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Modelling the cost of providing ambulance services

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ABSTRACT

The aim of this paper is to study how regional demography and accessibility patterns influence the cost of providing ambulance services. A secondary aim is to project future costs and demand for ambulance services based on population projections. We use data from south-east Norway, an area with both urban and rural areas. Our results show that accessibility patterns, urbanisation and demography are important factors in determining costs. Furthermore, an ageing population and an ongoing process of urbanisation will have an impact on both the demand for ambulance transport and the cost of providing these services.

1. Introduction

The effect of demographic changes, particularly of an ageing population, on travel demand is a topic which has received considerable attention in the literature in the past decade (e.g. Boschmann and Brady, 2013; Pettersson and Schmöcker, 2010; Mercado et al., 2010; Mercado and Páez, 2009; Newbold et al., 2005). In this paper we concentrate on a very specific type of travel demand, namely the demand for ambulances. Of particular interest is the geographical aspects of demography and demographic change. In our study area in Norway, urban areas tend to have a younger population than the surrounding suburban and rural areas. This pattern is expected to intensify over the coming decades. It is our aim to model how these patterns affect the cost of providing ambulances.

Costs related to the use of ambulance services have increased more than general health expenditures in Norway in the period 2005–2010 (Statistics Norway). There are several possible reasons for this, such as the centralisation of hospitals which has increased travel distances, better equipment, a higher number of better trained ambulance staff, and an increased demand for services from the ageing population (Norum and Elsbak, 2010). Lerner et al., 2006, p. 515 preformed a systematic literature review on papers that evaluate the economic value of Out-Of-Hospital Emergency Care Services (EMS), they conclude that: "There is a paucity of out of hospital care literature (EMS) that addresses cost and economic value."

The literature on EMS may be divided into three broad categories: economic, optimal location, and medical studies. Even though the literature focusing on the economics (costs) of running the ambulances is limited, there is a large literature focusing on the medical side of EMS (Delmelle et al., 2013) and the optimal location of ambulance services (Tavakoli and Lightner, 2004). In this paper, we focus on the cost of running road ambulances. The paper analyses the variation in the cost per capita of providing ambulance services to Norwegian municipalities. Tavakoli and Lightner (2004) compare the EMS services in the Nordic countries (Norway, Sweden, Denmark, Iceland and Finland), and conclude that there are more similarities than differences between these countries. The patterns described in this study are therefore likely to be applicable in the other Nordic countries.

We utilise a standard demand model framework adapted to analyse the public sector (Inman, 1979; Rubinfeld, 1987; Rattsø, 1989), where preferences are described by the age composition of the population and socio-economic variables. Given preferences and budget constraints, the demand equations are estimated based on cross-sectional data for ambulance spending. We model ambulance expenditures as a function of demographic factors and an accessibility measure capturing the distances to different health care providers.

The setting of our study is the south-eastern health region of Norway (Helse Sør-Øst or HSØ). In Norway, ambulance services are supplied by Regional Health Authorities (RHAs), which are state-owned regional health enterprises. In the case of the Helse Sør-Øst region, the ambulance services are devolved to six ambulance districts, which are also responsible for patient transportation.

The RHAs are responsible for all ambulance services, both related to specialist care, also a responsibility of the RHAs, and to primary and long-term care which are responsibilities of local governments (Johnsen, 2006). Ambulance services and other patient transportation accounts for 5.8% of the total spending of the four RHAs, approximately €600 million (4.5 billion Norwegian Kroner) and includes road transportation (ambulances, taxis and buses),

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sea transportation (boats) and air transportation (helicopters and ambulance planes) (Langhelle et al., 2004; Norum and Elsbak, 2011). The health services, including ambulances, are funded by grants from the central government. Except for small user fees for patient transportation, there are no out-of-pocket payments for service users.

The Helse Sør-Øst region covers an area of 103,550 km^2, and has a population of 2.7 million. With the exception of coastal areas, the region is sparsely populated. The hospitals most advanced in treating patients with multi-trauma and other severe illnesses are located in the capital, Oslo. The travelling distance to Oslo from within our study area is up to 379 km.

Table 1 provides some statistics for ambulances in each of Norway's four health regions. As can be seen, the Helse Sør-Øst region has the most ambulances of any health region in Norway. This is partly due to it having the largest population of the health regions, and partly due to the large area.

Note that ambulance helicopters may be used as a substitute for road ambulances. For long distances ambulance helicopters are used to transport critically ill patients to reduce travelling times. Our data do not include helicopter trips, but this is not necessarily a problem as these trips only make up a small proportion (1.6% in 2010) of the total number of ambulance trips.

