Making projections of long-term care: examples and methodological issues

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PSSRU Discussion paper 2004

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1. Introduction:

As the numbers of older people rises throughout the world, there have been concerns about the future affordability of public expenditure, particularly on pensions, health care and long-term care. In this context, the European Union's Economic Policy Committee (EPC) conducted a study of the impact of ageing on future public expenditure on pensions, health and long-term care and how it would affect the fiscal sustainability of public finances (Economic Policy Committee, 2001).

Projected increases in the numbers of users of long-term care, and concerns about the future availability of care provided by the family and other informal carers, have attracted more attention to the issue of the provision and financing of long-term care. There have been debates about how to provide and finance long-term care in most of Europe. These debates have concentrated, mainly, on the extent to which long-term care is an individual, family or state responsibility; the balance between care provided by families and public and private sector providers; financing arrangements, especially the balance between public finance and private payments; whether to provide care in-kind or cash payments; and the boundaries between health and social care (see, for example, Ikegami and Campbell 2002, Glendinning 1998, Karlsson 2002, OECD 1996).

These debates about the sustainability of public finances and how to provide and finance long-term care raise many questions. How many older people are likely to require long-term care services in the coming decades? How much are these services likely to cost? Will the cost to public funds prove affordable? In order to address these issues, it is useful to have reliable projections of future demand for long-term care and associated future long-term care expenditure.

Projections of long-term care demand can also be valuable as aids to planning. They can be used to illustrate the growth in supply of care required as the numbers of older people grow, and the impact that changes in the patterns of care could have on the volumes of services required.

This paper discusses various methodological approaches to making projections of future long-term care demand and expenditure. Section two discusses and, provides examples of, the main two approaches: cell-based models and microsimulation models. Section three discusses in detail the methodological approach chosen in the development of a specific model: the Personal Social Services Research Unit (PSSRU) long-term care model. Projections made with the PSSRU model are presented, as well as a discussion of the sensitivity of long-term care projections to various factors. Finally, section four concludes with some recommendations on making long-term care projections.

2. Critical analysis of different long-term care projections models

Projections of long-term care demand and expenditure can be produced in many different ways. Which method is best depends very much on two factors: what is the purpose of the projections, and what data are available. The main purposes of long-

term care projections tend to be, as discussed in the introduction, to assist in the planning of long-term services; to investigate the future affordability of long-term services; and to estimate the future implications of possible changes in patterns of care or funding mechanisms.

The availability of suitable data is, in most countries, an important limiting factor, when considering how to make long-term care projections. Long-term care has historically accounted for only a small proportion of public expenditure, especially compared to health care. As a result, few countries have systematically collected much data on long-term care provision and expenditure.

There are broadly two main approaches to making projections: cell-based (or macrosimulation) models and microsimulation models. The main feature that distinguishes the two types of model is that microsimulation models have as their unit of analysis individual people, families or households, while cell-based models have, as their unit of analysis, aggregates of individuals grouped by their characteristics (such as age and gender). Most long-term care models are cell-based, not only because it is a much simpler method of making projections, but also because very few countries have the data required to produce microsimulation models.

This section describes some examples of both cell-based and microsimulation models. It discusses the advantages and disadvantages of both approaches, and concludes with an example of the combination of a macro and a microsimulation model, and some recommendations on choosing an approach. A useful discussion outlining the differences between the two methods and their advantages and disadvantages is available in Wittenberg *et al*, (1998, p. 28). Spilauer (2002) has also compared both approaches in his review of microsimulation models.

2.1. Cell-based (or macrosimulation) models

Most models used to make projections of future demand for long-term care or of future expenditure are cell-based models that, as stated before, have as a unit of analysis groups of people rather than individuals. Most cell-based models are built using a spreadsheet. While it is possible to develop sophisticated systems of scenarios, the models tend to be relatively straightforward from a computing point of view.

In cell-based models the overall population is represented by an aggregated cross-classification table, in which the cells represent each possible combination of the characteristics considered. The number of cells grows with the number of characteristics and too many cells could make the models unwieldy. Most long-term care cell-based models (partly as a result of lack of data) only consider a limited number of variables and a result the number of cells does not become a problem. The model developed by the Personal Social Services Research Unit (PSSRU model) in the UK, which does have a considerable number of variables, deals with the potential explosion in the numbers of cells by limiting the number of variables used to those that are relevant in each part of the model. For further details, see section 3 of this paper.

There are several different types of cell-based models. The purpose for which the projections are made, the long-term care systems that they represent and the

availability of data determine to a great extent the design and complexity of the models. Below are descriptions of various long-term care cell-based models. An attempt has been made to classify them according to the factors they take into account.

Expenditure profile modelling:

The simplest form of long-term care projections model, which is also one of the most frequently used, consists in applying the current average costs of care for people of each age (and sometimes gender) group to the future numbers of people in that age (and gender) group. These average costs for each age and gender group are often called "expenditure profiles".

This method of making projections has the advantage of very low demands in terms of data and computing, and is widely used. It has been used in international comparisons by the OECD and, more recently, the European Union's Economic Policy Committee (EPC, 2001). As long as the data on the costs of care have been calculated using similar methods and coverage in the different countries, the projections obtained using this method are, in principle, highly comparable.

With regards long-term care, however, not all countries have even such basic data readily available. In the EPC study, while all EU countries (except Luxemburg) were able to provide age and gender specific health expenditure profiles, only ten countries provided them for long-term care. The lack of basic data partly reflects the absence in many countries of information systems to compile data on long-term care use and expenditure.

The main limitation of the "expenditure profile" projections is that they make the implicit assumption that the only factors that affect future long-term care expenditure are demography and inflation. However, there are many factors other than age that will determine future demand of long-term care and expenditure. Age is effectively just an imperfect proxy for need in such models.

The sensitivity of projections produced using this type of model can be investigated in respect of alternative demographic projections and alternative inflation assumptions. The sensitivity of these projections to changes in the prevalence of disability, the proportion of older people living alone or patterns of care cannot be readily investigated.

In the UK, the Department of Health model (House of Commons Health Committee, 1996, see also the review by Wittenberg, 1999) used age-specific expenditure profiles as its starting point, but adjustments were then made for assumed changes, under varying scenarios, in real costs of care, age-specific disability rates and some other factors.

Models that allow the exploration of dependency trends:

A slightly more sophisticated approach, used by Lagergren and Batljan (2000) in Sweden, is to calculate the long-term care costs of people with different degrees of

dependency. The model then applies prevalence rates of functional dependency to the projected future population in order to obtain the future numbers of people with dependency and, finally, their long-term care costs. This approach makes it possible to investigate separately the impact of changes in mortality and dependency on the future costs of long-term care.

A review by Wittenberg of models of long-term care projections (Wittenberg, 1999) identified, in Britain, two cell-based models that also went beyond age and gender expenditure profiles. The Institute of Actuaries' model (Nuttall et al, 1993, now partly updated by Rickayzen and Walsh, 2002) made projections of the future numbers of disabled people and of the costs of caring for them on varying assumptions about changes in age-specific mortality and disability rates. Hours of care demanded were estimated by assigning an assumed number of hours per week for each level of disability. The London Economics and the Institute for Public Policy Research (Richards et al, 1996) study effectively used the Institute of Actuaries central scenario, with some minor changes in assumptions, as its starting point on projected numbers of disabled people for each year to 2030. It then concentrated on estimating the breakdown of the aggregate level of care demanded between informal care, publicly funded care and privately funded care. The review by Wittenberg (1999) describes these models in detail.

Models that allow the exploration of changes in patterns of care:

A recent international study (Comas-Herrera and Wittenberg, 2003) investigated future long-term care expenditure in four different countries (Germany, Spain, Italy and the United Kingdom) and their sensitivity to factors such as demography, changes in the prevalence of dependency, changes in the balance between informal and formal care, changes in the balance between domiciliary and institutional care, and in the rates of growth of the unit costs of care. The study used existing models in Germany and the UK. A model for Spain was substantially expanded for use in the study, and a new Italian model was developed for the project. Three of those models are described below. The UK model, developed by the Personal Social Services Research Unit (PSSRU model), is described in more detail in section 3 of this paper.

The Spanish model is based on an earlier simpler model developed by Casado (Casado and Lopez Casasnovas, 2001). It was further developed by Patxot and Costa-Font as part of the European study (Patxot and Costa-Font, 2003). Their model calculates the future numbers of people with dependency by applying current dependency rates to the projected population. It then applies, to the future numbers of dependent older people, the current utilisation rates of services. The model can be used to investigate changes in mortality, dependency trends, utilisation of services and the future unit costs of care.

The Italian model was developed specifically for the European study by Comas-Herrera, Di Maio, Gori and Pozzi (2003). The model uses a similar structure as the Spanish model described above. There was only a short amount of time available to develop the model and the team were not able to explore all the possible sources of data. This model is currently being reviewed and improved by Vanara and Gori (?).

The German model was developed by Rothgang (Rothgang, 2003) to make projections of the future numbers of beneficiaries of public long-term care insurance, and of the future contribution rates for public long-term care insurance, under a number of scenarios. Rothgang's model applies the prevalence rates of the various degrees of dependency (that determine entitlement to insurance benefits), by age and gender, to the future numbers of older people. The model then calculates long-term care insurance expenditure by applying the value of the benefits to the numbers of recipients. This projected expenditure is then applied to a simple labour force and pensions model to calculate the future contribution rates necessary under various scenarios.

The value of the benefits in the German model depends not only on the severity of dependency but also on the type of benefits chosen. There is a choice between cash-benefits, in-kind care in people's own home, a mixture of cash and in-kind benefits, and institutional care. The model's base case assumes that the proportion of people by age, gender and dependency that choose the different types of benefits remains unchanged. Sensitivity analysis can be used to investigate the expenditure impact of changing the choice of benefits (as well as the impact of different assumptions about future mortality, dependency and changes in the real unit costs of care). A change in the choice of benefits would result, effectively, in a change in patterns of care.

None of the models described above consider whether older people live alone or with others, or whether they have access to an informal carer. They also do not consider the socio-economic status of care users. These are important factors in the demand for long-term care services, as changes in household composition or the economic situation of older people will affect their future demand for long-term care services. The UK's PSSRU model (and a nearly identical replica done for Catalonia, see Lopez-Casasnovas, Casado and Comas-Herrera, 2003) is, as far as the authors know, the only long-term care cell-based model that takes household type and economic situation (housing tenure) variables into account.

2.2. Microsimulation models

Microsimulation models can be defined as models that use simulation techniques and that take micro-level units (that is, in the case of long-term care models, the individual, family or household) as the basic units of analysis. They permit a more detailed consideration of distributional factors than cell-based models. A useful review of microsimulation methods in health care modelling can be found in Spilauer (2002).

Dynamic (as a opposed to static) microsimulation models simulate changes over time and in response to context changes. Monte-Carlo simulation, using information on transition rates between states, is used to determine transitions of micro-units from one state to another at each time period. Such transitions could include mortality, onset of dependency or admission to residential care.

Dynamic microsimulation models have the advantage of allowing the consideration of events over the lifetime. They can be used, for example, to simulate how long a person can expect to live in each of a number of health or dependency states. They can also be used to simulate a link between contributions to a pension or other

saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle.

Dynamic microsimulation models are potentially useful for the purposes of modelling future demand for long-term care and expenditure. The reason that there are not many such models (besides the substantial investment in data analysis and computing involved) is that the data they require is not available in most countries. A dynamic microsimulation model of long-term care would require a longitudinal data collection from which to draw information on transitions in health (or dependency) states and other variables including the use of long-term care.

The following sections describe three microsimulation models. Two of them are from the US and the third one investigates charging for long-term care in the UK.

US models

The Brookings Institution and Lewin-VHI Inc, and the Urban Institute, have developed Long-Term Care models using microsimulation techniques. In the US longitudinal data on health states, disability and use of long-term care is available from the National Long Term Care Survey and other surveys. The health state, family circumstances, incomes and other characteristics of a sample of individuals are simulated year by year to their deaths. The outputs of the microsimulations are grossed up to match official population projections by age and gender. These models have been described in some detail and compared with cell-based models by Wittenberg (1999).

The Brookings Institution and Lewin-VHI Inc. Long-Term Care Financing Model was originally developed in 1986-7 but updated and refined in 1988-9 using new data. This model projects the size, financial position, disability status, and nursing home and home care use and expenditures of elderly people through the year 2020. Expenditures are further extrapolated on a broader basis to the year 2050. The model has been used to simulate the effects of changes in the system for financing long-term care in the USA (Wiener et al, 1994). The model starts with a nationally representative sample of the adult population, with a record of each person's age, gender, income, assets, and other characteristics. It then simulates changes to each individual from 1986 to 2020. The changes simulated include onset and recovery from disability and commencement and termination of receipt of long term care services.

The Brookings Institution Lewin-VHI study assigns a source of funding for all elderly people who have been modelled to receive home care or nursing home care. Medicare funding is considered before payment from other sources. Where a person is admitted to non-Medicare nursing home care, the costs are attributed to the person's income and then non-housing assets. When the person's assets have been spent down to the Medicaid threshold, Medicaid is assumed to pay the difference between the person's income (less a personal allowance) and the Medicaid payment rate. In this way the Medicare and Medicaid systems are simulated.

The Urban Institute's Dynamic Simulation of Income Model (DYNASIM) was used to project the elderly population's characteristics, incomes, and needs to the year 2030 (Zedlewski et al, 1990). The study considers the future numbers of elderly people with

different levels of disability, incomes and other characteristics, under varying assumptions about future mortality and disability rates. It does not include projections of long-term care expenditure.

Both studies consider future trends in marital status and numbers of children as part of their simulations but do not investigate sensitivity to alternative assumptions. Marriage, divorce and widowhood are included in the microsimulations as is child-birth. Official data are used on marital status and on fertility. The related issue of the proportion of elderly people living alone is also considered in both models. The studies do not, however, make a link between living arrangement, as opposed to marital status, and probability of receipt of long term care.

Both studies consider income and assets in some detail in their simulations. The Urban Institute model was designed specifically to look at incomes, while the Brookings Lewin-VHI Long Term Care Financing Model is based on the Lewin-VHI Pension and Retirement Income Simulation Model (PRISM).

The studies modelled receipt of home care and receipt of residential care separately as functions of individual characteristics such as age, gender and dependency. The relationship between these characteristics and receipt of care is assumed to remain constant over time, at least as a base case. The Brookings Institution model gives the user a facility to simulate an increase in home care use and/or in nursing home use by adjusting the estimated probabilities of service receipt by a factor assumed for induced demand.

Informal care is not directly covered in either model. They take actual propensities to receive care in a base year as their starting point for projections. The Brookings study considers the impact on the balance between public and private expenditure of potential changes in real incomes and assets.

The Nuffield Community Care Studies Unit model

The Nuffield Community Care Studies Unit (NCCSU), in the UK, has developed a microsimulation model to simulate long-term care charges under different charging regimes (Hancock, 2000). It contains detailed information on the incomes, wealth, housing and other relevant characteristics of sample members, sufficient to make good estimates of their liability for care charges. The model permits analysis of the distributional consequences of different long-term care funding options.

The NCCSU model simulates what each older participant in the UK's Family Resources Survey would have to pay towards care home fees should he or she need long-term care. The model performs simulations for single people currently aged 65 and over, and for the older partner in couples where at least one partner is aged at least 65 years. The simulations are performed for a base year and for future years. Simulations for future years involve: ageing the sample of those currently aged 65 or more, allowing for deaths and the consequent effects of widowhood; modelling the evolution of their incomes and capital under certain assumptions; and making assumptions about future costs of care and the care charging, social security benefit and income tax regimes which will be in place for the year of interest. The model

makes a number of simplifying assumptions such as, for example, in predicting death there is no allowance for differences in mortality by income, social class or housing tenure.

Because it is more difficult to predict the future incomes of people who are not yet retired than it is for those who are already drawing pensions, the base year sample is not 'refreshed' as it is aged. This restricts the years and age ranges for which the model produces projections.

The microsimulation model does not predict how many or which older people will need care. It simply calculates what each person in a representative sample of older people would be required to contribute to the costs of residential or nursing home care should he or she need it, and how much would be contributed from different parts of the public purse. British data shows that, controlling for age, residents in care homes are, in comparison with older people generally, disproportionately likely to have lived alone and to have rented rather than owned their homes (Netten et al, 1998). Housing tenure and whether living alone are also both characteristics which affect liability for long-term care charges as well as probability of admission to care homes.

The NCCSU and PSSRU[1] jointly produced projections of future long-term care expenditure through an innovative linkage of their two models. This involved using outputs from the NCCSU microsimulation model as inputs to the PSSRU cell-based model. The NCCSU model produced projections of the future proportions of older people eligible for public funding should they require residential care and of their future contributions to the costs of their care under different funding arrangements. The PSSRU model produced projections of total public and private expenditure on long-term care to 2051 on the basis of the NCCSU projections and assumptions about future trends in life expectancy, dependency, real unit costs and patterns of care (Wittenberg et al, 2002 and Hancock et al, forthcoming).

2.3. Advantages and disadvantages of both approaches

Microsimulation models would offer some advantages for making projections of long-term care for older people, compared to cell-based models. One advantage, specially relevant for models that look at financing long-term care, is that they permit a more detailed consideration of distributional factors than cell-based models. An example would be the way in which different funding systems affect different income groups. In cell-based models the investigation of distributional issues is restricted to distribution by the variables used to define the cells.

A second advantage of microsimulation models is that, as discussed above, they can also be used to simulate a link between contributions to a pension or other saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle. This is important where a contributions-based insurance system is under consideration.

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[1] This research was financed by the Institute of Public Policy Research (IPPR), UK.

A further advantage is that the number of cells in cell-based models grows with the number of characteristics and too many cells could make the models unwieldy. In practice, most long-term care cell-based models (partly as a result of lack of data) consider only a limited number of variables and the number of cells does not in practice become a problem.

While there are many advantages to microsimulation (and in particular dynamic microsimulation) models, it is important to be aware that constructing a microsimulation model is a complex and time-consuming task. As discussed in Wittenberg et al (1998, p. 130), "... such work is not likely to be cost-effective unless there is a policy interest in the types of question that can only be answered through microsimulation; suitable data – generally longitudinal data- are available; and the expertise and resources are available".

Unfortunately, in most countries suitable data is not available, which is a key reason why cell-based models are more widely used. A useful approach to enable the investigation of distributional issues is to combine a cell-based model for long-term care with an existing microsimulation model of the incomes and assets of older people, as discussed above and in Hancock et al (forthcoming).

3. The PSSRU model

The PSSRU long-term care projections model was constructed as part of a project on long-term care finance, funded by the English Department of Health since 1996. The project is concerned with two related policy issues on the funding of long-term care for older people. The first is whether expenditure, and specifically public expenditure, on long-term care will remain sustainable over the coming decades, despite demographic pressures and potentially rising expectations. The second is what should be the balance between public and private expenditure on long-term care.

A detailed account of the long-term care projections model and of the data and assumptions and the methodology used can be found in Wittenberg *et al* (1998), a report that describes the first version of the model. The model has been regularly updated and expanded. A paper exploring sensitivity of an updated version of the model to various assumptions was published in Health Statistics Quarterly in 2001 (Wittenberg *et al*, 2001). The latest version of the model is described in Comas-Herrera et al (2003a).

The initial model was used to provide projections for the Royal Commission on Long-Term Care[2] (1999). More recently, new versions of the model have been used to provide projections for the HM Treasury Health Trends Review (Wanless, 2002) and for the Institute of Public Policy Research (Wittenberg *et al*, 2002 and Hancock *et al*, forthcoming). The latter involved innovative linkage between the PSSRU model and a microsimulation model developed by the Nuffield Community Care Studies Unit (NCCSU), as discussed above.

[2] A high level group set up by the Government to review the financing of long-term care and make recommendations about its future financing.

As well as the main model, other versions of the model have been developed. One of them investigates the future long-term care costs of cognitive impairment (Comas-Herrera et al 2003b), using MRC CFAS data (MRC CFAS, 1998). This enabled separate projections to be made of services for older people with cognitive impairment under a range of assumptions about future prevalence rates of cognitive impairment. This version of the model will be further described in section 3.5. Versions of the model have been developed for the National Assembly for Wales (Comas-Herrera et al, 2003c) and for the Catalan regional Government (Lopez-Casasnovas et al, 2003).

This section contains a discussion of the methodological issues addressed in designing the PSSRU model, in particular with regards the modelling of demand. It then provides a detailed description of the model, the assumptions made, and the base case projections.

3.1. Methodological choices in modelling demand and supply of long-term care

The PSSRU model aims to make projections of three key variables: the future numbers of dependent older people, the likely level of demand for long-term care services for elderly people and the costs associated with meeting this demand. The model covers public and private services and expenditure. It is cell-based (a macro-simulation model) and takes the form of a spreadsheet. An in-depth discussion of the methodological approach adopted in designing the model is available in Wittenberg et al (1998). This section summarises some of the main points.

