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Exploring the limitations of age-based models for health care planning

Thomas Mason [a,*], Matt Sutton [a], William Whittaker [a], Stephen Birch [a,b]

[a] Centre for Health Economics, Institute of Population Health, University of Manchester, Manchester, UK
[b] Centre for Health Economics and Policy Analysis, McMaster University, Hamilton, Canada

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ABSTRACT

Health care decision makers are required to make planning decisions over a medium to long term planning horizon. Whilst population ageing is an important consideration for planners, age-stratified demographic models may produce misleading estimates of future resource requirements if the actual relationship between age and health is not fixed. We present a methodology which tests whether the assumption of a fixed age–health relationship is valid and estimate the magnitude of planning errors using a long time-series of measures of chronic health and service utilisation (N = 2419) taken from the Great British General Household Survey (1980–2008). We find that age-only models contain significant omitted variable bias, and that the relationship between age and health varies significantly across birth cohorts. Chronic sickness has fallen across birth cohorts born between 1890 and 2008, particularly before birth year 1930. Generational health improvements have mitigated the effects of population ageing, meaning that the population rate of sickness fell between 1980 and 2008. Planning based only on age leads to overestimation of the population level of health care need if successive cohorts are becoming healthier. Many alternative approaches exist which allow planners to relax the assumption of a fixed relationship between age and health.

1. Introduction

Population ageing is a salient consideration for policymakers making decisions relating to the future allocation of resources. This is particularly germane in public health and health care policy-making, where decisions relating to the future allocation of resources often require decision-makers to plan for the future in the medium to long-term. The mean and median age of the population is increasing in many developed Western economies. The population in England and Wales, for example, is set to continue to increase in both size and average age (ONS, 2012a, 2012b). Health care planners might assume that this would lead to an increase in estimated future resource requirements in the absence of any technological, epidemiological or policy changes.

In public health and health care, decision-makers often restrict their focus to changes in demographics and ignore the possible effects of technological and epidemiological changes. Typically, plans are based on historical rates of service use per capita within arbitrary age groupings (see House of Commons Health Committee (2007) and Curson et al. (2010) for reviews of planning methods). For example, the Centre for Workforce Intelligence (the national health workforce planning organisation for England) estimated the future requirement for specialists in respiratory medicine until 2031 by applying historical rates of service use by five year age bands to future population estimates in these age bands (CfWI, 2011); and adopted the same approach for estimating requirements for other medical specialties (CfWI, 2010). Other studies have also used demographic projections by age to drive estimates of future health care resource requirements - either exploiting historical rates of utilisation by age, or assuming arbitrary continuations of past trends in rates of utilisation by age (Commission on the Future of Health Care in Canada and Romanow (2002); Lowthian et al., 2011; Shipman et al., 2004; Stabile and Greenblatt, 2010).

There are two problems with such an approach. Firstly, it conflates need with service use. Planning on this basis creates 'illusions of necessity' (Evans, 1985) as use of care is determined, at least in part; by health care supply (i.e. no independent measure of health care need in the population is being considered). Using historical measures of service use to plan resource requirements perpetuates historical over and under supply. Decision-makers should therefore use the best available measures of populations' health care needs

* Corresponding author.
E-mail address: thomas.mason@manchester.ac.uk (T. Mason).

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and not direct measures of service use.

The second problem with this approach is the focus of this paper: the implicit assumption that the relationship between age and health need does not vary over time (i.e. between successive generations). The main problem with the use of planning based on observed age-specific rates per capita is the implicit assumption that age is the only driver of the need for health care, with need assumed to remain constant by age over time. This causes future service requirements to be driven purely by demographic dynamics rather than epidemiological changes. The problems with basing planning on the utilisation of health care services or on age-only have been recognised when allocating health care budgets between geographical areas (Gravelle et al., 2003), but these insights have not been applied to planning future national health care resource requirements.

A singular focus on the effects of ageing can lead to discrepancies between estimates of future requirements and the reality. Previous studies have noted the overestimation of the impact of ageing on the need for services and total health care expenditures. Zweifel et al. (1999) noted that total health care expenditure depended on remaining lifetime as opposed to age, implying that the impact of population ageing on future expenditure growth would be less than many were predicting (Bös and von Weizsäcker, 1989). More recent studies have also concluded that “ageing will not contribute much to future growth of per capita health expenditure” (Steinmann et al., 2007).

