into different causes of death. Table 4 shows that this effect is significant only for mortality due to diseases of the respiratory system (group J). See also Bosma et al. (1999) and Deaton and Paxson (1999) for a discussion of the effect of education on mortality rates.¹⁶

In our study, we find a non-significant relationship between unemployment and mortality except for the wrongly specified OLS model. Ruhm (2000) analysed the relationship between unemployment and total (and age-specific) mortality rates, using US state level data for the 1972–1991 period. He found that total mortality exhibited a procyclical variation. However, the expected life span in Norway at birth is 82 years for females and 77 years for males. Thus, most people who die are pensioners, and the non-significant coefficient on unemployment is as expected.¹⁷

6. Concluding remarks

This study finds no significant relationship between mortality rates and the per capita number of GPs in a model that: (a) incorporates municipal fixed effects to allow for unmeasured factors, (b) allows for time persistence in mortality rates, and (c) treats the number of GPs in a district as endogenous. One possible explanation for this result might be related to the issues of patient mobility. If a patient living in a municipality with poor access to primary care visits a GP in a neighbouring municipality with a very good health care system, our estimates would be biased downwards. This point is discussed, for instance, in Robst (2001). However, the patient mobility in the primary health care system in Norway seems to be relatively low compared to findings in other studies, in particular in smaller municipalities (Grimsmo, 1995).

Even though we do not find a significant relationship between GPs and mortality rates, we do find a significant effect of the composition of GPs, where the presence of more independent contract GPs reduces mortality rates compared with situations where more of the GPs are employed by the municipality.

¹⁶ We also included income as an explanatory variable in addition to education. Income turned out to be insignificant in our regressions. Auster et al. (1969) find a positive effect of income on mortality, and at the same time a negative effect of education. Due to the strong trend in income changes over time and the high correlation between education and income, we have dropped the income variable from the final regressions. Deaton and Paxson (1999) find that neither trends in income or income inequality provide plausible explanation for the mortality decline observed in UK and US.

¹⁷ Cutler et al. (2002) used time series data from Mexico to analyse the relationship between mortality and economic crises. They found that mortality rates increased with economic crises, among the elderly and possibly among the very young. They discussed the reasons for an inverse relationship between mortality and economic crises. These were: (1) economic downturns reduce income, which reduces resources for consumption and investment of goods that improve or maintain good health; (2) economic downturns reduce public spending on health, which may affect groups particularly dependent on the public health system; (3) crises and economic conditions affect the informal care that families can provide for children and the aged.

Patients uniformly complain about long waiting times and lack of personal contact with GPs, as reflected in short consultations and long waiting times before the consultation takes place (Johnsen and Holtedahl, 1997). Since contracted self-employed GPs are paid by number of consultations and activity, there is an incentive for increased productivity and possible better quality in self-employed GP practices compared with where GPs are employed by the municipality on fixed salaries. Fixed salary contracts are sometimes used to recruit and retain GPs, especially in rural municipalities where the turnover rate can be high. Carlsen and Grytten (2000) found that places where relatively more physicians are municipally employed were associated with lower consumer satisfaction. The link between employed GPs and satisfaction can be explained by longer waiting times and thus poorer access to health care, and possibly also lower quality of care. These mechanisms can explain the positive effect on mortality rates of an increase in contract GPs relative to employed GPs.

This study cannot be used to determine the optimal number of GPs at the municipality level. We focused on the marginal effect of GPs from the current level of the per capita number of GPs. Given that we measured the effect of additional GPs on mortality rates, it is difficult to judge the effect and benefits of GPs, and compare them with the costs, because the effect on mortality is not usually translated into monetary equivalents. What is one extra year of life worth for one person and can this be compared with the cost to society of an extra GP? An alternative research strategy could measure cost per quality-adjusted life years (QALY). This measure combines both saved life years and quality of life, and could be used to compare the cost-effectiveness of different interventions. We did not have measures of quality of life at the municipality level, and such a measure is not usually available for this type of research. Future work will show if extra GPs affect the quality aspects of life rather than only crude mortality rates.

Even though we found no effect of additional GPs at the current level on mortality rates, we did find a positive effect on mortality rates from increasing the number of self-employed contract GPs relatively to GPs employed by the municipality on fixed salary contracts. Employed GPs have weaker incentives to see patients when compared with contracted GPs, resulting in poorer access to care and quality of care.

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