The first, crucial point is that *the model does not make forecasts about the future.* It makes projections on the basis of specific assumptions about future trends. The approach involves simulating the impact on demand of specified changes in demand drivers, such as demographic pressures, or specified changes in policy, such as the introduction of free personal care. It does not involve forecasting future policies or future patterns of care.

The second important point is to clarify the concept of demand in this context. Demand generally refers to the quantity of a good of service that people want to purchase at a given price. The demand by a person for goods or services is generally taken to be a function of the person's income, the price of the good, the price of other goods that may be close substitutes or complements, and the person's tastes. The latter may in turn be a function of the person's age, gender, occupation, health state, and other personal characteristics.

The demand for long-term care is complicated by at least three issues. First, it is important to consider the relationship between need and demand, which is discussed below. Second, it is important to distinguish between demand for different types of care. In particular it seems important to differentiate between demand that could be met by either informal or formal care and demand for formal health and social services. Third, it is difficult to observe "demand" alone. What is observed from data on service use is a combination of demand and supply (Norton, 2000).

Relationship between need and demand

Need for long-term care may arise from a number of sources or combination of sources. It may arise from limitations in physical health and/or in mental health. It may arise from a combination of limitations in health and difficulties in the person's environment, such as poor or unsuitable housing. Demand is not the same as need. It takes account of the person's ability and willingness to purchase the good or service. Demand for long-term care would arise if the person actually sought long-term care and was willing to pay, if required.

These considerations suggest that demand for long-term care can be regarded as a function of the following variables: age, gender, physical health, mental health, income, assets, preferences, and the costs of care (Evandrou and Winter, 1988; Davies et al, 1990 and Norton, 2000). A model of long-term care demand should in theory consider all of these. Preferences, however, are clearly intangible and changes in preferences or expectations are problematic to project.

Demand for different types of care

It is possible to distinguish three forms of long-term care in terms of costs to the care recipient. These are informal care by family and friends, publicly funded formal care, and privately purchased formal care. The first generally involves no financial cost to care recipients, the second may involve a cost depending on whether public support is subject to charges, and the third clearly involves a financial cost to care recipients or their families. This consideration, together with the potentially different nature of formal services and informal care, mean that the different types of care need to be considered as separate subsets of overall demand for long-term care.

Demand and supply of informal care

Demand for informal care could in principle be regarded as a function of the same variables as demand for long-term care generally. The concept of demand for informal care, however, has little meaning in practice in the absence of family or friends willing to supply such care; that is, in the absence of potential supply. Since a proportion of dependent people do not have a surviving close relative or friend, for some people informal care is not an option.

The supply of informal care depends on the availability of a potential carer. The most recent data on informal carers supplied by the General Household Survey (GHS) confirms that the majority of informal care is provided by spouses, children and children-in-law (Maher and Green 2002).

The supply of informal care depends not only on the availability of a potential carer but also on the potential carer's ability and willingness to provide care. The carer's ability and willingness to provide care may be affected by the carer's health and other commitments, including employment and child-care responsibilities. It may also be affected by the carer's income. People with higher incomes may prefer to purchase care

for their elderly relative, as the cost of any employment lost, that is, the opportunity cost of caring, would be higher.

The supply of informal care is clearly central, yet it cannot be considered independently of demand. Not all informal care is supplied to people with a need for care in the sense that they are dependent or disabled in some way. There is evidence that much informal care for elderly people is supplied to people who do not have disabilities and that carers often give care irrespective of need (Daatland 1983, Wenger 1992). This again relates to a fundamental characteristic of informal care. It is not just that people who need care do not necessarily receive it from the informal sector, it is also that caregivers often give care irrespective of need. If, then, the concern is with the support of dependent elderly people, not all the informal care supplied is relevant.

To consider the factors influencing whether or not an older person receives informal care, it is necessary to bring together the factors affecting demand and supply. This suggests that the provision of informal care to an individual is a function of the person's dependency, income, preferences, and availability of a partner, child or possibly other relative living nearby, and also of the potential carer's health, income, employment status, marital status, child-care responsibilities and preferences.

The PSSRU model treats the receipt of informal care as a function of the person's dependency (as an indicator of need) and of the person's household type (as an indicator of the likely availability of informal care). The former may be regarded as a demand variable and the latter as a supply variable. The function is thus a reduced form[3] that seeks to model actual receipt of informal help rather than a demand or a supply function.

Relationship between formal and informal care

It is important to consider the nature of the relationship between formal and informal care. An important issue is whether the amounts of formal and informal care provided are determined jointly, or whether the amount of formal care provided can be considered as a function of the amount of informal care. Joint determination implies that both informal and formal care are determined at the same time, with the level of informal and formal care jointly determined by the parties involved. Consecutive determination implies that formal care follows informal care sequentially and that informal care is taken into account when formal services are provided.

The approach to informal care adopted by service providers in the UK, certainly prior to the community care changes of the early 1990s, has been characterised by a model that treats carers as a resource and provides formal services very much in response to the amount of informal care received (Twigg and Atkin 1994). This is reflected in the importance of household composition as a variable determining receipt of formal services, since household composition to a large extent reflects the amount of informal care (Evandrou et al 1986, Evandrou 1987, Evandrou and Winter, 1988).

[3] By a "reduced form" function is meant the summarisation in one equation of a reciprocal inter-relationship between variables requiring two or more equations to describe in full. The single equation takes the perspective of the influence on one only of two causally interdependent variables.

For this reason, the PSSRU model has a sequential form. In the model, household type is one of the variables that determines receipt of informal care. Indeed, so close is the relationship between household type and informal care that the most recent version of the PSSRU model treats household type and informal care as a single variable with five categories: living alone without informal help, living alone with informal help, single living with others, married/cohabiting living with partner only and married/cohabiting living with partner and others. Receipt of informal care/household type, in turn, is one of the variables that determines receipt of formal care in the model.

Demand for formal care

This discussion of the relationship between formal and informal care suggests that the demand for formal care should be treated as a function not only of the variables affecting overall demand for long-term care but also of the provision of informal care. This is on the basis that formal care can and does sometimes substitute for informal care, especially when it is unavailable, and that informal care provision is often determined before formal care. The demand for formal care can, therefore, be regarded as a function of the person's age, gender, physical health, mental health, income, assets, preferences, and receipt of informal care, and of the costs of care.

For those with no informal carers, the overall demand for long-term care is effectively a demand for formal services. For those receiving informal care, the demand for formal services may be regarded as a demand for additional types of care or additional hours of care that remain unmet. Alternatively, or additionally, there may be a demand for formal services to provide respite for informal carers. This suggests that carer stress may be a further relevant factor.

The role of supply constraints in observed demand

The supply of formal services also requires discussion. Demand for long-term care alone is difficult to observe and the data used on service use is, in fact, a combination of demand and supply. The overall supply of publicly funded care is affected by policy decisions at central and local level about priorities for public expenditure. In modelling demand for formal care, these policy decisions need to be treated as exogenous to the model. This is on the basis that the purpose of the modelling is to inform decisions on public expenditure by providing information on projected changes in demand. To take account of policy constraints on supply in a model aiming to inform policy decisions on supply of public funds would be circular.

Market constraints on supply are also very important. A key constraint is the need to retain the inputs to formal care, especially care staff. Expenditure projections need to incorporate assumptions about unit costs of care and about rises in the real costs of care. These could be understood as assumptions about the real rises in wages and other payments for inputs to care that are necessary to ensure that supply is sufficient. Expenditure projections would thus effectively assume that supply of formal care will adjust to match demand for formal care and that demand will be no more constrained by supply in the future than in the base year. This is on the basis of an appropriate assumption about real rises in care costs.

Other methodological choices

The model contains a relatively large number of variables that, when combined in a cross-tabulation, create a relatively large number of categories (cells), as discussed below. This can cause a problem when using data from sample surveys, as the number of observations that relate to people in each category (cell) in the cross-tabulation may become too small. The PSSRU model deals with this problem by using multivariate (logistic regression) analysis to determine which variables, such as age, gender and dependency, are statistically significant in explaining the use of different services. The fitted values from the analysis are used as the probability of receipt of services for people in each category.

Another important feature of the design of the model is that it has been built in a way that allows the testing of alternative hypotheses about trends in the key factors affecting future demand for long-term care and expenditure. A nearly automated menu of alternative assumptions about trends in key factors has been developed that allows almost any combination of assumptions for the different factors to be tested.

3.2. Description of the model

The model described below seeks to model the demand for formal long-term care services, as a function of some of the key variables discussed in this section. These include not only the elderly person's age, dependency and other characteristics but also the person's receipt of informal care. The latter is a function of demand and supply factors relating to informal care.

The model does not seek to incorporate variables concerning the supply of formal care. It does not seem appropriate to do so, since one of the purposes of the model is to inform policy decisions concerning the supply of publicly funded care. Supply considerations are not, however, absent from the model. Assumptions are made about future rises in the real costs of care. These need to be sufficient to retain the inputs, especially staff, required to provide the levels of care demanded.

The description of the model provided here was first published in Comas-Herrera et al (2003a). The model consists of four main parts. The first part estimates the numbers of older people with different levels of dependency by age group, gender, household type and housing tenure. The second part estimates the levels of long-term care services required, by attaching a probability of receiving health and social care services to each cell. The third part of the model estimates total health and social services expenditure, and finally, in the fourth part, total expenditure is allocated to the various sources of funding.

Part One: Projected numbers of older people

The first part of the model classifies the projected numbers of older people into subgroups (or cells), according to age bands, gender, dependency and other key characteristics. The model uses the Government Actuary's Department (GAD 2003

and Shaw 2003) 2001-based interim population projections as the basis for the numbers of people by age band and gender in each year under consideration until 2031.

The projected older population by age band and gender are separated into dependency groups. The model uses as a measure of dependency the ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Four dependency groups have been used in the model (Box One). Information from the 1998/9 General Household Survey (GHS) was used to break down the private household population into the four groups.

BOX ONE
DEPENDENCY GROUPS USED IN THE PSSRU MODEL

The four dependency groups used in the model are as follows:

1. People able to perform ADL (personal care) tasks and IADL (domestic care) tasks without difficulty.
2. People with difficulty with IADL but not ADL tasks.
3. People with difficulty with one ADL task.
4. People who live in the community and have difficulty with two or more ADL tasks, and people who are in institutional care (hospital, nursing home or residential care home).

Another key factor in the receipt of long-term care is household type. Household type is an important structural correlate of informal care (Pickard *et al.* 2000). Informal care is combined with household composition in a five-fold classification: living alone without informal help; living alone with informal help; *de facto* single, living with others; married/cohabiting couple; and married/cohabiting couple, living with others. Household types where older people live with others, including married/cohabiting couples, have not been broken down between those with and without informal carers because all older people living with others have a potential carer and most of those who are dependent have an actual carer. In the 1998/9 General Household Survey (GHS), over 90% of dependent older people living with others received informal help with domestic tasks.

Projections of informal care/household composition in the PSSRU model are driven by the 1996-based GAD marital status and cohabitation projections (Shaw 1999, Shaw and Haskey 1999). The two marital status groups (those who are *de facto* married and those who are *de facto* single) are broken down into five household types using the 1998/9 GHS. The projections assume a 'steady state' regarding the propensity within marital status groups to live with others.

The model includes, for those living in private households, a simple breakdown by housing tenure, between those living in owner-occupied tenure and those living in rented accommodation. One reason for the inclusion of housing tenure is that it can be regarded as a simple proxy for socio-economic group. Another is that it is

relevant, in the case of older people living alone, to the division between those who fund their own residential or nursing home care and those who are funded by their local authority or health authority. The current means test for public support in residential or nursing home care generally takes account of the value of the person's home (unless it is occupied by their spouse or an older or disabled relative). This means that older home-owners who live alone generally need to fund their residential or nursing home care privately, while older tenants and older home-owners living with their spouse are often eligible for public funding.

The model divides the population into 440 cells. 40 of these relate to the institutional population by age (5 bands), gender, previous household type (2 categories) and previous housing tenure (2 categories), and 400 to the household population by age (5 bands), gender, dependency (4 groups), household type/informal care (5 categories) and tenure (2 categories).

It is important to point out that, as discussed in section 3.1, the 440 cells is the maximum number of combinations that the variables and categories used yield. In practice, the model does not use all the variables and categories simultaneously.

Part Two: Projected numbers of service recipients

The second part of the model projects the volumes of services demanded by combining the output of the first part of the model (the projected numbers of older people by dependency, household type/informal care and other characteristics) with functions that assign receipt of services to each sub-group of the older population. The services covered include a range of health and social services relevant to meeting long-term care needs.

The probability of receipt of each non-residential service, such as home care, day care, and community nursing, was estimated through multivariate (logistic regression) analysis of the 1998/9 GHS data. The independent variables were age, gender, dependency, marital status, household type/informal care and housing tenure. Separate analyses were undertaken for dependent and non-dependent older people, as few non-dependent older people received services other than chiropody and private domestic help. For non-dependent people, age was statistically significantly associated with probability of receipt of each service and gender, marital status and tenure with receipt of some services. For dependent people, age, severity of dependency and marital status or household type were statistically significantly associated with probability of receipt of most services, and gender and housing tenure with receipt of some services.

Demand for domiciliary services was calculated by using the fitted values from the logistic regression models as the estimated probabilities of receipt of each service by age band, gender, dependency and the other factors described above. These fitted values were then multiplied by the projected numbers of older people within each cell by age band and other needs-related circumstances to produce estimates of the numbers of service recipients.

Finally, these estimates of numbers of service recipients were multiplied by estimates of the average intensity of service receipt, i.e. the average number of home help hours or district nursing visits per recipient week. Information on intensity of service receipt by dependency was also obtained from the 1998/9 GHS.

The probability of receiving residential, nursing home or long-stay hospital care was estimated using a combination of data. Official national statistics were used on the total numbers in residential care homes and nursing homes (Department of Health, 2000a). A proportionate breakdown of care home residents by age band, gender, previous household type and previous housing tenure was derived from PSSRU surveys of residential care (Netten *et al*, 1998) and applied to the totals. This approach enabled the proportion of older people in residential care and nursing home to be estimated by age band, gender, household type and housing tenure. Hospital Episode Statistics data on the numbers of older patients by age and gender with stays exceeding 55 days were used as estimates of the numbers in long-stay hospital care. In the absence of data on this group's previous household type and housing tenure, a breakdown from the PSSRU survey data on nursing home residents was applied to hospital residents.

In summary, the numbers of recipients (*SERNO*) of each service (*j*) was estimated as:

$$SERNO_j = \sum_{i=1}^{440} p_{ij} \cdot n_i ,$$

where p_{ij} is the probability of a person in cell *i* (i=1 to 440) receiving service *j* (j=1 to 9) and n_i is the number of older people in cell *i*.

Part Three: Projected aggregate expenditure on long-term care services

The third part of the model projects the total expenditure on the formal services demanded applying unit costs of formal care, drawn from a PSSRU study (Netten *et al.* 2001a) and from Laing and Buisson (2001), to the volume of services projected in the second part of the model. The unit costs were uprated to 2001 prices using the health and social services deflators available from Netten *et al* (2002). The model covers the costs to the health service, social services and users of services, for those services included in the model. Estimated expenditure on home care and community nursing services has been grossed up broadly to match official data.

In summary, the model estimates total expenditure on long-term care (E_t), for each year (*t*), as the sum across all formal health and social services considered, *j* (j = 1 to 9) of the following: projected number of service recipients in year *t* ($serno_{jt}$) multiplied by the intensity of service receipt in terms of hours/visits per week (int_j) and multiplied by the unit cost of care inflated to the year to which the projection year relates (c_{jt}). This can be shown as:

$$E_t = \sum_{j=1}^{10} serno_{jt} \cdot int_j \cdot c_{jt}$$

Part Four: Projected breakdown of expenditure between funders

The fourth part of the model breaks down projected aggregate expenditure by source of funding: NHS, social services and service users. The costs of the health services included are assigned to the NHS. The costs of the social services are divided between personal social services and service users. As there are no national data on the quantities of privately funded care, the projections for privately funded care, especially on non-residential care, need to be treated with caution as it is not possible to verify that all privately funded care is captured by the model.

Residents of residential care and nursing homes are divided into privately and publicly funded residents. The breakdown for 2000 is based on Laing & Buisson data (Laing & Buisson, 2001) for independent sector homes and 1996 PSSRU survey data (Netten *et al*, 1998) for local authority homes. The Laing & Buisson estimates for the proportion of residents who are privately funded were reduced by two percentage points to take account of the changes to the funding system introduced in April 2001. The future trend in this proportion is derived from the projected rise in home-ownership by older people who live alone.

Expenditure on local authority funded residential care, home care, day care and meals is divided between local authority social services and users on the basis of Department of Health data on the proportion of gross costs of social services met by user charges. The proportion of costs met by users is held constant for future years. The full costs of privately funded residential and nursing home care and private domestic care, and a proportion of the costs of all other social services, are thus assigned to users.

3.3. Base case assumptions and projections

The PSSRU model produces projections on the basis of specific assumptions about future trends in the key drivers of demand for long-term care. The main assumptions used in the base case of the model are summarised in Box Two below. The base case projections take account of expected changes in factors exogenous to long-term care policy, such as demographic trends. The base case projections hold constant factors endogenous to long-term care policy, such as patterns of care and the funding system. The base case is used as a point of comparison when the assumptions of the model are subsequently varied in alternative scenarios.

BOX TWO

KEY ASSUMPTIONS OF THE BASE CASE OF THE PSSRU MODEL

- The number of people by age, gender changes in line with the latest Government Actuary's Department (GAD, 2003) 2001-based population projections.
- Marital status changes in line with GAD 1996-based marital status and cohabitation projections.

- There is a constant ratio of single people living alone to single people living with others and of married people living with partner only to married people living with partner and others
- Prevalence rates of dependency by age and gender remain unchanged, as reported in the 1998/9 General Household Survey (GHS) for Great Britain.
- Home-ownership rates, as reported in the 1998/9 GHS, rise in line with the Anchor Housing Trust projections (Forrest *et al*, 1996).
- All dependent older people living with others receive informal care.
- The proportions of older people receiving informal care, formal community care services and residential and nursing home care services remain constant for each sub-group by age, dependency and other needs-related characteristics.
- Social care unit costs rise by 1% per year and health care unit costs by 1.5% per year in real terms. Real Gross Domestic Product would grow by 2.25% per year.
- The supply of formal care will adjust to match demand[4] and demand will be no more constrained by supply in the future than in the base year.

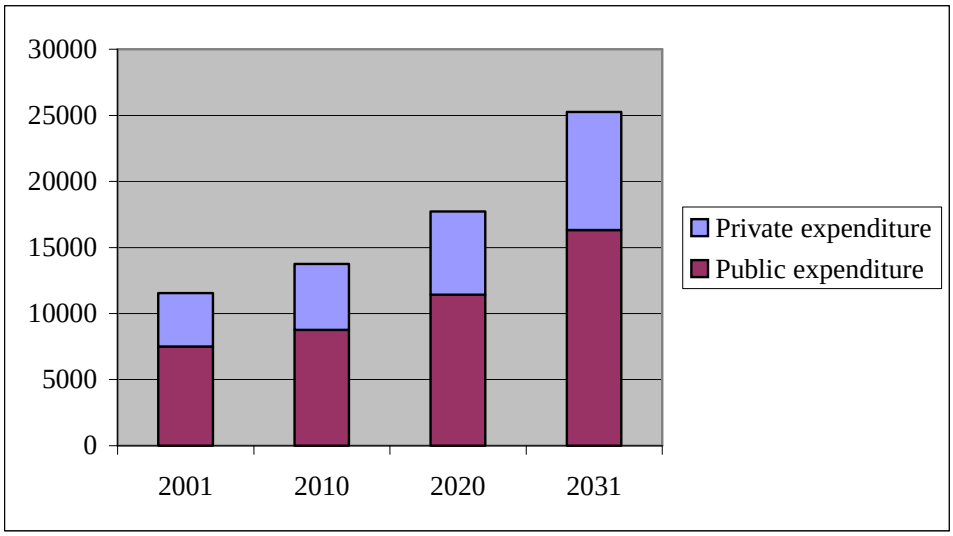
The GAD 2001-based principal population projections for England project that between 2001 and 2031 the numbers of people aged 65 or more will rise by 54%. The numbers of those aged 85 or more are projected to rise faster during this period, by 81%, from more than 950,000 to around 1,732,000. Much of this increase is a result of a projected rise in male life expectancy. Between 2001 and 2031, the numbers of men aged 85 or more are projected to rise by 155%, compared to a 52% rise in the number of women in that age group.

Under the base case assumptions, the numbers of dependent older people[5] would grow by 57% between 2001 and 2031, from 2,567,000 to 4,020,000. The numbers of users of non-residential formal services would rise by 58%, from 1,532,000, to 2,416,000. The numbers of older people in institutions would also rise by 58%, from nearly 400,000 to 627,000.

Figure 1: Projected expenditure (£m) by source of funding, England, 2001-2031, under base case assumptions.

[4] The model effectively assumes that the real rise in wages and other payments for care will ensure that supply is sufficient.