Previous studies have demonstrated that the relationships between age and indicators of population health vary over time: for example Parkin et al. (1999) illustrate that population health and related health care variables exhibit complex patterns which cannot be satisfactorily captured by age alone; and Holford (1991) demonstrated the issues and limitations that result from the existence of time trends that are strongly related to age in large datasets. Denton and Spencer (1999) illustrated that age-specific survival has changed over time using Canadian data, implying that traditional definitions of ‘old age’ had become outdated as a basis for policy development and service planning. Denton et al. (2003) applied these findings to estimations of physician requirements in Canada. However, these studies limited attention to the impact of changes in survival on planning future resources without considering differences in health status (and hence need for health care) within surviving populations. In this paper we extend the notion of changes in survival to also incorporate changes in health among survivors.

Discrepancies in the medium and long-term estimates of health care resource requirements are unsurprising given that forecasting in not an exact science. However, the goal of decision-makers is to minimise these discrepancies and allow the best chance of allocating resources optimally.

The advantage of an age-based model at the population level is that the data required to construct such a model are generally easily available. Historical rates of service use in age bands can be applied to future population estimates (with the same age banding) to give total service use in each age band. The bands can then be summed to give an estimate of the total population service requirements in each year. Alternative approaches which may set out to improve the precision of medium to long-term planning models need to preserve the simplicity of the data requirements for policymakers. In this paper, we focus on allowing the relationship between age and health needs to vary, without significantly increasing the data requirements of current approaches. Current models tend to use historical rates of service use applied to estimates of the population by age. We propose two simple changes: firstly, to use a measure of need and not use; and second, to allow for generational differences in need between birth cohorts.

The focus of this paper is to consider whether medium to long-term analyses of the impact of ageing on public policy should contain sufficient flexibility for changes in the epidemiology of populations to be incorporated. We test whether the assumption that the relationship between health and age is identical across different generations is valid; and the extent to which this assumption may lead to discrepancies in estimates of future resource requirements is quantified. Using time-series data, we identify the separate effects of age, year of observation and birth cohort using methods developed for the analysis of the relationship between ageing, savings and economic growth (Deaton and Paxson, 1994). We show how the estimated future levels of health vary depending on whether we use age-only models or methods which allow for generational differences.

The application provides empirical evidence of the flaw in current approaches to planning and illustrates the scale of the errors inherent in this approach. The framework we set out is one approach amongst many (Glenn, 2005; Smith, 2008) which can be adopted in order to relax assumptions about the relationship between health and age whilst maintaining simple data and estimation requirements. A large literature exists on the modelling of age, year and cohort. The most commonly used method was introduced by Mason et al. (1973) and involves equating either two age, two period, or two cohort dummies; which allows for estimation. The strength of this method lies firstly in its simplicity; and second in that the underlying assumption is not usually a substantial misrepresentation of reality, particularly if adjacent dummies are equated. We adopt a similar age, year and cohort approach for similar reasons: to keep the model simple for practical use by planners, and because we do not believe that the identifying assumption is unreasonable.

2. Methods

We assume that the decision-maker wishes to estimate the health of the population for some future year, $T+x$. This total level of health (H) can be expressed as the total size of the population (P) multiplied by the mean level of health per capita (h).

$$H_{T+x} = P_{T+x} h_{T+x} \tag{1}$$

In most countries, future population estimates are produced based on the key determinants of population dynamics: birth rates, death rates and migration rates (ONS, 2012a). The strata that the decision-maker can use for estimates are limited by data availability. The availability of consistent historic data is of primary concern, requiring census data or representative survey data on health over enough years to identify trends. Age is commonly available in most historic datasets and these strata are also often available in population estimates. Therefore, the decision-maker can enhance (1) by stratifying by age (j):

$$H_{T+x} = \sum_{j=1}^{J} \left(P_{j,T+x} h_{j,T+x} \right) \tag{2}$$

The key consideration for the decision maker is how to estimate $h_{j,T+x}$. The traditional approach is to apply a set of historical age-specific values ($h_{j,t-y}$) to population estimates (sometimes with age refinement). This is the equivalent to running a standard regression model of health on a set of age dummies (a_j). This is feasible using data from only one cross-section but we assume access to multiple cross-sections and we estimate:

$$h_{j,t} = \kappa + \beta_j a_{j,t} + \varepsilon_{j,t} \tag{3}$$