Based on the findings from the initial analysis, and by using projections of future demographic developments, we obtain an estimate of future ambulance costs. Such estimates are useful in deciding where investments in services should be directed in future. First, it is likely that the ongoing process of centralisation in Norway through rural to urban migration will continue (Harvold and Nordahl, 2012). This suggests lower future costs as travel distances to health providers will be reduced. On the other hand, the population in the rural areas is ageing suggesting higher transport demand and therefore higher costs. Our analysis takes into account these and other factors in projecting future cots.

The paper is structured as follows: Section 2 outlines the theoretical approach taken in the paper. Section 3 describes the study area and the data. In Section 4 we estimate our econometric models and discuss the results. We turn to the issue of projecting future development of costs in Section 5 and then offer some concluding remarks in Section 6.

2. Demand for ambulance services

Public government resource allocation is usually analysed within a demand framework, as surveyed by Inman (1979), Rubinfeld (1987) and Wildasin (1986), and adapted to the Norwegian context by Rattsø (1989). There are two basic elements in the model. First, allocation decisions are restricted by the total revenues, in this case that expenses to ambulance trips sum up to the total revenues given by the grant from the RHA to each ambulance district. Second, the population's demand for ambulance services is conditioned by demand factors such as the size and age composition of the population, and cost factors related for example to the settlement pattern of the population. Formally, utility derived from demand for services, and contingent upon cost factors, are maximised subject to a budget constraint.

Dummy variables describing each ambulance district are included to work as 'fixed effects' in our econometric model. The fixed effects capture supply side variation in services, as well as unobserved demand-side variables. Using this estimation technique we are able to study the effects of the demand-side variables within each region.

Our model utilises variation in the per capita cost of ambulance services allocated to municipal level. Ambulance costs per capita can be decomposed as shown in the following equation:

$$\frac{\text{Cost}}{\text{Inhabitant}} = \frac{\text{Cost}}{\text{Call}} \times \frac{\text{Calls}}{\text{Inhabitant}} \quad (1)$$

Many previous studies in the literature have focused on factors determining the demand for ambulance services. Of course, the demand for services will also influence the total cost of providing the services, which is our variable of interest. Setzler et al. (2009) provide a review of studies which aim to model the demand. Several studies have found that age is an important predictor (Clark et al., 1999; Rucker et al., 1997; Cadigan and Bugarin, 1989; Kvålseth and Deems, 1979; Aldrich et al., 1971), with the highest demand for services occurring in the youngest and oldest age groups. This may have implications for future demand. Hjorthol et al. (2010) notes that an ageing population in Scandinavia is expected to increase health care expenditures. Ambulance expenditures are therefore also likely to increase if demand increases with age.

In addition to age, some studies also find socio-economic factors such as income, ethnicity and employment status to be important predictors of demand (Rucker et al., 1997; Kamenetzky et al., 1982; Kvålseth and Deems, 1979; Siler, 1975).

Studies dealing with the costs of providing ambulance services have tended to focus on optimising the location of ambulance stations, particularly in rural areas (Felder and Brinkmann, 2002; Daberkow, 1977; Daberkow and King, 1977; ReVelle et al., 1977). One of the key constraints in such models is maintaining an acceptable response time (Peleg and Pliskin, 2004). This can be challenging in sparsely populated areas where the demand may be low, but where an ambulance must be kept in a state of readiness.

Rather than predicting the optimal location of ambulance stations, we are interested in analysing what determines the current cost structure. We therefore take the location of the ambulance stations as given. We expect the per capita cost of providing ambulance services to be significantly higher in the sparsely-populated, rural areas of our study area.

3. Data and the study area

Our data cover activities of road ambulances during the years 2009 and 2010 in the south-east of Norway, in the health region Helse Sør-Øst. We average these data over the two years. Some municipalities had to be excluded from the analysis due to incomplete data. These municipalities were in the south of our study area. This left us with a total of 140 municipalities out of the 172 municipalities in the Helse Sør-Øst region.

The region covers a diverse area, from the capital Oslo and the urban areas concentrated around Oslo Fjord to sparsely populated

Table 1
Summary of ambulances in Norway by health region. Source: Statistics Norway. Expenses excluding depreciation, by type of expenditure and activity.

Region	Ambulances	Hours per week	Number of assignments	km driven	Area (km^2)	Population
Sør-Øst	197	27,720	300,504	14,191,411	103,550	2,707,012
Vest	82	12,570	86,895	4,181,492	40,791	1,012,202
Midt-Norge	94	17,465	73,675	4,614,407	53,200	673,364
Nord	125	21,754	75,328	5,780,605	106,708	465,621
Total	498	79,509	536,402	28,767,915	304,249	4,858,199