[5] Defined as having problems with at least one IADL or one ADL.



Projected long-term care expenditure would grow by 118%, from nearly 11.6 billion in 2001 to just above 25 billion in 2031 (figure 1). If Gross Domestic Product rose by 2.25% per year, long-term care expenditure would grow from 1.46% of GDP in 2001 to 1.64% in 2031. Table 1 shows these base case projections in greater detail.

Table 1: Projected numbers of older people (thousands), service recipients (thousands) and expenditure (£ billion) under base case assumptions, 2001 to 2031.

	2001	2010	2020	2031	% growth 2001 to 2031
Numbers of older people (aged 65 or more)	7,821	8,455	10,073	12,049	54.1%
Numbers of people aged 85 or more	957	1,127	1,313	1,732	80.9%
Numbers of older people with some dependency	2,567	2,773	3,258	4,020	56.6%
Numbers of users of local authority home help services	372	399	457	586	57.8%
Numbers of users of community nursing services	422	453	533	657	55.7%
Numbers of users of private domestic help	745	846	993	1,231	65.2%
Numbers of users of any non-residential service[6]	1,532	1,653	1,935	2,416	57.7%
Numbers of people in residential care homes	238	257	293	373	57.1%
Numbers of people in nursing homes	134	145	168	213	59.1%
Numbers of people in institutions	397	430	493	627	57.8%
Public long-term care expenditure (£ billion)	7.5	8.8	11.4	16.3	117.4%
Private[7] long-term care expenditure (£ billion)	4.1	5.0	6.3	8.9	120.2%

[6] Local authority home care, district nursing, day centre care, meals or private domestic help

Total long-term care expenditure (£ billion)	11.6	13.8	17.7	25.3	118.4%
Total long-term care expenditure as a % of GDP	1.46%	1.42%	1.44%	1.64%	12.3%

Source: model estimates.

The model produces projections of future long-term care expenditure based on a specified set of base case assumptions. This set of assumptions seems plausible but is clearly not the only possible set. A substantial part of the PSSRU study of long-term care projections has involved the investigation of the sensitivity of the projections to changes in the assumptions made in the model, which is discussed below.

Finally, it is important to point out that the expenditure projections obtained using the model do not constitute the total costs of long-term care to society. That would require inclusion of the costs of a wider range of services to a wider range of public agencies and service users and the opportunity costs of informal care. It should also be stressed that no allowance has been made for changes in public expectations about the quality, range or level of care.

3.4. Sensitivity analysis in the PSSRU model: the effect of changes in the key assumptions

This section examines the model's sensitivity to any changes in the key assumptions, with particular regard to changes relating to the future numbers of older people, dependency rates, the availability of informal care, patterns of formal care and the unit costs of care.

Future numbers of older people

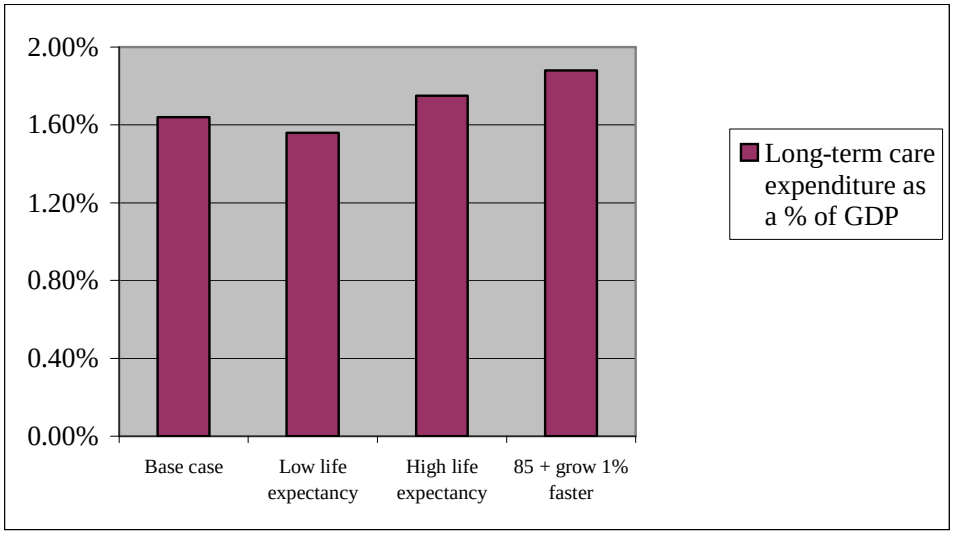
The Government Actuary's Department (GAD) population projections for England produce a rise of 54 per cent in numbers of people aged 65 or more between 2001 and 2031, while numbers of those over 85 will rise by 81 per cent.

Mortality rates in old age are the key factor affecting the projected number of older people, and numbers of very old people in particular. As the proportion of older people with dependency rises sharply with age, the model's projections are very sensitive to the assumptions about the numbers of very elderly people. Figure 2 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions. The assumptions are: the GAD's low and high life expectancy 2000-based population projection variants, and an assumption according to which the numbers of people aged 85 or more would rise faster than projected by the GAD's principal projection, by 1% more per year. This assumption has been chosen because it corresponds roughly to the extent of past under-estimation of the numbers of very elderly people (Shaw, 1994). According to data gathered by Robine (2003), the official population projections of most European countries have consistently underestimated the future numbers of older people, specially of the very old. It is debatable whether the most

[7] Includes user fees and co-payments.

recent UK projections, based on a changed approach (Shaw, 2000), will still prove to be under-estimates.

Figure 2: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about changes in life expectancy

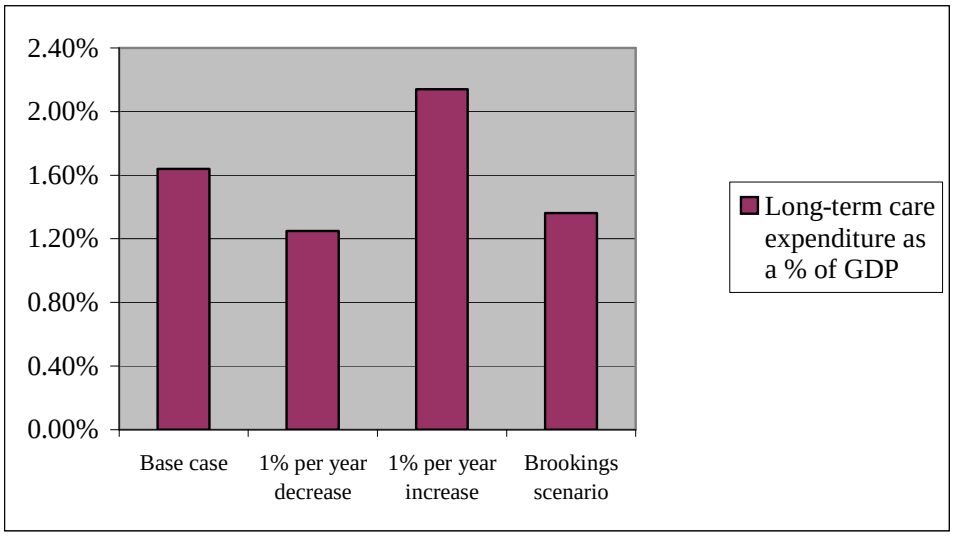


Dependency

If falling mortality rates were accompanied by falling rates of dependency, this would (at least partially) offset the impact of demographic pressures on demand. Constant dependency rates could be regarded as a pessimistic assumption. The 'Brookings scenario' is a less pessimistic assumption that moves the age-specific dependency rate up by one year for each one-year increase in life expectancy.

While there are differing views about whether age-specific dependency rates can be expected to rise, fall or remain much the same, projections of demand for long-term care are highly sensitive to assumptions about dependency. Figure 3 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions: a 1% increase and decrease per year in the prevalence rates of dependency, and the 'Brookings scenario'.

Figure 3: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about dependency trends.



Availability of informal care

The GAD marital status projections imply that there is likely to be an increase in spouse carers of dependent older people, at least until 2020 (see Wittenberg et al, 2001 for more details). The PSSRU model base case takes this into account, but does not take into account other possible changes in the availability of informal care.

The proportion of older people living with an adult child in Great Britain declined from 42 per cent in 1962 to 14 per cent in 1986, and has subsequently declined still further (Grundy 1995, Grundy and Glaser 1997). If by 2031 fewer older people receive informal care from children living in the same household, it could be assumed that more people may move into residential homes. In addition, it is possible that more older married couples may also require admission to residential care, if there is a decline in informal care by children.

Various scenarios have been developed to test the impact on the model's projections for formal services of a decline in informal care. Compared to the base case, all of these produce varying degrees of increases in public expenditure and increased numbers of those in institutional care. But much depends on the size of the decline in informal care and on the extent to which such care is substituted by residential care or by moderate packages of domiciliary services.

Future patterns of care

The model can be used to explore the impact of changes in the patterns of services. The scenarios explored assume a shift in the balance of care from institutional to domiciliary, a change in the eligibility criteria for home care and an increase in support for informal carers.

The first scenario considered here assumes that projected numbers in nursing and residential homes would by 2020 be 10 per cent lower than the base case, and that

people 'diverted' from nursing homes would receive an average of eight hours' home care and 1.5 community nurse visits a week while those 'diverted' from residential homes would receive eight hours' home care. This follows a similar scenario in the National Beds Inquiry for England (Department of Health, 2000b).

The second scenario investigated the potential impact of introducing a national entitlement to free formal care for all older people with moderate to severe dependency (two or more ADLs) whether or not they were receiving informal care. (This scenario mirrors, to a certain extent, the entitlement to long-term care in Germany). This scenario assumes 5.75 hours of formal home care a week and 100 per cent take-up.

The GAD marital status projections suggested that in future there was likely to be an increase in spouse carers of dependent older people. However, many spouse carers are elderly and in need of support themselves. The third scenario looked at providing support to the most heavily burdened carers (defined as those providing personal care to older people living in the same household) and explores the implications of making the same services available to those living with others as those living alone: the 'carer-blind' approach.

In the first scenario, projected public spending was lower than in the base case as the packages of domiciliary care were less costly than institutional care. The national entitlement scenario, however, had substantial cost implications with numbers of those using home help nearly doubling. Under the 'carer-blind' scenario projected long-term care expenditure would also be higher than under the base case.

Unit costs and economic growth

Spending on long-term care is highly sensitive to relatively small changes in future unit costs. The base case of the model assumes that real unit costs will rise in line with historical trends in input pay and prices: one per cent per year for social care and 1.5 per cent a year for health care. GDP is assumed to rise by 2.25 per cent a year.

Residential care, home care and day care are all highly labour intensive. An alternative scenario investigates the impact of assuming that future unit costs will rise in line with projected rises in earnings. This scenario is based on the Treasury's long-term assumptions, published in the 2003 Budget (HM Treasury, 2003), for productivity growth (as an indicator of possible future rises in care staff earnings) and for growth in GDP. In this scenario, spending on long-term care would rise to nearly £31bn compared to £25bn under the base case.

Overall findings of the sensitivity analysis

Overall, the sensitivity analysis shows that projected future demand for long-term care services for older people in the UK is sensitive to assumptions about the future numbers of older people and about future prevalence rates of dependency. It is also sensitive to assumptions about the future availability of informal care. Projected future expenditure on long-term care for older people is also sensitive to assumptions

about future rises in the real unit costs of services, such as the cost of an hour's home care. The sensitivity of the model to changes in the assumptions made means that the projections should not be regarded as forecasts of the future.

A recent international study[8] investigated the sensitivity of projections of long-term care expenditure for older people to assumptions on trends in the key drivers of demand for care (Comas-Herrera and Wittenberg, 2003). This comparative study investigated the key factors that are likely to affect future expenditure on long-term care services in Germany, Spain, Italy and the United Kingdom. The approach involved investigating how sensitive long-term care projections are to assumptions made about future trends in different factors, using comparable projection models.

The sensitivity analysis showed that projections of long-term care expenditure in all four countries are sensitive to assumptions about future mortality and dependency rates. They are also highly sensitive to assumptions about future real rises in the unit costs of care. They are sensitive to scenarios involving a relative decline in informal care where this results in greater use of residential care. They are somewhat less sensitive to assumptions about changes in the patterns of formal care.

3.5. Projections of long-term care expenditure due to dementia

As discussed in section 3.4, future demand for long-term care and associated expenditure are very sensitive to changes in the assumptions made about trends in dependency of older people. The definition of dependency used in the PSSRU model is based on the ability to perform instrumental activities of daily living (IADLs) and activities of daily living (ADL). One of the causes of difficulties in the performance of IADLs and ADLs is dementia. Most of those with dementia who require long-term care are likely to have difficulties with IADLs or ADLs. It is unlikely that a model of long-term care demand that uses IADLs and ADLs would omit large numbers of older people requiring long-term care. Nevertheless, , there are important reasons for having a model that can distinguish between those who have functional dependency only and those who have functional dependency and suffer from dementia.

The first reason is that there are important differences in the patterns of care for people with and without dementia given the same ADL problems, specially for those with severe cognitive impairment. People with severe cognitive impairment are more likely to rely on formal care and, in particular, are more likely to be institutionalised (Bauld et al, 2000, Boersma *et al*, 1997, and Netten *et al*, 2001b). If the future numbers of people with dementia were to rise at different rates than the future numbers of people with ADL problems due to other causes, projections made using a model that only used an overall ADL definition would not be appropriate to plan the future services required for people with dementia.

Another reason why it is important to have a model that takes specific account of dementia is that it would permit an investigation of the potentially cost-saving impact

[8] Funded by the European Commission.

of new drugs for people with Alzheimer's Disease. This would be an important issue to explore.

PSSRU[9] developed a version of their model to make projections, for the next 30 years, of future numbers of older people with cognitive impairment, their demand for long-term care services and the future costs of their care under a range of specified assumptions (Comas-Herrera et al, 2003b). The term cognitive impairment is used here to describe one of the manifestations of dementia.

The study set out to explore the impact of factors that are likely to affect future long-term care expenditure associated with cognitive impairment, in particular changes in the future prevalence rates of mild and severe cognitive impairment. The study also investigated the impact of changes in the patterns of care specific to those with dementia, for example, increasing support to informal carers.

The study found that, under the base case, the numbers of people with cognitive impairment would increase faster between 1998 and 2031 than the numbers of people with functional disability only (66% and 58% respectively). This implies that demand for long-term care will rise at a faster rate among those with cognitive impairment than would be suggested by projections of the overall demand for long-term care based on functional disability. For example, between 1998 and 2031, the number of people with cognitive impairment in institutional care is projected to increase by 63%, compared to a projected 52% increase in the total number of older people in institutions. These results show that, when planning future service requirements for older people with cognitive impairment, it would be important to have specific projections.

The results of the model also showed that, unless more effective treatments for cognitive impairment are developed and made widely available, the numbers of older people with cognitive impairment will rise significantly over the next 30 years. This means that substantial rises in formal services will be required. The implication is that there is a need to develop, and make widely available, better treatments to slow down the progressive decline associated with dementia.

4. Conclusion: recommendations on making long-term care projections

4.1. Choosing the methodological approach

When designing a long-term care projections model, the first step is to be clear on the purpose of the modelling. Key questions are whether the aim is to produce aggregate projections of the future numbers of older people requiring long-term care and of long-term care expenditures, or to investigate the impact of alternative financing mechanisms on different groups. The purpose will influence the choice of type of model, for example, whether to construct a cell-based or microsimulation model.

[9] Funding from the Alzheimer's Research Trust and access to MRC CFAS data (MRC CFAS, 1998) are gratefully acknowledged.

Another key aspect to be clear about is the coverage of the model. Important questions include: will the model include only older people? Will it cover both public and private expenditure or just public long-term care expenditure? Will it include informal care by family and friends or only formal services?

The second step is to investigate all the available sources of data. The ideal situation would be to find a nationally representative survey covering the health, dependency, household situation, income, assets and long-term care use of people in the community and in care homes and hospitals. Single surveys with all the relevant information are not available in most countries. As a result, a variety of sources containing information on some of the aspects need to be used. The description of the UK's PSSRU long-term care model in section 3 explains how various sources of information were used to obtain an overall picture (in terms of data) of long-term care in the UK. The quality of the data used and the construction of a baseline that represents as accurately as possible the current long-term care arrangements is crucial for the reliability of the projections.

Determining the architecture of the model is a complex exercise. In the case of cell-based models it is necessary to balance the need for sufficient cells to address the range of policy issues with the need for a model simple enough to be useable. The greater the breakdown into more cells, the greater the flexibility of the model; but too many cells could render it unduly complex to build and use.

If opting for a cell-based model, it is also important to consider whether there are existing microsimulation models that already model the income and assets (as well as other characteristics) of older people. If so, it may be possible to combine a cell-based model of long-term care projections with a microsimulation model that investigates the impact of different funding mechanisms over time and between different groups.

4.2. Choosing the base case set of assumptions

Projections models generally need to incorporate initial assumptions on future levels of key variables. These may be that key variables will remain constant over time, change in line with past trends or change in line with expert views. Long-term care models need to incorporate assumptions about future trends in the main drivers of demand for long-term care and long-term care expenditure.

It is useful to choose a core set of assumptions about future trends to form a 'base case' that can act as a reference case against which the effect of changes in the different assumptions can be investigated. The approach taken in the UK's PSSRU model has involved taking account within the base case of expected changes in factors exogenous to long-term care policy[10], such as trends in the numbers of older people by age, gender and marital status, and holding constant factors endogenous to long-term care policy, such as patterns of care and the funding system.

[10] The definition of exogenous and endogenous factors use here should be interpreted in relative terms rather than absolute terms: all factors could be at least partly endogenous in the sense that they could be affected by policy changes in the long-term.

The factors affecting the future numbers of dependent older people requiring long-term care are mainly exogenous to long-term care policy. They include demographic change and dependency rates. These two factors affect the overall need for long-term care. There are other important exogenous factors that also affect demand for long-term care, either by influencing the propensity to seek care or by influencing the type and amounts of care that will be sought. These factors include individual preferences, which may reflect age, gender, income and other personal characteristics but which are difficult to model. Demand for formal care is also crucially affected by the availability of informal care.

As well as the exogenous factors mentioned above, the receipt of long-term care is influenced by factors endogenous to long-term care policy, such as the availability and accessibility of formal services, the funding system, and the policy incentives or disincentives to the provision of informal care.

Future long-term care expenditure is determined not only by changes in the volume of services demanded but also by rises in the unit costs of long-term care, such as the cost of an hour's home care. Since long-term care services are labour-intensive services, trends in the unit costs of care will depend largely on trends in the earnings of care staff. The future affordability of long-term care depends also on how much the economy grows in the future.

The PSSRU model aims, as discussed above, to use base case assumptions that reflect "expected changes" in the main exogenous factors. However, there is not always consensus on what assumptions reflect those "expected changes". While using the official population and marital projections as base case assumptions is not very contentious, the choice of a base case assumption for trends in dependency and in unit costs is less straightforward as there is no consensus in the literature about future dependency rates and long-term economic trends. It is important to keep the base case assumptions under review in the light of new evidence.

4.3. Carrying out sensitivity analysis and interpreting the projections

Given the great degree of uncertainty about future trends in the drivers of demand for long-term care, it is very important to carry out sensitivity analysis to investigate the impact of changing each of the base case assumptions of the models.

The importance of the results of the sensitivity analysis lies in the fact that it is beyond the present state of knowledge to set probabilities for future trends in the factors examined. Yet it is important for policy and planning purposes to demonstrate the extent of sensitivity of future long-term care expenditures to assumptions about these trends. The findings of the PSSRU and other models suggest that policy-makers need to plan for uncertainty in future demand for long-term care for dependent older people. Future mortality and prevalence rates and rises in unit care costs, which are inevitably uncertain, have substantial implications for future demand for long-term care and associated expenditure.

It is also important to recognise that most models will not have taken account of the

impact of rising expectations, as their likely impact would be very difficult to measure and quantify. It seems plausible that rising real incomes will be accompanied by rising expectations for more and better quality care.

The approach taken by the PSSRU study of long-term care projections has been to emphasize that the model makes projections based on assumptions, rather than forecasts. That means that, instead of asserting what the future demand for long-term care and expenditure will be, the model's projections show what the future demand and expenditure would be like given the assumptions specified.

Acknowledgements

Most of the research reported here has been carried out as part of the Personal Social Services Research Unit's long-term research programme, financed by the Department of Health. Bleddyn Davies and Robin Darton have contributed to some of the research reported in this paper. All views reported here are those of the authors. The report does not purport to represent the views of the Department of Health.

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Making projections of long-term care: examples and methodological issues

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PSSRU Discussion paper 2004

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1. Introduction:

As the numbers of older people rises throughout the world, there have been concerns about the future affordability of public expenditure, particularly on pensions, health care and long-term care. In this context, the European Union's Economic Policy Committee (EPC) conducted a study of the impact of ageing on future public expenditure on pensions, health and long-term care and how it would affect the fiscal sustainability of public finances (Economic Policy Committee, 2001).

Projected increases in the numbers of users of long-term care, and concerns about the future availability of care provided by the family and other informal carers, have attracted more attention to the issue of the provision and financing of long-term care. There have been debates about how to provide and finance long-term care in most of Europe. These debates have concentrated, mainly, on the extent to which long-term care is an individual, family or state responsibility; the balance between care provided by families and public and private sector providers; financing arrangements, especially the balance between public finance and private payments; whether to provide care in-kind or cash payments; and the boundaries between health and social care (see, for example, Ikegami and Campbell 2002, Glendinning 1998, Karlsson 2002, OECD 1996).

These debates about the sustainability of public finances and how to provide and finance long-term care raise many questions. How many older people are likely to require long-term care services in the coming decades? How much are these services likely to cost? Will the cost to public funds prove affordable? In order to address these issues, it is useful to have reliable projections of future demand for long-term care and associated future long-term care expenditure.

Projections of long-term care demand can also be valuable as aids to planning. They can be used to illustrate the growth in supply of care required as the numbers of older people grow, and the impact that changes in the patterns of care could have on the volumes of services required.

This paper discusses various methodological approaches to making projections of future long-term care demand and expenditure. Section two discusses and, provides examples of, the main two approaches: cell-based models and microsimulation models. Section three discusses in detail the methodological approach chosen in the development of a specific model: the Personal Social Services Research Unit (PSSRU) long-term care model. Projections made with the PSSRU model are presented, as well as a discussion of the sensitivity of long-term care projections to various factors. Finally, section four concludes with some recommendations on making long-term care projections.

2. Critical analysis of different long-term care projections models

Projections of long-term care demand and expenditure can be produced in many different ways. Which method is best depends very much on two factors: what is the purpose of the projections, and what data are available. The main purposes of long-

term care projections tend to be, as discussed in the introduction, to assist in the planning of long-term services; to investigate the future affordability of long-term services; and to estimate the future implications of possible changes in patterns of care or funding mechanisms.

The availability of suitable data is, in most countries, an important limiting factor, when considering how to make long-term care projections. Long-term care has historically accounted for only a small proportion of public expenditure, especially compared to health care. As a result, few countries have systematically collected much data on long-term care provision and expenditure.

There are broadly two main approaches to making projections: cell-based (or macrosimulation) models and microsimulation models. The main feature that distinguishes the two types of model is that microsimulation models have as their unit of analysis individual people, families or households, while cell-based models have, as their unit of analysis, aggregates of individuals grouped by their characteristics (such as age and gender). Most long-term care models are cell-based, not only because it is a much simpler method of making projections, but also because very few countries have the data required to produce microsimulation models.

This section describes some examples of both cell-based and microsimulation models. It discusses the advantages and disadvantages of both approaches, and concludes with an example of the combination of a macro and a microsimulation model, and some recommendations on choosing an approach. A useful discussion outlining the differences between the two methods and their advantages and disadvantages is available in Wittenberg *et al*, (1998, p. 28). Spilauer (2002) has also compared both approaches in his review of microsimulation models.

2.1. Cell-based (or macrosimulation) models

Most models used to make projections of future demand for long-term care or of future expenditure are cell-based models that, as stated before, have as a unit of analysis groups of people rather than individuals. Most cell-based models are built using a spreadsheet. While it is possible to develop sophisticated systems of scenarios, the models tend to be relatively straightforward from a computing point of view.

In cell-based models the overall population is represented by an aggregated cross-classification table, in which the cells represent each possible combination of the characteristics considered. The number of cells grows with the number of characteristics and too many cells could make the models unwieldy. Most long-term care cell-based models (partly as a result of lack of data) only consider a limited number of variables and a result the number of cells does not become a problem. The model developed by the Personal Social Services Research Unit (PSSRU model) in the UK, which does have a considerable number of variables, deals with the potential explosion in the numbers of cells by limiting the number of variables used to those that are relevant in each part of the model. For further details, see section 3 of this paper.

There are several different types of cell-based models. The purpose for which the projections are made, the long-term care systems that they represent and the

availability of data determine to a great extent the design and complexity of the models. Below are descriptions of various long-term care cell-based models. An attempt has been made to classify them according to the factors they take into account.

Expenditure profile modelling:

The simplest form of long-term care projections model, which is also one of the most frequently used, consists in applying the current average costs of care for people of each age (and sometimes gender) group to the future numbers of people in that age (and gender) group. These average costs for each age and gender group are often called "expenditure profiles".

This method of making projections has the advantage of very low demands in terms of data and computing, and is widely used. It has been used in international comparisons by the OECD and, more recently, the European Union's Economic Policy Committee (EPC, 2001). As long as the data on the costs of care have been calculated using similar methods and coverage in the different countries, the projections obtained using this method are, in principle, highly comparable.

With regards long-term care, however, not all countries have even such basic data readily available. In the EPC study, while all EU countries (except Luxemburg) were able to provide age and gender specific health expenditure profiles, only ten countries provided them for long-term care. The lack of basic data partly reflects the absence in many countries of information systems to compile data on long-term care use and expenditure.

The main limitation of the "expenditure profile" projections is that they make the implicit assumption that the only factors that affect future long-term care expenditure are demography and inflation. However, there are many factors other than age that will determine future demand of long-term care and expenditure. Age is effectively just an imperfect proxy for need in such models.

The sensitivity of projections produced using this type of model can be investigated in respect of alternative demographic projections and alternative inflation assumptions. The sensitivity of these projections to changes in the prevalence of disability, the proportion of older people living alone or patterns of care cannot be readily investigated.

In the UK, the Department of Health model (House of Commons Health Committee, 1996, see also the review by Wittenberg, 1999) used age-specific expenditure profiles as its starting point, but adjustments were then made for assumed changes, under varying scenarios, in real costs of care, age-specific disability rates and some other factors.

Models that allow the exploration of dependency trends:

A slightly more sophisticated approach, used by Lagergren and Batljan (2000) in Sweden, is to calculate the long-term care costs of people with different degrees of

dependency. The model then applies prevalence rates of functional dependency to the projected future population in order to obtain the future numbers of people with dependency and, finally, their long-term care costs. This approach makes it possible to investigate separately the impact of changes in mortality and dependency on the future costs of long-term care.

A review by Wittenberg of models of long-term care projections (Wittenberg, 1999) identified, in Britain, two cell-based models that also went beyond age and gender expenditure profiles. The Institute of Actuaries' model (Nuttall et al, 1993, now partly updated by Rickayzen and Walsh, 2002) made projections of the future numbers of disabled people and of the costs of caring for them on varying assumptions about changes in age-specific mortality and disability rates. Hours of care demanded were estimated by assigning an assumed number of hours per week for each level of disability. The London Economics and the Institute for Public Policy Research (Richards et al, 1996) study effectively used the Institute of Actuaries central scenario, with some minor changes in assumptions, as its starting point on projected numbers of disabled people for each year to 2030. It then concentrated on estimating the breakdown of the aggregate level of care demanded between informal care, publicly funded care and privately funded care. The review by Wittenberg (1999) describes these models in detail.

Models that allow the exploration of changes in patterns of care:

A recent international study (Comas-Herrera and Wittenberg, 2003) investigated future long-term care expenditure in four different countries (Germany, Spain, Italy and the United Kingdom) and their sensitivity to factors such as demography, changes in the prevalence of dependency, changes in the balance between informal and formal care, changes in the balance between domiciliary and institutional care, and in the rates of growth of the unit costs of care. The study used existing models in Germany and the UK. A model for Spain was substantially expanded for use in the study, and a new Italian model was developed for the project. Three of those models are described below. The UK model, developed by the Personal Social Services Research Unit (PSSRU model), is described in more detail in section 3 of this paper.

The Spanish model is based on an earlier simpler model developed by Casado (Casado and Lopez Casasnovas, 2001). It was further developed by Patxot and Costa-Font as part of the European study (Patxot and Costa-Font, 2003). Their model calculates the future numbers of people with dependency by applying current dependency rates to the projected population. It then applies, to the future numbers of dependent older people, the current utilisation rates of services. The model can be used to investigate changes in mortality, dependency trends, utilisation of services and the future unit costs of care.

The Italian model was developed specifically for the European study by Comas-Herrera, Di Maio, Gori and Pozzi (2003). The model uses a similar structure as the Spanish model described above. There was only a short amount of time available to develop the model and the team were not able to explore all the possible sources of data. This model is currently being reviewed and improved by Vanara and Gori (?).

The German model was developed by Rothgang (Rothgang, 2003) to make projections of the future numbers of beneficiaries of public long-term care insurance, and of the future contribution rates for public long-term care insurance, under a number of scenarios. Rothgang's model applies the prevalence rates of the various degrees of dependency (that determine entitlement to insurance benefits), by age and gender, to the future numbers of older people. The model then calculates long-term care insurance expenditure by applying the value of the benefits to the numbers of recipients. This projected expenditure is then applied to a simple labour force and pensions model to calculate the future contribution rates necessary under various scenarios.

The value of the benefits in the German model depends not only on the severity of dependency but also on the type of benefits chosen. There is a choice between cash-benefits, in-kind care in people's own home, a mixture of cash and in-kind benefits, and institutional care. The model's base case assumes that the proportion of people by age, gender and dependency that choose the different types of benefits remains unchanged. Sensitivity analysis can be used to investigate the expenditure impact of changing the choice of benefits (as well as the impact of different assumptions about future mortality, dependency and changes in the real unit costs of care). A change in the choice of benefits would result, effectively, in a change in patterns of care.

None of the models described above consider whether older people live alone or with others, or whether they have access to an informal carer. They also do not consider the socio-economic status of care users. These are important factors in the demand for long-term care services, as changes in household composition or the economic situation of older people will affect their future demand for long-term care services. The UK's PSSRU model (and a nearly identical replica done for Catalonia, see Lopez-Casasnovas, Casado and Comas-Herrera, 2003) is, as far as the authors know, the only long-term care cell-based model that takes household type and economic situation (housing tenure) variables into account.

2.2. Microsimulation models

Microsimulation models can be defined as models that use simulation techniques and that take micro-level units (that is, in the case of long-term care models, the individual, family or household) as the basic units of analysis. They permit a more detailed consideration of distributional factors than cell-based models. A useful review of microsimulation methods in health care modelling can be found in Spilauer (2002).

Dynamic (as a opposed to static) microsimulation models simulate changes over time and in response to context changes. Monte-Carlo simulation, using information on transition rates between states, is used to determine transitions of micro-units from one state to another at each time period. Such transitions could include mortality, onset of dependency or admission to residential care.

Dynamic microsimulation models have the advantage of allowing the consideration of events over the lifetime. They can be used, for example, to simulate how long a person can expect to live in each of a number of health or dependency states. They can also be used to simulate a link between contributions to a pension or other

saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle.

Dynamic microsimulation models are potentially useful for the purposes of modelling future demand for long-term care and expenditure. The reason that there are not many such models (besides the substantial investment in data analysis and computing involved) is that the data they require is not available in most countries. A dynamic microsimulation model of long-term care would require a longitudinal data collection from which to draw information on transitions in health (or dependency) states and other variables including the use of long-term care.

The following sections describe three microsimulation models. Two of them are from the US and the third one investigates charging for long-term care in the UK.

US models

The Brookings Institution and Lewin-VHI Inc, and the Urban Institute, have developed Long-Term Care models using microsimulation techniques. In the US longitudinal data on health states, disability and use of long-term care is available from the National Long Term Care Survey and other surveys. The health state, family circumstances, incomes and other characteristics of a sample of individuals are simulated year by year to their deaths. The outputs of the microsimulations are grossed up to match official population projections by age and gender. These models have been described in some detail and compared with cell-based models by Wittenberg (1999).

The Brookings Institution and Lewin-VHI Inc. Long-Term Care Financing Model was originally developed in 1986-7 but updated and refined in 1988-9 using new data. This model projects the size, financial position, disability status, and nursing home and home care use and expenditures of elderly people through the year 2020. Expenditures are further extrapolated on a broader basis to the year 2050. The model has been used to simulate the effects of changes in the system for financing long-term care in the USA (Wiener et al, 1994). The model starts with a nationally representative sample of the adult population, with a record of each person's age, gender, income, assets, and other characteristics. It then simulates changes to each individual from 1986 to 2020. The changes simulated include onset and recovery from disability and commencement and termination of receipt of long term care services.

The Brookings Institution Lewin-VHI study assigns a source of funding for all elderly people who have been modelled to receive home care or nursing home care. Medicare funding is considered before payment from other sources. Where a person is admitted to non-Medicare nursing home care, the costs are attributed to the person's income and then non-housing assets. When the person's assets have been spent down to the Medicaid threshold, Medicaid is assumed to pay the difference between the person's income (less a personal allowance) and the Medicaid payment rate. In this way the Medicare and Medicaid systems are simulated.

The Urban Institute's Dynamic Simulation of Income Model (DYNASIM) was used to project the elderly population's characteristics, incomes, and needs to the year 2030 (Zedlewski et al, 1990). The study considers the future numbers of elderly people with

different levels of disability, incomes and other characteristics, under varying assumptions about future mortality and disability rates. It does not include projections of long-term care expenditure.

Both studies consider future trends in marital status and numbers of children as part of their simulations but do not investigate sensitivity to alternative assumptions. Marriage, divorce and widowhood are included in the microsimulations as is child-birth. Official data are used on marital status and on fertility. The related issue of the proportion of elderly people living alone is also considered in both models. The studies do not, however, make a link between living arrangement, as opposed to marital status, and probability of receipt of long term care.

Both studies consider income and assets in some detail in their simulations. The Urban Institute model was designed specifically to look at incomes, while the Brookings Lewin-VHI Long Term Care Financing Model is based on the Lewin-VHI Pension and Retirement Income Simulation Model (PRISM).

The studies modelled receipt of home care and receipt of residential care separately as functions of individual characteristics such as age, gender and dependency. The relationship between these characteristics and receipt of care is assumed to remain constant over time, at least as a base case. The Brookings Institution model gives the user a facility to simulate an increase in home care use and/or in nursing home use by adjusting the estimated probabilities of service receipt by a factor assumed for induced demand.

Informal care is not directly covered in either model. They take actual propensities to receive care in a base year as their starting point for projections. The Brookings study considers the impact on the balance between public and private expenditure of potential changes in real incomes and assets.

The Nuffield Community Care Studies Unit model

The Nuffield Community Care Studies Unit (NCCSU), in the UK, has developed a microsimulation model to simulate long-term care charges under different charging regimes (Hancock, 2000). It contains detailed information on the incomes, wealth, housing and other relevant characteristics of sample members, sufficient to make good estimates of their liability for care charges. The model permits analysis of the distributional consequences of different long-term care funding options.

The NCCSU model simulates what each older participant in the UK's Family Resources Survey would have to pay towards care home fees should he or she need long-term care. The model performs simulations for single people currently aged 65 and over, and for the older partner in couples where at least one partner is aged at least 65 years. The simulations are performed for a base year and for future years. Simulations for future years involve: ageing the sample of those currently aged 65 or more, allowing for deaths and the consequent effects of widowhood; modelling the evolution of their incomes and capital under certain assumptions; and making assumptions about future costs of care and the care charging, social security benefit and income tax regimes which will be in place for the year of interest. The model

makes a number of simplifying assumptions such as, for example, in predicting death there is no allowance for differences in mortality by income, social class or housing tenure.

Because it is more difficult to predict the future incomes of people who are not yet retired than it is for those who are already drawing pensions, the base year sample is not 'refreshed' as it is aged. This restricts the years and age ranges for which the model produces projections.

The microsimulation model does not predict how many or which older people will need care. It simply calculates what each person in a representative sample of older people would be required to contribute to the costs of residential or nursing home care should he or she need it, and how much would be contributed from different parts of the public purse. British data shows that, controlling for age, residents in care homes are, in comparison with older people generally, disproportionately likely to have lived alone and to have rented rather than owned their homes (Netten et al, 1998). Housing tenure and whether living alone are also both characteristics which affect liability for long-term care charges as well as probability of admission to care homes.

The NCCSU and PSSRU[1] jointly produced projections of future long-term care expenditure through an innovative linkage of their two models. This involved using outputs from the NCCSU microsimulation model as inputs to the PSSRU cell-based model. The NCCSU model produced projections of the future proportions of older people eligible for public funding should they require residential care and of their future contributions to the costs of their care under different funding arrangements. The PSSRU model produced projections of total public and private expenditure on long-term care to 2051 on the basis of the NCCSU projections and assumptions about future trends in life expectancy, dependency, real unit costs and patterns of care (Wittenberg et al, 2002 and Hancock et al, forthcoming).

2.3. Advantages and disadvantages of both approaches

Microsimulation models would offer some advantages for making projections of long-term care for older people, compared to cell-based models. One advantage, specially relevant for models that look at financing long-term care, is that they permit a more detailed consideration of distributional factors than cell-based models. An example would be the way in which different funding systems affect different income groups. In cell-based models the investigation of distributional issues is restricted to distribution by the variables used to define the cells.

A second advantage of microsimulation models is that, as discussed above, they can also be used to simulate a link between contributions to a pension or other saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle. This is important where a contributions-based insurance system is under consideration.

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[1] This research was financed by the Institute of Public Policy Research (IPPR), UK.

A further advantage is that the number of cells in cell-based models grows with the number of characteristics and too many cells could make the models unwieldy. In practice, most long-term care cell-based models (partly as a result of lack of data) consider only a limited number of variables and the number of cells does not in practice become a problem.

While there are many advantages to microsimulation (and in particular dynamic microsimulation) models, it is important to be aware that constructing a microsimulation model is a complex and time-consuming task. As discussed in Wittenberg et al (1998, p. 130), "... such work is not likely to be cost-effective unless there is a policy interest in the types of question that can only be answered through microsimulation; suitable data – generally longitudinal data- are available; and the expertise and resources are available".

Unfortunately, in most countries suitable data is not available, which is a key reason why cell-based models are more widely used. A useful approach to enable the investigation of distributional issues is to combine a cell-based model for long-term care with an existing microsimulation model of the incomes and assets of older people, as discussed above and in Hancock et al (forthcoming).

3. The PSSRU model

The PSSRU long-term care projections model was constructed as part of a project on long-term care finance, funded by the English Department of Health since 1996. The project is concerned with two related policy issues on the funding of long-term care for older people. The first is whether expenditure, and specifically public expenditure, on long-term care will remain sustainable over the coming decades, despite demographic pressures and potentially rising expectations. The second is what should be the balance between public and private expenditure on long-term care.

A detailed account of the long-term care projections model and of the data and assumptions and the methodology used can be found in Wittenberg *et al* (1998), a report that describes the first version of the model. The model has been regularly updated and expanded. A paper exploring sensitivity of an updated version of the model to various assumptions was published in Health Statistics Quarterly in 2001 (Wittenberg *et al*, 2001). The latest version of the model is described in Comas-Herrera et al (2003a).

The initial model was used to provide projections for the Royal Commission on Long-Term Care[2] (1999). More recently, new versions of the model have been used to provide projections for the HM Treasury Health Trends Review (Wanless, 2002) and for the Institute of Public Policy Research (Wittenberg *et al*, 2002 and Hancock *et al*, forthcoming). The latter involved innovative linkage between the PSSRU model and a microsimulation model developed by the Nuffield Community Care Studies Unit (NCCSU), as discussed above.

[2] A high level group set up by the Government to review the financing of long-term care and make recommendations about its future financing.

As well as the main model, other versions of the model have been developed. One of them investigates the future long-term care costs of cognitive impairment (Comas-Herrera et al 2003b), using MRC CFAS data (MRC CFAS, 1998). This enabled separate projections to be made of services for older people with cognitive impairment under a range of assumptions about future prevalence rates of cognitive impairment. This version of the model will be further described in section 3.5. Versions of the model have been developed for the National Assembly for Wales (Comas-Herrera et al, 2003c) and for the Catalan regional Government (Lopez-Casasnovas et al, 2003).

This section contains a discussion of the methodological issues addressed in designing the PSSRU model, in particular with regards the modelling of demand. It then provides a detailed description of the model, the assumptions made, and the base case projections.

3.1. Methodological choices in modelling demand and supply of long-term care

The PSSRU model aims to make projections of three key variables: the future numbers of dependent older people, the likely level of demand for long-term care services for elderly people and the costs associated with meeting this demand. The model covers public and private services and expenditure. It is cell-based (a macro-simulation model) and takes the form of a spreadsheet. An in-depth discussion of the methodological approach adopted in designing the model is available in Wittenberg et al (1998). This section summarises some of the main points.

The first, crucial point is that *the model does not make forecasts about the future.* It makes projections on the basis of specific assumptions about future trends. The approach involves simulating the impact on demand of specified changes in demand drivers, such as demographic pressures, or specified changes in policy, such as the introduction of free personal care. It does not involve forecasting future policies or future patterns of care.

The second important point is to clarify the concept of demand in this context. Demand generally refers to the quantity of a good of service that people want to purchase at a given price. The demand by a person for goods or services is generally taken to be a function of the person's income, the price of the good, the price of other goods that may be close substitutes or complements, and the person's tastes. The latter may in turn be a function of the person's age, gender, occupation, health state, and other personal characteristics.

The demand for long-term care is complicated by at least three issues. First, it is important to consider the relationship between need and demand, which is discussed below. Second, it is important to distinguish between demand for different types of care. In particular it seems important to differentiate between demand that could be met by either informal or formal care and demand for formal health and social services. Third, it is difficult to observe "demand" alone. What is observed from data on service use is a combination of demand and supply (Norton, 2000).

Relationship between need and demand

Need for long-term care may arise from a number of sources or combination of sources. It may arise from limitations in physical health and/or in mental health. It may arise from a combination of limitations in health and difficulties in the person's environment, such as poor or unsuitable housing. Demand is not the same as need. It takes account of the person's ability and willingness to purchase the good or service. Demand for long-term care would arise if the person actually sought long-term care and was willing to pay, if required.

These considerations suggest that demand for long-term care can be regarded as a function of the following variables: age, gender, physical health, mental health, income, assets, preferences, and the costs of care (Evandrou and Winter, 1988; Davies et al, 1990 and Norton, 2000). A model of long-term care demand should in theory consider all of these. Preferences, however, are clearly intangible and changes in preferences or expectations are problematic to project.

Demand for different types of care

It is possible to distinguish three forms of long-term care in terms of costs to the care recipient. These are informal care by family and friends, publicly funded formal care, and privately purchased formal care. The first generally involves no financial cost to care recipients, the second may involve a cost depending on whether public support is subject to charges, and the third clearly involves a financial cost to care recipients or their families. This consideration, together with the potentially different nature of formal services and informal care, mean that the different types of care need to be considered as separate subsets of overall demand for long-term care.

Demand and supply of informal care

Demand for informal care could in principle be regarded as a function of the same variables as demand for long-term care generally. The concept of demand for informal care, however, has little meaning in practice in the absence of family or friends willing to supply such care; that is, in the absence of potential supply. Since a proportion of dependent people do not have a surviving close relative or friend, for some people informal care is not an option.

The supply of informal care depends on the availability of a potential carer. The most recent data on informal carers supplied by the General Household Survey (GHS) confirms that the majority of informal care is provided by spouses, children and children-in-law (Maher and Green 2002).

The supply of informal care depends not only on the availability of a potential carer but also on the potential carer's ability and willingness to provide care. The carer's ability and willingness to provide care may be affected by the carer's health and other commitments, including employment and child-care responsibilities. It may also be affected by the carer's income. People with higher incomes may prefer to purchase care

for their elderly relative, as the cost of any employment lost, that is, the opportunity cost of caring, would be higher.

The supply of informal care is clearly central, yet it cannot be considered independently of demand. Not all informal care is supplied to people with a need for care in the sense that they are dependent or disabled in some way. There is evidence that much informal care for elderly people is supplied to people who do not have disabilities and that carers often give care irrespective of need (Daatland 1983, Wenger 1992). This again relates to a fundamental characteristic of informal care. It is not just that people who need care do not necessarily receive it from the informal sector, it is also that caregivers often give care irrespective of need. If, then, the concern is with the support of dependent elderly people, not all the informal care supplied is relevant.

To consider the factors influencing whether or not an older person receives informal care, it is necessary to bring together the factors affecting demand and supply. This suggests that the provision of informal care to an individual is a function of the person's dependency, income, preferences, and availability of a partner, child or possibly other relative living nearby, and also of the potential carer's health, income, employment status, marital status, child-care responsibilities and preferences.

The PSSRU model treats the receipt of informal care as a function of the person's dependency (as an indicator of need) and of the person's household type (as an indicator of the likely availability of informal care). The former may be regarded as a demand variable and the latter as a supply variable. The function is thus a reduced form[3] that seeks to model actual receipt of informal help rather than a demand or a supply function.

Relationship between formal and informal care

It is important to consider the nature of the relationship between formal and informal care. An important issue is whether the amounts of formal and informal care provided are determined jointly, or whether the amount of formal care provided can be considered as a function of the amount of informal care. Joint determination implies that both informal and formal care are determined at the same time, with the level of informal and formal care jointly determined by the parties involved. Consecutive determination implies that formal care follows informal care sequentially and that informal care is taken into account when formal services are provided.

The approach to informal care adopted by service providers in the UK, certainly prior to the community care changes of the early 1990s, has been characterised by a model that treats carers as a resource and provides formal services very much in response to the amount of informal care received (Twigg and Atkin 1994). This is reflected in the importance of household composition as a variable determining receipt of formal services, since household composition to a large extent reflects the amount of informal care (Evandrou et al 1986, Evandrou 1987, Evandrou and Winter, 1988).

[3] By a "reduced form" function is meant the summarisation in one equation of a reciprocal inter-relationship between variables requiring two or more equations to describe in full. The single equation takes the perspective of the influence on one only of two causally interdependent variables.

For this reason, the PSSRU model has a sequential form. In the model, household type is one of the variables that determines receipt of informal care. Indeed, so close is the relationship between household type and informal care that the most recent version of the PSSRU model treats household type and informal care as a single variable with five categories: living alone without informal help, living alone with informal help, single living with others, married/cohabiting living with partner only and married/cohabiting living with partner and others. Receipt of informal care/household type, in turn, is one of the variables that determines receipt of formal care in the model.

Demand for formal care

This discussion of the relationship between formal and informal care suggests that the demand for formal care should be treated as a function not only of the variables affecting overall demand for long-term care but also of the provision of informal care. This is on the basis that formal care can and does sometimes substitute for informal care, especially when it is unavailable, and that informal care provision is often determined before formal care. The demand for formal care can, therefore, be regarded as a function of the person's age, gender, physical health, mental health, income, assets, preferences, and receipt of informal care, and of the costs of care.

For those with no informal carers, the overall demand for long-term care is effectively a demand for formal services. For those receiving informal care, the demand for formal services may be regarded as a demand for additional types of care or additional hours of care that remain unmet. Alternatively, or additionally, there may be a demand for formal services to provide respite for informal carers. This suggests that carer stress may be a further relevant factor.

The role of supply constraints in observed demand

The supply of formal services also requires discussion. Demand for long-term care alone is difficult to observe and the data used on service use is, in fact, a combination of demand and supply. The overall supply of publicly funded care is affected by policy decisions at central and local level about priorities for public expenditure. In modelling demand for formal care, these policy decisions need to be treated as exogenous to the model. This is on the basis that the purpose of the modelling is to inform decisions on public expenditure by providing information on projected changes in demand. To take account of policy constraints on supply in a model aiming to inform policy decisions on supply of public funds would be circular.

Market constraints on supply are also very important. A key constraint is the need to retain the inputs to formal care, especially care staff. Expenditure projections need to incorporate assumptions about unit costs of care and about rises in the real costs of care. These could be understood as assumptions about the real rises in wages and other payments for inputs to care that are necessary to ensure that supply is sufficient. Expenditure projections would thus effectively assume that supply of formal care will adjust to match demand for formal care and that demand will be no more constrained by supply in the future than in the base year. This is on the basis of an appropriate assumption about real rises in care costs.

Other methodological choices

The model contains a relatively large number of variables that, when combined in a cross-tabulation, create a relatively large number of categories (cells), as discussed below. This can cause a problem when using data from sample surveys, as the number of observations that relate to people in each category (cell) in the cross-tabulation may become too small. The PSSRU model deals with this problem by using multivariate (logistic regression) analysis to determine which variables, such as age, gender and dependency, are statistically significant in explaining the use of different services. The fitted values from the analysis are used as the probability of receipt of services for people in each category.

Another important feature of the design of the model is that it has been built in a way that allows the testing of alternative hypotheses about trends in the key factors affecting future demand for long-term care and expenditure. A nearly automated menu of alternative assumptions about trends in key factors has been developed that allows almost any combination of assumptions for the different factors to be tested.

3.2. Description of the model

The model described below seeks to model the demand for formal long-term care services, as a function of some of the key variables discussed in this section. These include not only the elderly person's age, dependency and other characteristics but also the person's receipt of informal care. The latter is a function of demand and supply factors relating to informal care.

The model does not seek to incorporate variables concerning the supply of formal care. It does not seem appropriate to do so, since one of the purposes of the model is to inform policy decisions concerning the supply of publicly funded care. Supply considerations are not, however, absent from the model. Assumptions are made about future rises in the real costs of care. These need to be sufficient to retain the inputs, especially staff, required to provide the levels of care demanded.

The description of the model provided here was first published in Comas-Herrera et al (2003a). The model consists of four main parts. The first part estimates the numbers of older people with different levels of dependency by age group, gender, household type and housing tenure. The second part estimates the levels of long-term care services required, by attaching a probability of receiving health and social care services to each cell. The third part of the model estimates total health and social services expenditure, and finally, in the fourth part, total expenditure is allocated to the various sources of funding.

Part One: Projected numbers of older people

The first part of the model classifies the projected numbers of older people into subgroups (or cells), according to age bands, gender, dependency and other key characteristics. The model uses the Government Actuary's Department (GAD 2003

and Shaw 2003) 2001-based interim population projections as the basis for the numbers of people by age band and gender in each year under consideration until 2031.

The projected older population by age band and gender are separated into dependency groups. The model uses as a measure of dependency the ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Four dependency groups have been used in the model (Box One). Information from the 1998/9 General Household Survey (GHS) was used to break down the private household population into the four groups.

BOX ONE
DEPENDENCY GROUPS USED IN THE PSSRU MODEL

The four dependency groups used in the model are as follows:

1. People able to perform ADL (personal care) tasks and IADL (domestic care) tasks without difficulty.
2. People with difficulty with IADL but not ADL tasks.
3. People with difficulty with one ADL task.
4. People who live in the community and have difficulty with two or more ADL tasks, and people who are in institutional care (hospital, nursing home or residential care home).

Another key factor in the receipt of long-term care is household type. Household type is an important structural correlate of informal care (Pickard *et al.* 2000). Informal care is combined with household composition in a five-fold classification: living alone without informal help; living alone with informal help; *de facto* single, living with others; married/cohabiting couple; and married/cohabiting couple, living with others. Household types where older people live with others, including married/cohabiting couples, have not been broken down between those with and without informal carers because all older people living with others have a potential carer and most of those who are dependent have an actual carer. In the 1998/9 General Household Survey (GHS), over 90% of dependent older people living with others received informal help with domestic tasks.

Projections of informal care/household composition in the PSSRU model are driven by the 1996-based GAD marital status and cohabitation projections (Shaw 1999, Shaw and Haskey 1999). The two marital status groups (those who are *de facto* married and those who are *de facto* single) are broken down into five household types using the 1998/9 GHS. The projections assume a 'steady state' regarding the propensity within marital status groups to live with others.

The model includes, for those living in private households, a simple breakdown by housing tenure, between those living in owner-occupied tenure and those living in rented accommodation. One reason for the inclusion of housing tenure is that it can be regarded as a simple proxy for socio-economic group. Another is that it is

relevant, in the case of older people living alone, to the division between those who fund their own residential or nursing home care and those who are funded by their local authority or health authority. The current means test for public support in residential or nursing home care generally takes account of the value of the person's home (unless it is occupied by their spouse or an older or disabled relative). This means that older home-owners who live alone generally need to fund their residential or nursing home care privately, while older tenants and older home-owners living with their spouse are often eligible for public funding.

The model divides the population into 440 cells. 40 of these relate to the institutional population by age (5 bands), gender, previous household type (2 categories) and previous housing tenure (2 categories), and 400 to the household population by age (5 bands), gender, dependency (4 groups), household type/informal care (5 categories) and tenure (2 categories).

It is important to point out that, as discussed in section 3.1, the 440 cells is the maximum number of combinations that the variables and categories used yield. In practice, the model does not use all the variables and categories simultaneously.

Part Two: Projected numbers of service recipients

The second part of the model projects the volumes of services demanded by combining the output of the first part of the model (the projected numbers of older people by dependency, household type/informal care and other characteristics) with functions that assign receipt of services to each sub-group of the older population. The services covered include a range of health and social services relevant to meeting long-term care needs.

The probability of receipt of each non-residential service, such as home care, day care, and community nursing, was estimated through multivariate (logistic regression) analysis of the 1998/9 GHS data. The independent variables were age, gender, dependency, marital status, household type/informal care and housing tenure. Separate analyses were undertaken for dependent and non-dependent older people, as few non-dependent older people received services other than chiropody and private domestic help. For non-dependent people, age was statistically significantly associated with probability of receipt of each service and gender, marital status and tenure with receipt of some services. For dependent people, age, severity of dependency and marital status or household type were statistically significantly associated with probability of receipt of most services, and gender and housing tenure with receipt of some services.

Demand for domiciliary services was calculated by using the fitted values from the logistic regression models as the estimated probabilities of receipt of each service by age band, gender, dependency and the other factors described above. These fitted values were then multiplied by the projected numbers of older people within each cell by age band and other needs-related circumstances to produce estimates of the numbers of service recipients.

Finally, these estimates of numbers of service recipients were multiplied by estimates of the average intensity of service receipt, i.e. the average number of home help hours or district nursing visits per recipient week. Information on intensity of service receipt by dependency was also obtained from the 1998/9 GHS.

The probability of receiving residential, nursing home or long-stay hospital care was estimated using a combination of data. Official national statistics were used on the total numbers in residential care homes and nursing homes (Department of Health, 2000a). A proportionate breakdown of care home residents by age band, gender, previous household type and previous housing tenure was derived from PSSRU surveys of residential care (Netten *et al*, 1998) and applied to the totals. This approach enabled the proportion of older people in residential care and nursing home to be estimated by age band, gender, household type and housing tenure. Hospital Episode Statistics data on the numbers of older patients by age and gender with stays exceeding 55 days were used as estimates of the numbers in long-stay hospital care. In the absence of data on this group's previous household type and housing tenure, a breakdown from the PSSRU survey data on nursing home residents was applied to hospital residents.

In summary, the numbers of recipients (*SERNO*) of each service (*j*) was estimated as:

$$SERNO_j = \sum_{i=1}^{440} p_{ij} \cdot n_i ,$$

where p_{ij} is the probability of a person in cell *i* (i=1 to 440) receiving service *j* (j=1 to 9) and n_i is the number of older people in cell *i*.

Part Three: Projected aggregate expenditure on long-term care services

The third part of the model projects the total expenditure on the formal services demanded applying unit costs of formal care, drawn from a PSSRU study (Netten *et al.* 2001a) and from Laing and Buisson (2001), to the volume of services projected in the second part of the model. The unit costs were uprated to 2001 prices using the health and social services deflators available from Netten *et al* (2002). The model covers the costs to the health service, social services and users of services, for those services included in the model. Estimated expenditure on home care and community nursing services has been grossed up broadly to match official data.

In summary, the model estimates total expenditure on long-term care (E_t), for each year (*t*), as the sum across all formal health and social services considered, *j* (j = 1 to 9) of the following: projected number of service recipients in year *t* ($serno_{jt}$) multiplied by the intensity of service receipt in terms of hours/visits per week (int_j) and multiplied by the unit cost of care inflated to the year to which the projection year relates (c_{jt}). This can be shown as:

$$E_t = \sum_{j=1}^{10} serno_{jt} \cdot int_j \cdot c_{jt}$$

Part Four: Projected breakdown of expenditure between funders

The fourth part of the model breaks down projected aggregate expenditure by source of funding: NHS, social services and service users. The costs of the health services included are assigned to the NHS. The costs of the social services are divided between personal social services and service users. As there are no national data on the quantities of privately funded care, the projections for privately funded care, especially on non-residential care, need to be treated with caution as it is not possible to verify that all privately funded care is captured by the model.

Residents of residential care and nursing homes are divided into privately and publicly funded residents. The breakdown for 2000 is based on Laing & Buisson data (Laing & Buisson, 2001) for independent sector homes and 1996 PSSRU survey data (Netten *et al*, 1998) for local authority homes. The Laing & Buisson estimates for the proportion of residents who are privately funded were reduced by two percentage points to take account of the changes to the funding system introduced in April 2001. The future trend in this proportion is derived from the projected rise in home-ownership by older people who live alone.

Expenditure on local authority funded residential care, home care, day care and meals is divided between local authority social services and users on the basis of Department of Health data on the proportion of gross costs of social services met by user charges. The proportion of costs met by users is held constant for future years. The full costs of privately funded residential and nursing home care and private domestic care, and a proportion of the costs of all other social services, are thus assigned to users.

3.3. Base case assumptions and projections

The PSSRU model produces projections on the basis of specific assumptions about future trends in the key drivers of demand for long-term care. The main assumptions used in the base case of the model are summarised in Box Two below. The base case projections take account of expected changes in factors exogenous to long-term care policy, such as demographic trends. The base case projections hold constant factors endogenous to long-term care policy, such as patterns of care and the funding system. The base case is used as a point of comparison when the assumptions of the model are subsequently varied in alternative scenarios.

BOX TWO

KEY ASSUMPTIONS OF THE BASE CASE OF THE PSSRU MODEL

- The number of people by age, gender changes in line with the latest Government Actuary's Department (GAD, 2003) 2001-based population projections.
- Marital status changes in line with GAD 1996-based marital status and cohabitation projections.

- There is a constant ratio of single people living alone to single people living with others and of married people living with partner only to married people living with partner and others
- Prevalence rates of dependency by age and gender remain unchanged, as reported in the 1998/9 General Household Survey (GHS) for Great Britain.
- Home-ownership rates, as reported in the 1998/9 GHS, rise in line with the Anchor Housing Trust projections (Forrest *et al*, 1996).
- All dependent older people living with others receive informal care.
- The proportions of older people receiving informal care, formal community care services and residential and nursing home care services remain constant for each sub-group by age, dependency and other needs-related characteristics.
- Social care unit costs rise by 1% per year and health care unit costs by 1.5% per year in real terms. Real Gross Domestic Product would grow by 2.25% per year.
- The supply of formal care will adjust to match demand[4] and demand will be no more constrained by supply in the future than in the base year.

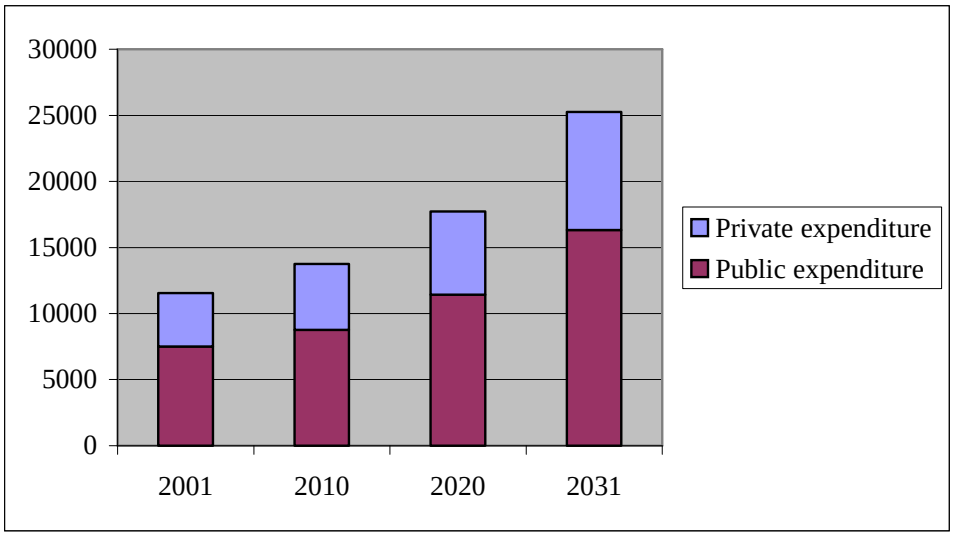
The GAD 2001-based principal population projections for England project that between 2001 and 2031 the numbers of people aged 65 or more will rise by 54%. The numbers of those aged 85 or more are projected to rise faster during this period, by 81%, from more than 950,000 to around 1,732,000. Much of this increase is a result of a projected rise in male life expectancy. Between 2001 and 2031, the numbers of men aged 85 or more are projected to rise by 155%, compared to a 52% rise in the number of women in that age group.

Under the base case assumptions, the numbers of dependent older people[5] would grow by 57% between 2001 and 2031, from 2,567,000 to 4,020,000. The numbers of users of non-residential formal services would rise by 58%, from 1,532,000, to 2,416,000. The numbers of older people in institutions would also rise by 58%, from nearly 400,000 to 627,000.

Figure 1: Projected expenditure (£m) by source of funding, England, 2001-2031, under base case assumptions.

[4] The model effectively assumes that the real rise in wages and other payments for care will ensure that supply is sufficient.

[5] Defined as having problems with at least one IADL or one ADL.



Projected long-term care expenditure would grow by 118%, from nearly 11.6 billion in 2001 to just above 25 billion in 2031 (figure 1). If Gross Domestic Product rose by 2.25% per year, long-term care expenditure would grow from 1.46% of GDP in 2001 to 1.64% in 2031. Table 1 shows these base case projections in greater detail.

Table 1: Projected numbers of older people (thousands), service recipients (thousands) and expenditure (£ billion) under base case assumptions, 2001 to 2031.

	2001	2010	2020	2031	% growth 2001 to 2031
Numbers of older people (aged 65 or more)	7,821	8,455	10,073	12,049	54.1%
Numbers of people aged 85 or more	957	1,127	1,313	1,732	80.9%
Numbers of older people with some dependency	2,567	2,773	3,258	4,020	56.6%
Numbers of users of local authority home help services	372	399	457	586	57.8%
Numbers of users of community nursing services	422	453	533	657	55.7%
Numbers of users of private domestic help	745	846	993	1,231	65.2%
Numbers of users of any non-residential service[6]	1,532	1,653	1,935	2,416	57.7%
Numbers of people in residential care homes	238	257	293	373	57.1%
Numbers of people in nursing homes	134	145	168	213	59.1%
Numbers of people in institutions	397	430	493	627	57.8%
Public long-term care expenditure (£ billion)	7.5	8.8	11.4	16.3	117.4%
Private[7] long-term care expenditure (£ billion)	4.1	5.0	6.3	8.9	120.2%

[6] Local authority home care, district nursing, day centre care, meals or private domestic help

Total long-term care expenditure (£ billion)	11.6	13.8	17.7	25.3	118.4%
Total long-term care expenditure as a % of GDP	1.46%	1.42%	1.44%	1.64%	12.3%

Source: model estimates.

The model produces projections of future long-term care expenditure based on a specified set of base case assumptions. This set of assumptions seems plausible but is clearly not the only possible set. A substantial part of the PSSRU study of long-term care projections has involved the investigation of the sensitivity of the projections to changes in the assumptions made in the model, which is discussed below.

Finally, it is important to point out that the expenditure projections obtained using the model do not constitute the total costs of long-term care to society. That would require inclusion of the costs of a wider range of services to a wider range of public agencies and service users and the opportunity costs of informal care. It should also be stressed that no allowance has been made for changes in public expectations about the quality, range or level of care.

3.4. Sensitivity analysis in the PSSRU model: the effect of changes in the key assumptions

This section examines the model's sensitivity to any changes in the key assumptions, with particular regard to changes relating to the future numbers of older people, dependency rates, the availability of informal care, patterns of formal care and the unit costs of care.

Future numbers of older people

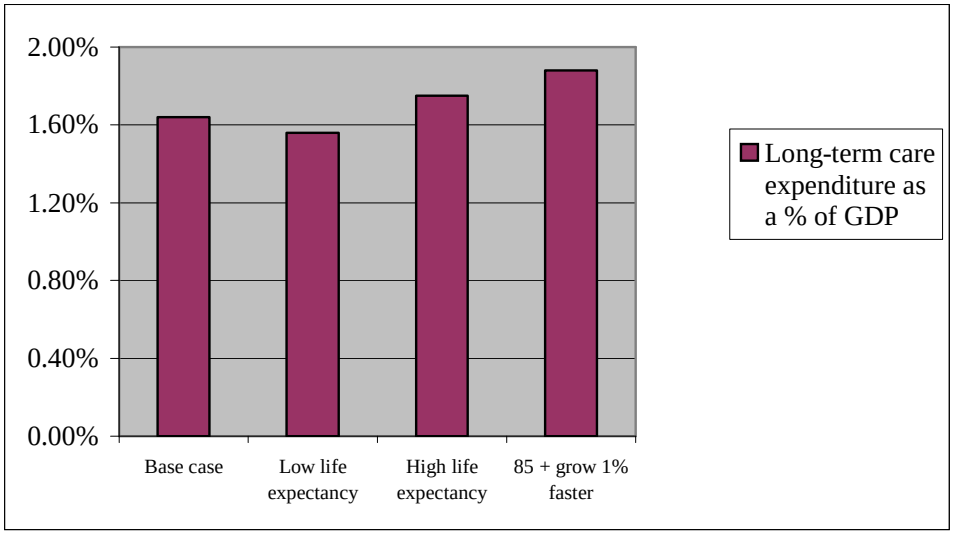
The Government Actuary's Department (GAD) population projections for England produce a rise of 54 per cent in numbers of people aged 65 or more between 2001 and 2031, while numbers of those over 85 will rise by 81 per cent.

Mortality rates in old age are the key factor affecting the projected number of older people, and numbers of very old people in particular. As the proportion of older people with dependency rises sharply with age, the model's projections are very sensitive to the assumptions about the numbers of very elderly people. Figure 2 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions. The assumptions are: the GAD's low and high life expectancy 2000-based population projection variants, and an assumption according to which the numbers of people aged 85 or more would rise faster than projected by the GAD's principal projection, by 1% more per year. This assumption has been chosen because it corresponds roughly to the extent of past under-estimation of the numbers of very elderly people (Shaw, 1994). According to data gathered by Robine (2003), the official population projections of most European countries have consistently underestimated the future numbers of older people, specially of the very old. It is debatable whether the most

[7] Includes user fees and co-payments.

recent UK projections, based on a changed approach (Shaw, 2000), will still prove to be under-estimates.

Figure 2: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about changes in life expectancy

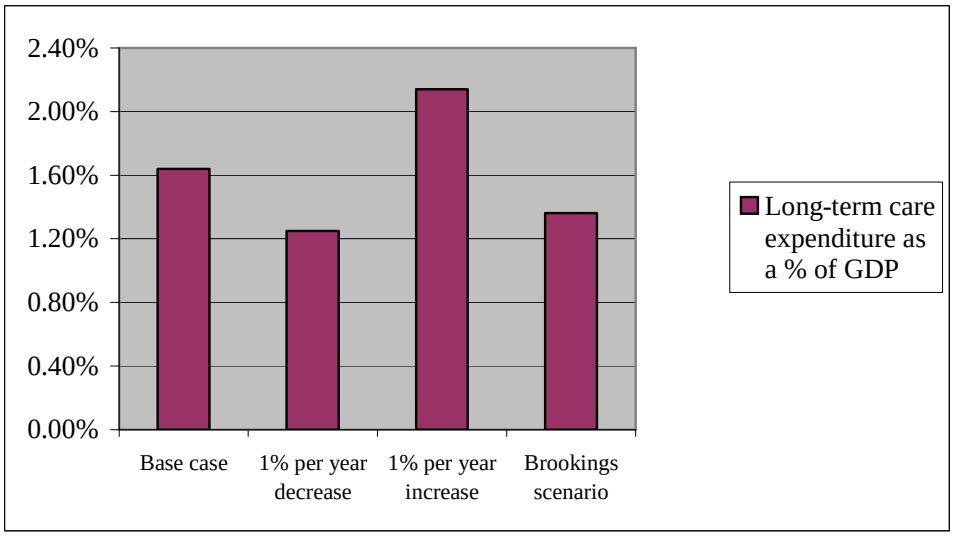


Dependency

If falling mortality rates were accompanied by falling rates of dependency, this would (at least partially) offset the impact of demographic pressures on demand. Constant dependency rates could be regarded as a pessimistic assumption. The 'Brookings scenario' is a less pessimistic assumption that moves the age-specific dependency rate up by one year for each one-year increase in life expectancy.

While there are differing views about whether age-specific dependency rates can be expected to rise, fall or remain much the same, projections of demand for long-term care are highly sensitive to assumptions about dependency. Figure 3 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions: a 1% increase and decrease per year in the prevalence rates of dependency, and the 'Brookings scenario'.

Figure 3: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about dependency trends.



Availability of informal care

The GAD marital status projections imply that there is likely to be an increase in spouse carers of dependent older people, at least until 2020 (see Wittenberg et al, 2001 for more details). The PSSRU model base case takes this into account, but does not take into account other possible changes in the availability of informal care.

The proportion of older people living with an adult child in Great Britain declined from 42 per cent in 1962 to 14 per cent in 1986, and has subsequently declined still further (Grundy 1995, Grundy and Glaser 1997). If by 2031 fewer older people receive informal care from children living in the same household, it could be assumed that more people may move into residential homes. In addition, it is possible that more older married couples may also require admission to residential care, if there is a decline in informal care by children.

Various scenarios have been developed to test the impact on the model's projections for formal services of a decline in informal care. Compared to the base case, all of these produce varying degrees of increases in public expenditure and increased numbers of those in institutional care. But much depends on the size of the decline in informal care and on the extent to which such care is substituted by residential care or by moderate packages of domiciliary services.

Future patterns of care

The model can be used to explore the impact of changes in the patterns of services. The scenarios explored assume a shift in the balance of care from institutional to domiciliary, a change in the eligibility criteria for home care and an increase in support for informal carers.

The first scenario considered here assumes that projected numbers in nursing and residential homes would by 2020 be 10 per cent lower than the base case, and that

people 'diverted' from nursing homes would receive an average of eight hours' home care and 1.5 community nurse visits a week while those 'diverted' from residential homes would receive eight hours' home care. This follows a similar scenario in the National Beds Inquiry for England (Department of Health, 2000b).

The second scenario investigated the potential impact of introducing a national entitlement to free formal care for all older people with moderate to severe dependency (two or more ADLs) whether or not they were receiving informal care. (This scenario mirrors, to a certain extent, the entitlement to long-term care in Germany). This scenario assumes 5.75 hours of formal home care a week and 100 per cent take-up.

The GAD marital status projections suggested that in future there was likely to be an increase in spouse carers of dependent older people. However, many spouse carers are elderly and in need of support themselves. The third scenario looked at providing support to the most heavily burdened carers (defined as those providing personal care to older people living in the same household) and explores the implications of making the same services available to those living with others as those living alone: the 'carer-blind' approach.

In the first scenario, projected public spending was lower than in the base case as the packages of domiciliary care were less costly than institutional care. The national entitlement scenario, however, had substantial cost implications with numbers of those using home help nearly doubling. Under the 'carer-blind' scenario projected long-term care expenditure would also be higher than under the base case.

Unit costs and economic growth

Spending on long-term care is highly sensitive to relatively small changes in future unit costs. The base case of the model assumes that real unit costs will rise in line with historical trends in input pay and prices: one per cent per year for social care and 1.5 per cent a year for health care. GDP is assumed to rise by 2.25 per cent a year.

Residential care, home care and day care are all highly labour intensive. An alternative scenario investigates the impact of assuming that future unit costs will rise in line with projected rises in earnings. This scenario is based on the Treasury's long-term assumptions, published in the 2003 Budget (HM Treasury, 2003), for productivity growth (as an indicator of possible future rises in care staff earnings) and for growth in GDP. In this scenario, spending on long-term care would rise to nearly £31bn compared to £25bn under the base case.

Overall findings of the sensitivity analysis

Overall, the sensitivity analysis shows that projected future demand for long-term care services for older people in the UK is sensitive to assumptions about the future numbers of older people and about future prevalence rates of dependency. It is also sensitive to assumptions about the future availability of informal care. Projected future expenditure on long-term care for older people is also sensitive to assumptions

about future rises in the real unit costs of services, such as the cost of an hour's home care. The sensitivity of the model to changes in the assumptions made means that the projections should not be regarded as forecasts of the future.

A recent international study[8] investigated the sensitivity of projections of long-term care expenditure for older people to assumptions on trends in the key drivers of demand for care (Comas-Herrera and Wittenberg, 2003). This comparative study investigated the key factors that are likely to affect future expenditure on long-term care services in Germany, Spain, Italy and the United Kingdom. The approach involved investigating how sensitive long-term care projections are to assumptions made about future trends in different factors, using comparable projection models.

The sensitivity analysis showed that projections of long-term care expenditure in all four countries are sensitive to assumptions about future mortality and dependency rates. They are also highly sensitive to assumptions about future real rises in the unit costs of care. They are sensitive to scenarios involving a relative decline in informal care where this results in greater use of residential care. They are somewhat less sensitive to assumptions about changes in the patterns of formal care.

3.5. Projections of long-term care expenditure due to dementia

As discussed in section 3.4, future demand for long-term care and associated expenditure are very sensitive to changes in the assumptions made about trends in dependency of older people. The definition of dependency used in the PSSRU model is based on the ability to perform instrumental activities of daily living (IADLs) and activities of daily living (ADL). One of the causes of difficulties in the performance of IADLs and ADLs is dementia. Most of those with dementia who require long-term care are likely to have difficulties with IADLs or ADLs. It is unlikely that a model of long-term care demand that uses IADLs and ADLs would omit large numbers of older people requiring long-term care. Nevertheless, , there are important reasons for having a model that can distinguish between those who have functional dependency only and those who have functional dependency and suffer from dementia.

The first reason is that there are important differences in the patterns of care for people with and without dementia given the same ADL problems, specially for those with severe cognitive impairment. People with severe cognitive impairment are more likely to rely on formal care and, in particular, are more likely to be institutionalised (Bauld et al, 2000, Boersma *et al*, 1997, and Netten *et al*, 2001b). If the future numbers of people with dementia were to rise at different rates than the future numbers of people with ADL problems due to other causes, projections made using a model that only used an overall ADL definition would not be appropriate to plan the future services required for people with dementia.

Another reason why it is important to have a model that takes specific account of dementia is that it would permit an investigation of the potentially cost-saving impact

[8] Funded by the European Commission.

of new drugs for people with Alzheimer's Disease. This would be an important issue to explore.

PSSRU[9] developed a version of their model to make projections, for the next 30 years, of future numbers of older people with cognitive impairment, their demand for long-term care services and the future costs of their care under a range of specified assumptions (Comas-Herrera et al, 2003b). The term cognitive impairment is used here to describe one of the manifestations of dementia.

The study set out to explore the impact of factors that are likely to affect future long-term care expenditure associated with cognitive impairment, in particular changes in the future prevalence rates of mild and severe cognitive impairment. The study also investigated the impact of changes in the patterns of care specific to those with dementia, for example, increasing support to informal carers.

The study found that, under the base case, the numbers of people with cognitive impairment would increase faster between 1998 and 2031 than the numbers of people with functional disability only (66% and 58% respectively). This implies that demand for long-term care will rise at a faster rate among those with cognitive impairment than would be suggested by projections of the overall demand for long-term care based on functional disability. For example, between 1998 and 2031, the number of people with cognitive impairment in institutional care is projected to increase by 63%, compared to a projected 52% increase in the total number of older people in institutions. These results show that, when planning future service requirements for older people with cognitive impairment, it would be important to have specific projections.

The results of the model also showed that, unless more effective treatments for cognitive impairment are developed and made widely available, the numbers of older people with cognitive impairment will rise significantly over the next 30 years. This means that substantial rises in formal services will be required. The implication is that there is a need to develop, and make widely available, better treatments to slow down the progressive decline associated with dementia.

4. Conclusion: recommendations on making long-term care projections

4.1. Choosing the methodological approach

When designing a long-term care projections model, the first step is to be clear on the purpose of the modelling. Key questions are whether the aim is to produce aggregate projections of the future numbers of older people requiring long-term care and of long-term care expenditures, or to investigate the impact of alternative financing mechanisms on different groups. The purpose will influence the choice of type of model, for example, whether to construct a cell-based or microsimulation model.

[9] Funding from the Alzheimer's Research Trust and access to MRC CFAS data (MRC CFAS, 1998) are gratefully acknowledged.

Another key aspect to be clear about is the coverage of the model. Important questions include: will the model include only older people? Will it cover both public and private expenditure or just public long-term care expenditure? Will it include informal care by family and friends or only formal services?

The second step is to investigate all the available sources of data. The ideal situation would be to find a nationally representative survey covering the health, dependency, household situation, income, assets and long-term care use of people in the community and in care homes and hospitals. Single surveys with all the relevant information are not available in most countries. As a result, a variety of sources containing information on some of the aspects need to be used. The description of the UK's PSSRU long-term care model in section 3 explains how various sources of information were used to obtain an overall picture (in terms of data) of long-term care in the UK. The quality of the data used and the construction of a baseline that represents as accurately as possible the current long-term care arrangements is crucial for the reliability of the projections.

Determining the architecture of the model is a complex exercise. In the case of cell-based models it is necessary to balance the need for sufficient cells to address the range of policy issues with the need for a model simple enough to be useable. The greater the breakdown into more cells, the greater the flexibility of the model; but too many cells could render it unduly complex to build and use.

If opting for a cell-based model, it is also important to consider whether there are existing microsimulation models that already model the income and assets (as well as other characteristics) of older people. If so, it may be possible to combine a cell-based model of long-term care projections with a microsimulation model that investigates the impact of different funding mechanisms over time and between different groups.

4.2. Choosing the base case set of assumptions

Projections models generally need to incorporate initial assumptions on future levels of key variables. These may be that key variables will remain constant over time, change in line with past trends or change in line with expert views. Long-term care models need to incorporate assumptions about future trends in the main drivers of demand for long-term care and long-term care expenditure.

It is useful to choose a core set of assumptions about future trends to form a 'base case' that can act as a reference case against which the effect of changes in the different assumptions can be investigated. The approach taken in the UK's PSSRU model has involved taking account within the base case of expected changes in factors exogenous to long-term care policy[10], such as trends in the numbers of older people by age, gender and marital status, and holding constant factors endogenous to long-term care policy, such as patterns of care and the funding system.

[10] The definition of exogenous and endogenous factors use here should be interpreted in relative terms rather than absolute terms: all factors could be at least partly endogenous in the sense that they could be affected by policy changes in the long-term.

The factors affecting the future numbers of dependent older people requiring long-term care are mainly exogenous to long-term care policy. They include demographic change and dependency rates. These two factors affect the overall need for long-term care. There are other important exogenous factors that also affect demand for long-term care, either by influencing the propensity to seek care or by influencing the type and amounts of care that will be sought. These factors include individual preferences, which may reflect age, gender, income and other personal characteristics but which are difficult to model. Demand for formal care is also crucially affected by the availability of informal care.

As well as the exogenous factors mentioned above, the receipt of long-term care is influenced by factors endogenous to long-term care policy, such as the availability and accessibility of formal services, the funding system, and the policy incentives or disincentives to the provision of informal care.

Future long-term care expenditure is determined not only by changes in the volume of services demanded but also by rises in the unit costs of long-term care, such as the cost of an hour's home care. Since long-term care services are labour-intensive services, trends in the unit costs of care will depend largely on trends in the earnings of care staff. The future affordability of long-term care depends also on how much the economy grows in the future.

The PSSRU model aims, as discussed above, to use base case assumptions that reflect "expected changes" in the main exogenous factors. However, there is not always consensus on what assumptions reflect those "expected changes". While using the official population and marital projections as base case assumptions is not very contentious, the choice of a base case assumption for trends in dependency and in unit costs is less straightforward as there is no consensus in the literature about future dependency rates and long-term economic trends. It is important to keep the base case assumptions under review in the light of new evidence.

4.3. Carrying out sensitivity analysis and interpreting the projections

Given the great degree of uncertainty about future trends in the drivers of demand for long-term care, it is very important to carry out sensitivity analysis to investigate the impact of changing each of the base case assumptions of the models.

The importance of the results of the sensitivity analysis lies in the fact that it is beyond the present state of knowledge to set probabilities for future trends in the factors examined. Yet it is important for policy and planning purposes to demonstrate the extent of sensitivity of future long-term care expenditures to assumptions about these trends. The findings of the PSSRU and other models suggest that policy-makers need to plan for uncertainty in future demand for long-term care for dependent older people. Future mortality and prevalence rates and rises in unit care costs, which are inevitably uncertain, have substantial implications for future demand for long-term care and associated expenditure.

It is also important to recognise that most models will not have taken account of the

impact of rising expectations, as their likely impact would be very difficult to measure and quantify. It seems plausible that rising real incomes will be accompanied by rising expectations for more and better quality care.

The approach taken by the PSSRU study of long-term care projections has been to emphasize that the model makes projections based on assumptions, rather than forecasts. That means that, instead of asserting what the future demand for long-term care and expenditure will be, the model's projections show what the future demand and expenditure would be like given the assumptions specified.

Acknowledgements

Most of the research reported here has been carried out as part of the Personal Social Services Research Unit's long-term research programme, financed by the Department of Health. Bleddyn Davies and Robin Darton have contributed to some of the research reported in this paper. All views reported here are those of the authors. The report does not purport to represent the views of the Department of Health.

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Making projections of long-term care: examples and methodological issues

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PSSRU Discussion paper 2004

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1. Introduction:

As the numbers of older people rises throughout the world, there have been concerns about the future affordability of public expenditure, particularly on pensions, health care and long-term care. In this context, the European Union's Economic Policy Committee (EPC) conducted a study of the impact of ageing on future public expenditure on pensions, health and long-term care and how it would affect the fiscal sustainability of public finances (Economic Policy Committee, 2001).

Projected increases in the numbers of users of long-term care, and concerns about the future availability of care provided by the family and other informal carers, have attracted more attention to the issue of the provision and financing of long-term care. There have been debates about how to provide and finance long-term care in most of Europe. These debates have concentrated, mainly, on the extent to which long-term care is an individual, family or state responsibility; the balance between care provided by families and public and private sector providers; financing arrangements, especially the balance between public finance and private payments; whether to provide care in-kind or cash payments; and the boundaries between health and social care (see, for example, Ikegami and Campbell 2002, Glendinning 1998, Karlsson 2002, OECD 1996).

These debates about the sustainability of public finances and how to provide and finance long-term care raise many questions. How many older people are likely to require long-term care services in the coming decades? How much are these services likely to cost? Will the cost to public funds prove affordable? In order to address these issues, it is useful to have reliable projections of future demand for long-term care and associated future long-term care expenditure.

Projections of long-term care demand can also be valuable as aids to planning. They can be used to illustrate the growth in supply of care required as the numbers of older people grow, and the impact that changes in the patterns of care could have on the volumes of services required.

This paper discusses various methodological approaches to making projections of future long-term care demand and expenditure. Section two discusses and, provides examples of, the main two approaches: cell-based models and microsimulation models. Section three discusses in detail the methodological approach chosen in the development of a specific model: the Personal Social Services Research Unit (PSSRU) long-term care model. Projections made with the PSSRU model are presented, as well as a discussion of the sensitivity of long-term care projections to various factors. Finally, section four concludes with some recommendations on making long-term care projections.

2. Critical analysis of different long-term care projections models

Projections of long-term care demand and expenditure can be produced in many different ways. Which method is best depends very much on two factors: what is the purpose of the projections, and what data are available. The main purposes of long-

term care projections tend to be, as discussed in the introduction, to assist in the planning of long-term services; to investigate the future affordability of long-term services; and to estimate the future implications of possible changes in patterns of care or funding mechanisms.

The availability of suitable data is, in most countries, an important limiting factor, when considering how to make long-term care projections. Long-term care has historically accounted for only a small proportion of public expenditure, especially compared to health care. As a result, few countries have systematically collected much data on long-term care provision and expenditure.

There are broadly two main approaches to making projections: cell-based (or macrosimulation) models and microsimulation models. The main feature that distinguishes the two types of model is that microsimulation models have as their unit of analysis individual people, families or households, while cell-based models have, as their unit of analysis, aggregates of individuals grouped by their characteristics (such as age and gender). Most long-term care models are cell-based, not only because it is a much simpler method of making projections, but also because very few countries have the data required to produce microsimulation models.

This section describes some examples of both cell-based and microsimulation models. It discusses the advantages and disadvantages of both approaches, and concludes with an example of the combination of a macro and a microsimulation model, and some recommendations on choosing an approach. A useful discussion outlining the differences between the two methods and their advantages and disadvantages is available in Wittenberg *et al*, (1998, p. 28). Spilauer (2002) has also compared both approaches in his review of microsimulation models.

2.1. Cell-based (or macrosimulation) models

Most models used to make projections of future demand for long-term care or of future expenditure are cell-based models that, as stated before, have as a unit of analysis groups of people rather than individuals. Most cell-based models are built using a spreadsheet. While it is possible to develop sophisticated systems of scenarios, the models tend to be relatively straightforward from a computing point of view.

In cell-based models the overall population is represented by an aggregated cross-classification table, in which the cells represent each possible combination of the characteristics considered. The number of cells grows with the number of characteristics and too many cells could make the models unwieldy. Most long-term care cell-based models (partly as a result of lack of data) only consider a limited number of variables and a result the number of cells does not become a problem. The model developed by the Personal Social Services Research Unit (PSSRU model) in the UK, which does have a considerable number of variables, deals with the potential explosion in the numbers of cells by limiting the number of variables used to those that are relevant in each part of the model. For further details, see section 3 of this paper.

There are several different types of cell-based models. The purpose for which the projections are made, the long-term care systems that they represent and the

availability of data determine to a great extent the design and complexity of the models. Below are descriptions of various long-term care cell-based models. An attempt has been made to classify them according to the factors they take into account.

Expenditure profile modelling:

The simplest form of long-term care projections model, which is also one of the most frequently used, consists in applying the current average costs of care for people of each age (and sometimes gender) group to the future numbers of people in that age (and gender) group. These average costs for each age and gender group are often called "expenditure profiles".

This method of making projections has the advantage of very low demands in terms of data and computing, and is widely used. It has been used in international comparisons by the OECD and, more recently, the European Union's Economic Policy Committee (EPC, 2001). As long as the data on the costs of care have been calculated using similar methods and coverage in the different countries, the projections obtained using this method are, in principle, highly comparable.

With regards long-term care, however, not all countries have even such basic data readily available. In the EPC study, while all EU countries (except Luxemburg) were able to provide age and gender specific health expenditure profiles, only ten countries provided them for long-term care. The lack of basic data partly reflects the absence in many countries of information systems to compile data on long-term care use and expenditure.

The main limitation of the "expenditure profile" projections is that they make the implicit assumption that the only factors that affect future long-term care expenditure are demography and inflation. However, there are many factors other than age that will determine future demand of long-term care and expenditure. Age is effectively just an imperfect proxy for need in such models.

The sensitivity of projections produced using this type of model can be investigated in respect of alternative demographic projections and alternative inflation assumptions. The sensitivity of these projections to changes in the prevalence of disability, the proportion of older people living alone or patterns of care cannot be readily investigated.

In the UK, the Department of Health model (House of Commons Health Committee, 1996, see also the review by Wittenberg, 1999) used age-specific expenditure profiles as its starting point, but adjustments were then made for assumed changes, under varying scenarios, in real costs of care, age-specific disability rates and some other factors.

Models that allow the exploration of dependency trends:

A slightly more sophisticated approach, used by Lagergren and Batljan (2000) in Sweden, is to calculate the long-term care costs of people with different degrees of

dependency. The model then applies prevalence rates of functional dependency to the projected future population in order to obtain the future numbers of people with dependency and, finally, their long-term care costs. This approach makes it possible to investigate separately the impact of changes in mortality and dependency on the future costs of long-term care.

A review by Wittenberg of models of long-term care projections (Wittenberg, 1999) identified, in Britain, two cell-based models that also went beyond age and gender expenditure profiles. The Institute of Actuaries' model (Nuttall et al, 1993, now partly updated by Rickayzen and Walsh, 2002) made projections of the future numbers of disabled people and of the costs of caring for them on varying assumptions about changes in age-specific mortality and disability rates. Hours of care demanded were estimated by assigning an assumed number of hours per week for each level of disability. The London Economics and the Institute for Public Policy Research (Richards et al, 1996) study effectively used the Institute of Actuaries central scenario, with some minor changes in assumptions, as its starting point on projected numbers of disabled people for each year to 2030. It then concentrated on estimating the breakdown of the aggregate level of care demanded between informal care, publicly funded care and privately funded care. The review by Wittenberg (1999) describes these models in detail.

Models that allow the exploration of changes in patterns of care:

A recent international study (Comas-Herrera and Wittenberg, 2003) investigated future long-term care expenditure in four different countries (Germany, Spain, Italy and the United Kingdom) and their sensitivity to factors such as demography, changes in the prevalence of dependency, changes in the balance between informal and formal care, changes in the balance between domiciliary and institutional care, and in the rates of growth of the unit costs of care. The study used existing models in Germany and the UK. A model for Spain was substantially expanded for use in the study, and a new Italian model was developed for the project. Three of those models are described below. The UK model, developed by the Personal Social Services Research Unit (PSSRU model), is described in more detail in section 3 of this paper.

The Spanish model is based on an earlier simpler model developed by Casado (Casado and Lopez Casasnovas, 2001). It was further developed by Patxot and Costa-Font as part of the European study (Patxot and Costa-Font, 2003). Their model calculates the future numbers of people with dependency by applying current dependency rates to the projected population. It then applies, to the future numbers of dependent older people, the current utilisation rates of services. The model can be used to investigate changes in mortality, dependency trends, utilisation of services and the future unit costs of care.

The Italian model was developed specifically for the European study by Comas-Herrera, Di Maio, Gori and Pozzi (2003). The model uses a similar structure as the Spanish model described above. There was only a short amount of time available to develop the model and the team were not able to explore all the possible sources of data. This model is currently being reviewed and improved by Vanara and Gori (?).

The German model was developed by Rothgang (Rothgang, 2003) to make projections of the future numbers of beneficiaries of public long-term care insurance, and of the future contribution rates for public long-term care insurance, under a number of scenarios. Rothgang's model applies the prevalence rates of the various degrees of dependency (that determine entitlement to insurance benefits), by age and gender, to the future numbers of older people. The model then calculates long-term care insurance expenditure by applying the value of the benefits to the numbers of recipients. This projected expenditure is then applied to a simple labour force and pensions model to calculate the future contribution rates necessary under various scenarios.

The value of the benefits in the German model depends not only on the severity of dependency but also on the type of benefits chosen. There is a choice between cash-benefits, in-kind care in people's own home, a mixture of cash and in-kind benefits, and institutional care. The model's base case assumes that the proportion of people by age, gender and dependency that choose the different types of benefits remains unchanged. Sensitivity analysis can be used to investigate the expenditure impact of changing the choice of benefits (as well as the impact of different assumptions about future mortality, dependency and changes in the real unit costs of care). A change in the choice of benefits would result, effectively, in a change in patterns of care.

None of the models described above consider whether older people live alone or with others, or whether they have access to an informal carer. They also do not consider the socio-economic status of care users. These are important factors in the demand for long-term care services, as changes in household composition or the economic situation of older people will affect their future demand for long-term care services. The UK's PSSRU model (and a nearly identical replica done for Catalonia, see Lopez-Casasnovas, Casado and Comas-Herrera, 2003) is, as far as the authors know, the only long-term care cell-based model that takes household type and economic situation (housing tenure) variables into account.

2.2. Microsimulation models

Microsimulation models can be defined as models that use simulation techniques and that take micro-level units (that is, in the case of long-term care models, the individual, family or household) as the basic units of analysis. They permit a more detailed consideration of distributional factors than cell-based models. A useful review of microsimulation methods in health care modelling can be found in Spilauer (2002).

Dynamic (as a opposed to static) microsimulation models simulate changes over time and in response to context changes. Monte-Carlo simulation, using information on transition rates between states, is used to determine transitions of micro-units from one state to another at each time period. Such transitions could include mortality, onset of dependency or admission to residential care.

Dynamic microsimulation models have the advantage of allowing the consideration of events over the lifetime. They can be used, for example, to simulate how long a person can expect to live in each of a number of health or dependency states. They can also be used to simulate a link between contributions to a pension or other

saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle.

Dynamic microsimulation models are potentially useful for the purposes of modelling future demand for long-term care and expenditure. The reason that there are not many such models (besides the substantial investment in data analysis and computing involved) is that the data they require is not available in most countries. A dynamic microsimulation model of long-term care would require a longitudinal data collection from which to draw information on transitions in health (or dependency) states and other variables including the use of long-term care.

The following sections describe three microsimulation models. Two of them are from the US and the third one investigates charging for long-term care in the UK.

US models

The Brookings Institution and Lewin-VHI Inc, and the Urban Institute, have developed Long-Term Care models using microsimulation techniques. In the US longitudinal data on health states, disability and use of long-term care is available from the National Long Term Care Survey and other surveys. The health state, family circumstances, incomes and other characteristics of a sample of individuals are simulated year by year to their deaths. The outputs of the microsimulations are grossed up to match official population projections by age and gender. These models have been described in some detail and compared with cell-based models by Wittenberg (1999).

The Brookings Institution and Lewin-VHI Inc. Long-Term Care Financing Model was originally developed in 1986-7 but updated and refined in 1988-9 using new data. This model projects the size, financial position, disability status, and nursing home and home care use and expenditures of elderly people through the year 2020. Expenditures are further extrapolated on a broader basis to the year 2050. The model has been used to simulate the effects of changes in the system for financing long-term care in the USA (Wiener et al, 1994). The model starts with a nationally representative sample of the adult population, with a record of each person's age, gender, income, assets, and other characteristics. It then simulates changes to each individual from 1986 to 2020. The changes simulated include onset and recovery from disability and commencement and termination of receipt of long term care services.

The Brookings Institution Lewin-VHI study assigns a source of funding for all elderly people who have been modelled to receive home care or nursing home care. Medicare funding is considered before payment from other sources. Where a person is admitted to non-Medicare nursing home care, the costs are attributed to the person's income and then non-housing assets. When the person's assets have been spent down to the Medicaid threshold, Medicaid is assumed to pay the difference between the person's income (less a personal allowance) and the Medicaid payment rate. In this way the Medicare and Medicaid systems are simulated.

The Urban Institute's Dynamic Simulation of Income Model (DYNASIM) was used to project the elderly population's characteristics, incomes, and needs to the year 2030 (Zedlewski et al, 1990). The study considers the future numbers of elderly people with

different levels of disability, incomes and other characteristics, under varying assumptions about future mortality and disability rates. It does not include projections of long-term care expenditure.

Both studies consider future trends in marital status and numbers of children as part of their simulations but do not investigate sensitivity to alternative assumptions. Marriage, divorce and widowhood are included in the microsimulations as is child-birth. Official data are used on marital status and on fertility. The related issue of the proportion of elderly people living alone is also considered in both models. The studies do not, however, make a link between living arrangement, as opposed to marital status, and probability of receipt of long term care.

Both studies consider income and assets in some detail in their simulations. The Urban Institute model was designed specifically to look at incomes, while the Brookings Lewin-VHI Long Term Care Financing Model is based on the Lewin-VHI Pension and Retirement Income Simulation Model (PRISM).

The studies modelled receipt of home care and receipt of residential care separately as functions of individual characteristics such as age, gender and dependency. The relationship between these characteristics and receipt of care is assumed to remain constant over time, at least as a base case. The Brookings Institution model gives the user a facility to simulate an increase in home care use and/or in nursing home use by adjusting the estimated probabilities of service receipt by a factor assumed for induced demand.

Informal care is not directly covered in either model. They take actual propensities to receive care in a base year as their starting point for projections. The Brookings study considers the impact on the balance between public and private expenditure of potential changes in real incomes and assets.

The Nuffield Community Care Studies Unit model

The Nuffield Community Care Studies Unit (NCCSU), in the UK, has developed a microsimulation model to simulate long-term care charges under different charging regimes (Hancock, 2000). It contains detailed information on the incomes, wealth, housing and other relevant characteristics of sample members, sufficient to make good estimates of their liability for care charges. The model permits analysis of the distributional consequences of different long-term care funding options.

The NCCSU model simulates what each older participant in the UK's Family Resources Survey would have to pay towards care home fees should he or she need long-term care. The model performs simulations for single people currently aged 65 and over, and for the older partner in couples where at least one partner is aged at least 65 years. The simulations are performed for a base year and for future years. Simulations for future years involve: ageing the sample of those currently aged 65 or more, allowing for deaths and the consequent effects of widowhood; modelling the evolution of their incomes and capital under certain assumptions; and making assumptions about future costs of care and the care charging, social security benefit and income tax regimes which will be in place for the year of interest. The model

makes a number of simplifying assumptions such as, for example, in predicting death there is no allowance for differences in mortality by income, social class or housing tenure.

Because it is more difficult to predict the future incomes of people who are not yet retired than it is for those who are already drawing pensions, the base year sample is not 'refreshed' as it is aged. This restricts the years and age ranges for which the model produces projections.

The microsimulation model does not predict how many or which older people will need care. It simply calculates what each person in a representative sample of older people would be required to contribute to the costs of residential or nursing home care should he or she need it, and how much would be contributed from different parts of the public purse. British data shows that, controlling for age, residents in care homes are, in comparison with older people generally, disproportionately likely to have lived alone and to have rented rather than owned their homes (Netten et al, 1998). Housing tenure and whether living alone are also both characteristics which affect liability for long-term care charges as well as probability of admission to care homes.

The NCCSU and PSSRU[1] jointly produced projections of future long-term care expenditure through an innovative linkage of their two models. This involved using outputs from the NCCSU microsimulation model as inputs to the PSSRU cell-based model. The NCCSU model produced projections of the future proportions of older people eligible for public funding should they require residential care and of their future contributions to the costs of their care under different funding arrangements. The PSSRU model produced projections of total public and private expenditure on long-term care to 2051 on the basis of the NCCSU projections and assumptions about future trends in life expectancy, dependency, real unit costs and patterns of care (Wittenberg et al, 2002 and Hancock et al, forthcoming).

2.3. Advantages and disadvantages of both approaches

Microsimulation models would offer some advantages for making projections of long-term care for older people, compared to cell-based models. One advantage, specially relevant for models that look at financing long-term care, is that they permit a more detailed consideration of distributional factors than cell-based models. An example would be the way in which different funding systems affect different income groups. In cell-based models the investigation of distributional issues is restricted to distribution by the variables used to define the cells.

A second advantage of microsimulation models is that, as discussed above, they can also be used to simulate a link between contributions to a pension or other saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle. This is important where a contributions-based insurance system is under consideration.

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[1] This research was financed by the Institute of Public Policy Research (IPPR), UK.

A further advantage is that the number of cells in cell-based models grows with the number of characteristics and too many cells could make the models unwieldy. In practice, most long-term care cell-based models (partly as a result of lack of data) consider only a limited number of variables and the number of cells does not in practice become a problem.

While there are many advantages to microsimulation (and in particular dynamic microsimulation) models, it is important to be aware that constructing a microsimulation model is a complex and time-consuming task. As discussed in Wittenberg et al (1998, p. 130), "... such work is not likely to be cost-effective unless there is a policy interest in the types of question that can only be answered through microsimulation; suitable data – generally longitudinal data- are available; and the expertise and resources are available".

Unfortunately, in most countries suitable data is not available, which is a key reason why cell-based models are more widely used. A useful approach to enable the investigation of distributional issues is to combine a cell-based model for long-term care with an existing microsimulation model of the incomes and assets of older people, as discussed above and in Hancock et al (forthcoming).

3. The PSSRU model

The PSSRU long-term care projections model was constructed as part of a project on long-term care finance, funded by the English Department of Health since 1996. The project is concerned with two related policy issues on the funding of long-term care for older people. The first is whether expenditure, and specifically public expenditure, on long-term care will remain sustainable over the coming decades, despite demographic pressures and potentially rising expectations. The second is what should be the balance between public and private expenditure on long-term care.

A detailed account of the long-term care projections model and of the data and assumptions and the methodology used can be found in Wittenberg *et al* (1998), a report that describes the first version of the model. The model has been regularly updated and expanded. A paper exploring sensitivity of an updated version of the model to various assumptions was published in Health Statistics Quarterly in 2001 (Wittenberg *et al*, 2001). The latest version of the model is described in Comas-Herrera et al (2003a).

The initial model was used to provide projections for the Royal Commission on Long-Term Care[2] (1999). More recently, new versions of the model have been used to provide projections for the HM Treasury Health Trends Review (Wanless, 2002) and for the Institute of Public Policy Research (Wittenberg *et al*, 2002 and Hancock *et al*, forthcoming). The latter involved innovative linkage between the PSSRU model and a microsimulation model developed by the Nuffield Community Care Studies Unit (NCCSU), as discussed above.

[2] A high level group set up by the Government to review the financing of long-term care and make recommendations about its future financing.

As well as the main model, other versions of the model have been developed. One of them investigates the future long-term care costs of cognitive impairment (Comas-Herrera et al 2003b), using MRC CFAS data (MRC CFAS, 1998). This enabled separate projections to be made of services for older people with cognitive impairment under a range of assumptions about future prevalence rates of cognitive impairment. This version of the model will be further described in section 3.5. Versions of the model have been developed for the National Assembly for Wales (Comas-Herrera et al, 2003c) and for the Catalan regional Government (Lopez-Casasnovas et al, 2003).

This section contains a discussion of the methodological issues addressed in designing the PSSRU model, in particular with regards the modelling of demand. It then provides a detailed description of the model, the assumptions made, and the base case projections.

3.1. Methodological choices in modelling demand and supply of long-term care

The PSSRU model aims to make projections of three key variables: the future numbers of dependent older people, the likely level of demand for long-term care services for elderly people and the costs associated with meeting this demand. The model covers public and private services and expenditure. It is cell-based (a macro-simulation model) and takes the form of a spreadsheet. An in-depth discussion of the methodological approach adopted in designing the model is available in Wittenberg et al (1998). This section summarises some of the main points.

The first, crucial point is that *the model does not make forecasts about the future.* It makes projections on the basis of specific assumptions about future trends. The approach involves simulating the impact on demand of specified changes in demand drivers, such as demographic pressures, or specified changes in policy, such as the introduction of free personal care. It does not involve forecasting future policies or future patterns of care.

The second important point is to clarify the concept of demand in this context. Demand generally refers to the quantity of a good of service that people want to purchase at a given price. The demand by a person for goods or services is generally taken to be a function of the person's income, the price of the good, the price of other goods that may be close substitutes or complements, and the person's tastes. The latter may in turn be a function of the person's age, gender, occupation, health state, and other personal characteristics.

The demand for long-term care is complicated by at least three issues. First, it is important to consider the relationship between need and demand, which is discussed below. Second, it is important to distinguish between demand for different types of care. In particular it seems important to differentiate between demand that could be met by either informal or formal care and demand for formal health and social services. Third, it is difficult to observe "demand" alone. What is observed from data on service use is a combination of demand and supply (Norton, 2000).

Relationship between need and demand

Need for long-term care may arise from a number of sources or combination of sources. It may arise from limitations in physical health and/or in mental health. It may arise from a combination of limitations in health and difficulties in the person's environment, such as poor or unsuitable housing. Demand is not the same as need. It takes account of the person's ability and willingness to purchase the good or service. Demand for long-term care would arise if the person actually sought long-term care and was willing to pay, if required.

These considerations suggest that demand for long-term care can be regarded as a function of the following variables: age, gender, physical health, mental health, income, assets, preferences, and the costs of care (Evandrou and Winter, 1988; Davies et al, 1990 and Norton, 2000). A model of long-term care demand should in theory consider all of these. Preferences, however, are clearly intangible and changes in preferences or expectations are problematic to project.

Demand for different types of care

It is possible to distinguish three forms of long-term care in terms of costs to the care recipient. These are informal care by family and friends, publicly funded formal care, and privately purchased formal care. The first generally involves no financial cost to care recipients, the second may involve a cost depending on whether public support is subject to charges, and the third clearly involves a financial cost to care recipients or their families. This consideration, together with the potentially different nature of formal services and informal care, mean that the different types of care need to be considered as separate subsets of overall demand for long-term care.

Demand and supply of informal care

Demand for informal care could in principle be regarded as a function of the same variables as demand for long-term care generally. The concept of demand for informal care, however, has little meaning in practice in the absence of family or friends willing to supply such care; that is, in the absence of potential supply. Since a proportion of dependent people do not have a surviving close relative or friend, for some people informal care is not an option.

The supply of informal care depends on the availability of a potential carer. The most recent data on informal carers supplied by the General Household Survey (GHS) confirms that the majority of informal care is provided by spouses, children and children-in-law (Maher and Green 2002).

The supply of informal care depends not only on the availability of a potential carer but also on the potential carer's ability and willingness to provide care. The carer's ability and willingness to provide care may be affected by the carer's health and other commitments, including employment and child-care responsibilities. It may also be affected by the carer's income. People with higher incomes may prefer to purchase care

for their elderly relative, as the cost of any employment lost, that is, the opportunity cost of caring, would be higher.

The supply of informal care is clearly central, yet it cannot be considered independently of demand. Not all informal care is supplied to people with a need for care in the sense that they are dependent or disabled in some way. There is evidence that much informal care for elderly people is supplied to people who do not have disabilities and that carers often give care irrespective of need (Daatland 1983, Wenger 1992). This again relates to a fundamental characteristic of informal care. It is not just that people who need care do not necessarily receive it from the informal sector, it is also that caregivers often give care irrespective of need. If, then, the concern is with the support of dependent elderly people, not all the informal care supplied is relevant.

To consider the factors influencing whether or not an older person receives informal care, it is necessary to bring together the factors affecting demand and supply. This suggests that the provision of informal care to an individual is a function of the person's dependency, income, preferences, and availability of a partner, child or possibly other relative living nearby, and also of the potential carer's health, income, employment status, marital status, child-care responsibilities and preferences.

The PSSRU model treats the receipt of informal care as a function of the person's dependency (as an indicator of need) and of the person's household type (as an indicator of the likely availability of informal care). The former may be regarded as a demand variable and the latter as a supply variable. The function is thus a reduced form[3] that seeks to model actual receipt of informal help rather than a demand or a supply function.

Relationship between formal and informal care

It is important to consider the nature of the relationship between formal and informal care. An important issue is whether the amounts of formal and informal care provided are determined jointly, or whether the amount of formal care provided can be considered as a function of the amount of informal care. Joint determination implies that both informal and formal care are determined at the same time, with the level of informal and formal care jointly determined by the parties involved. Consecutive determination implies that formal care follows informal care sequentially and that informal care is taken into account when formal services are provided.

The approach to informal care adopted by service providers in the UK, certainly prior to the community care changes of the early 1990s, has been characterised by a model that treats carers as a resource and provides formal services very much in response to the amount of informal care received (Twigg and Atkin 1994). This is reflected in the importance of household composition as a variable determining receipt of formal services, since household composition to a large extent reflects the amount of informal care (Evandrou et al 1986, Evandrou 1987, Evandrou and Winter, 1988).

[3] By a "reduced form" function is meant the summarisation in one equation of a reciprocal inter-relationship between variables requiring two or more equations to describe in full. The single equation takes the perspective of the influence on one only of two causally interdependent variables.

For this reason, the PSSRU model has a sequential form. In the model, household type is one of the variables that determines receipt of informal care. Indeed, so close is the relationship between household type and informal care that the most recent version of the PSSRU model treats household type and informal care as a single variable with five categories: living alone without informal help, living alone with informal help, single living with others, married/cohabiting living with partner only and married/cohabiting living with partner and others. Receipt of informal care/household type, in turn, is one of the variables that determines receipt of formal care in the model.

Demand for formal care

This discussion of the relationship between formal and informal care suggests that the demand for formal care should be treated as a function not only of the variables affecting overall demand for long-term care but also of the provision of informal care. This is on the basis that formal care can and does sometimes substitute for informal care, especially when it is unavailable, and that informal care provision is often determined before formal care. The demand for formal care can, therefore, be regarded as a function of the person's age, gender, physical health, mental health, income, assets, preferences, and receipt of informal care, and of the costs of care.

For those with no informal carers, the overall demand for long-term care is effectively a demand for formal services. For those receiving informal care, the demand for formal services may be regarded as a demand for additional types of care or additional hours of care that remain unmet. Alternatively, or additionally, there may be a demand for formal services to provide respite for informal carers. This suggests that carer stress may be a further relevant factor.

The role of supply constraints in observed demand

The supply of formal services also requires discussion. Demand for long-term care alone is difficult to observe and the data used on service use is, in fact, a combination of demand and supply. The overall supply of publicly funded care is affected by policy decisions at central and local level about priorities for public expenditure. In modelling demand for formal care, these policy decisions need to be treated as exogenous to the model. This is on the basis that the purpose of the modelling is to inform decisions on public expenditure by providing information on projected changes in demand. To take account of policy constraints on supply in a model aiming to inform policy decisions on supply of public funds would be circular.

Market constraints on supply are also very important. A key constraint is the need to retain the inputs to formal care, especially care staff. Expenditure projections need to incorporate assumptions about unit costs of care and about rises in the real costs of care. These could be understood as assumptions about the real rises in wages and other payments for inputs to care that are necessary to ensure that supply is sufficient. Expenditure projections would thus effectively assume that supply of formal care will adjust to match demand for formal care and that demand will be no more constrained by supply in the future than in the base year. This is on the basis of an appropriate assumption about real rises in care costs.

Other methodological choices

The model contains a relatively large number of variables that, when combined in a cross-tabulation, create a relatively large number of categories (cells), as discussed below. This can cause a problem when using data from sample surveys, as the number of observations that relate to people in each category (cell) in the cross-tabulation may become too small. The PSSRU model deals with this problem by using multivariate (logistic regression) analysis to determine which variables, such as age, gender and dependency, are statistically significant in explaining the use of different services. The fitted values from the analysis are used as the probability of receipt of services for people in each category.

Another important feature of the design of the model is that it has been built in a way that allows the testing of alternative hypotheses about trends in the key factors affecting future demand for long-term care and expenditure. A nearly automated menu of alternative assumptions about trends in key factors has been developed that allows almost any combination of assumptions for the different factors to be tested.

3.2. Description of the model

The model described below seeks to model the demand for formal long-term care services, as a function of some of the key variables discussed in this section. These include not only the elderly person's age, dependency and other characteristics but also the person's receipt of informal care. The latter is a function of demand and supply factors relating to informal care.

The model does not seek to incorporate variables concerning the supply of formal care. It does not seem appropriate to do so, since one of the purposes of the model is to inform policy decisions concerning the supply of publicly funded care. Supply considerations are not, however, absent from the model. Assumptions are made about future rises in the real costs of care. These need to be sufficient to retain the inputs, especially staff, required to provide the levels of care demanded.

The description of the model provided here was first published in Comas-Herrera et al (2003a). The model consists of four main parts. The first part estimates the numbers of older people with different levels of dependency by age group, gender, household type and housing tenure. The second part estimates the levels of long-term care services required, by attaching a probability of receiving health and social care services to each cell. The third part of the model estimates total health and social services expenditure, and finally, in the fourth part, total expenditure is allocated to the various sources of funding.

Part One: Projected numbers of older people

The first part of the model classifies the projected numbers of older people into subgroups (or cells), according to age bands, gender, dependency and other key characteristics. The model uses the Government Actuary's Department (GAD 2003

and Shaw 2003) 2001-based interim population projections as the basis for the numbers of people by age band and gender in each year under consideration until 2031.

The projected older population by age band and gender are separated into dependency groups. The model uses as a measure of dependency the ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Four dependency groups have been used in the model (Box One). Information from the 1998/9 General Household Survey (GHS) was used to break down the private household population into the four groups.

BOX ONE
DEPENDENCY GROUPS USED IN THE PSSRU MODEL

The four dependency groups used in the model are as follows:

1. People able to perform ADL (personal care) tasks and IADL (domestic care) tasks without difficulty.
2. People with difficulty with IADL but not ADL tasks.
3. People with difficulty with one ADL task.
4. People who live in the community and have difficulty with two or more ADL tasks, and people who are in institutional care (hospital, nursing home or residential care home).

Another key factor in the receipt of long-term care is household type. Household type is an important structural correlate of informal care (Pickard *et al.* 2000). Informal care is combined with household composition in a five-fold classification: living alone without informal help; living alone with informal help; *de facto* single, living with others; married/cohabiting couple; and married/cohabiting couple, living with others. Household types where older people live with others, including married/cohabiting couples, have not been broken down between those with and without informal carers because all older people living with others have a potential carer and most of those who are dependent have an actual carer. In the 1998/9 General Household Survey (GHS), over 90% of dependent older people living with others received informal help with domestic tasks.

Projections of informal care/household composition in the PSSRU model are driven by the 1996-based GAD marital status and cohabitation projections (Shaw 1999, Shaw and Haskey 1999). The two marital status groups (those who are *de facto* married and those who are *de facto* single) are broken down into five household types using the 1998/9 GHS. The projections assume a 'steady state' regarding the propensity within marital status groups to live with others.

The model includes, for those living in private households, a simple breakdown by housing tenure, between those living in owner-occupied tenure and those living in rented accommodation. One reason for the inclusion of housing tenure is that it can be regarded as a simple proxy for socio-economic group. Another is that it is

relevant, in the case of older people living alone, to the division between those who fund their own residential or nursing home care and those who are funded by their local authority or health authority. The current means test for public support in residential or nursing home care generally takes account of the value of the person's home (unless it is occupied by their spouse or an older or disabled relative). This means that older home-owners who live alone generally need to fund their residential or nursing home care privately, while older tenants and older home-owners living with their spouse are often eligible for public funding.

The model divides the population into 440 cells. 40 of these relate to the institutional population by age (5 bands), gender, previous household type (2 categories) and previous housing tenure (2 categories), and 400 to the household population by age (5 bands), gender, dependency (4 groups), household type/informal care (5 categories) and tenure (2 categories).

It is important to point out that, as discussed in section 3.1, the 440 cells is the maximum number of combinations that the variables and categories used yield. In practice, the model does not use all the variables and categories simultaneously.

Part Two: Projected numbers of service recipients

The second part of the model projects the volumes of services demanded by combining the output of the first part of the model (the projected numbers of older people by dependency, household type/informal care and other characteristics) with functions that assign receipt of services to each sub-group of the older population. The services covered include a range of health and social services relevant to meeting long-term care needs.

The probability of receipt of each non-residential service, such as home care, day care, and community nursing, was estimated through multivariate (logistic regression) analysis of the 1998/9 GHS data. The independent variables were age, gender, dependency, marital status, household type/informal care and housing tenure. Separate analyses were undertaken for dependent and non-dependent older people, as few non-dependent older people received services other than chiropody and private domestic help. For non-dependent people, age was statistically significantly associated with probability of receipt of each service and gender, marital status and tenure with receipt of some services. For dependent people, age, severity of dependency and marital status or household type were statistically significantly associated with probability of receipt of most services, and gender and housing tenure with receipt of some services.

Demand for domiciliary services was calculated by using the fitted values from the logistic regression models as the estimated probabilities of receipt of each service by age band, gender, dependency and the other factors described above. These fitted values were then multiplied by the projected numbers of older people within each cell by age band and other needs-related circumstances to produce estimates of the numbers of service recipients.

Finally, these estimates of numbers of service recipients were multiplied by estimates of the average intensity of service receipt, i.e. the average number of home help hours or district nursing visits per recipient week. Information on intensity of service receipt by dependency was also obtained from the 1998/9 GHS.

The probability of receiving residential, nursing home or long-stay hospital care was estimated using a combination of data. Official national statistics were used on the total numbers in residential care homes and nursing homes (Department of Health, 2000a). A proportionate breakdown of care home residents by age band, gender, previous household type and previous housing tenure was derived from PSSRU surveys of residential care (Netten *et al*, 1998) and applied to the totals. This approach enabled the proportion of older people in residential care and nursing home to be estimated by age band, gender, household type and housing tenure. Hospital Episode Statistics data on the numbers of older patients by age and gender with stays exceeding 55 days were used as estimates of the numbers in long-stay hospital care. In the absence of data on this group's previous household type and housing tenure, a breakdown from the PSSRU survey data on nursing home residents was applied to hospital residents.

In summary, the numbers of recipients (*SERNO*) of each service (*j*) was estimated as:

$$SERNO_j = \sum_{i=1}^{440} p_{ij} \cdot n_i ,$$

where p_{ij} is the probability of a person in cell *i* (i=1 to 440) receiving service *j* (j=1 to 9) and n_i is the number of older people in cell *i*.

Part Three: Projected aggregate expenditure on long-term care services

The third part of the model projects the total expenditure on the formal services demanded applying unit costs of formal care, drawn from a PSSRU study (Netten *et al.* 2001a) and from Laing and Buisson (2001), to the volume of services projected in the second part of the model. The unit costs were uprated to 2001 prices using the health and social services deflators available from Netten *et al* (2002). The model covers the costs to the health service, social services and users of services, for those services included in the model. Estimated expenditure on home care and community nursing services has been grossed up broadly to match official data.

In summary, the model estimates total expenditure on long-term care (E_t), for each year (*t*), as the sum across all formal health and social services considered, *j* (j = 1 to 9) of the following: projected number of service recipients in year *t* ($serno_{jt}$) multiplied by the intensity of service receipt in terms of hours/visits per week (int_j) and multiplied by the unit cost of care inflated to the year to which the projection year relates (c_{jt}). This can be shown as:

$$E_t = \sum_{j=1}^{10} serno_{jt} \cdot int_j \cdot c_{jt}$$

Part Four: Projected breakdown of expenditure between funders

The fourth part of the model breaks down projected aggregate expenditure by source of funding: NHS, social services and service users. The costs of the health services included are assigned to the NHS. The costs of the social services are divided between personal social services and service users. As there are no national data on the quantities of privately funded care, the projections for privately funded care, especially on non-residential care, need to be treated with caution as it is not possible to verify that all privately funded care is captured by the model.

Residents of residential care and nursing homes are divided into privately and publicly funded residents. The breakdown for 2000 is based on Laing & Buisson data (Laing & Buisson, 2001) for independent sector homes and 1996 PSSRU survey data (Netten *et al*, 1998) for local authority homes. The Laing & Buisson estimates for the proportion of residents who are privately funded were reduced by two percentage points to take account of the changes to the funding system introduced in April 2001. The future trend in this proportion is derived from the projected rise in home-ownership by older people who live alone.

Expenditure on local authority funded residential care, home care, day care and meals is divided between local authority social services and users on the basis of Department of Health data on the proportion of gross costs of social services met by user charges. The proportion of costs met by users is held constant for future years. The full costs of privately funded residential and nursing home care and private domestic care, and a proportion of the costs of all other social services, are thus assigned to users.

3.3. Base case assumptions and projections

The PSSRU model produces projections on the basis of specific assumptions about future trends in the key drivers of demand for long-term care. The main assumptions used in the base case of the model are summarised in Box Two below. The base case projections take account of expected changes in factors exogenous to long-term care policy, such as demographic trends. The base case projections hold constant factors endogenous to long-term care policy, such as patterns of care and the funding system. The base case is used as a point of comparison when the assumptions of the model are subsequently varied in alternative scenarios.

BOX TWO

KEY ASSUMPTIONS OF THE BASE CASE OF THE PSSRU MODEL

- The number of people by age, gender changes in line with the latest Government Actuary's Department (GAD, 2003) 2001-based population projections.
- Marital status changes in line with GAD 1996-based marital status and cohabitation projections.

- There is a constant ratio of single people living alone to single people living with others and of married people living with partner only to married people living with partner and others
- Prevalence rates of dependency by age and gender remain unchanged, as reported in the 1998/9 General Household Survey (GHS) for Great Britain.
- Home-ownership rates, as reported in the 1998/9 GHS, rise in line with the Anchor Housing Trust projections (Forrest *et al*, 1996).
- All dependent older people living with others receive informal care.
- The proportions of older people receiving informal care, formal community care services and residential and nursing home care services remain constant for each sub-group by age, dependency and other needs-related characteristics.
- Social care unit costs rise by 1% per year and health care unit costs by 1.5% per year in real terms. Real Gross Domestic Product would grow by 2.25% per year.
- The supply of formal care will adjust to match demand[4] and demand will be no more constrained by supply in the future than in the base year.

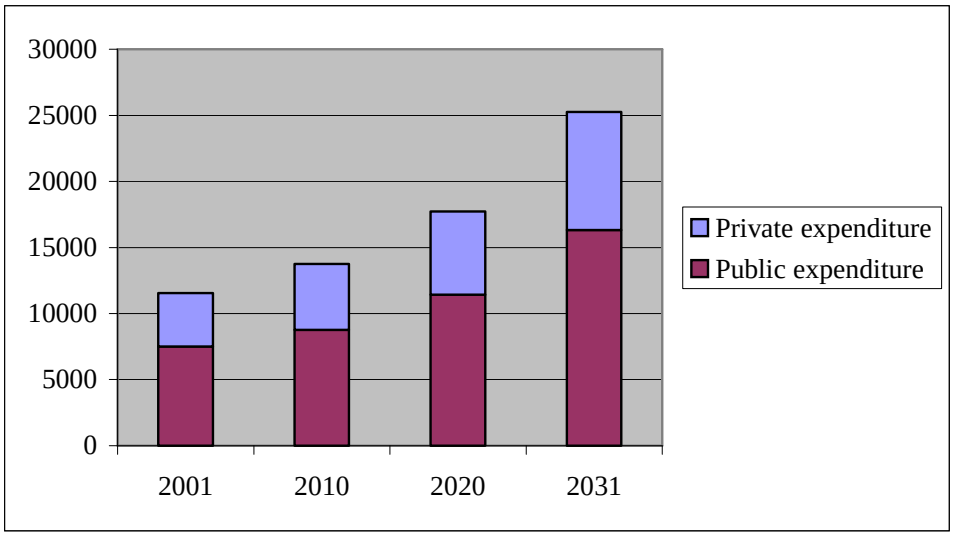
The GAD 2001-based principal population projections for England project that between 2001 and 2031 the numbers of people aged 65 or more will rise by 54%. The numbers of those aged 85 or more are projected to rise faster during this period, by 81%, from more than 950,000 to around 1,732,000. Much of this increase is a result of a projected rise in male life expectancy. Between 2001 and 2031, the numbers of men aged 85 or more are projected to rise by 155%, compared to a 52% rise in the number of women in that age group.

Under the base case assumptions, the numbers of dependent older people[5] would grow by 57% between 2001 and 2031, from 2,567,000 to 4,020,000. The numbers of users of non-residential formal services would rise by 58%, from 1,532,000, to 2,416,000. The numbers of older people in institutions would also rise by 58%, from nearly 400,000 to 627,000.

Figure 1: Projected expenditure (£m) by source of funding, England, 2001-2031, under base case assumptions.

[4] The model effectively assumes that the real rise in wages and other payments for care will ensure that supply is sufficient.

[5] Defined as having problems with at least one IADL or one ADL.



Projected long-term care expenditure would grow by 118%, from nearly 11.6 billion in 2001 to just above 25 billion in 2031 (figure 1). If Gross Domestic Product rose by 2.25% per year, long-term care expenditure would grow from 1.46% of GDP in 2001 to 1.64% in 2031. Table 1 shows these base case projections in greater detail.

Table 1: Projected numbers of older people (thousands), service recipients (thousands) and expenditure (£ billion) under base case assumptions, 2001 to 2031.

	2001	2010	2020	2031	% growth 2001 to 2031
Numbers of older people (aged 65 or more)	7,821	8,455	10,073	12,049	54.1%
Numbers of people aged 85 or more	957	1,127	1,313	1,732	80.9%
Numbers of older people with some dependency	2,567	2,773	3,258	4,020	56.6%
Numbers of users of local authority home help services	372	399	457	586	57.8%
Numbers of users of community nursing services	422	453	533	657	55.7%
Numbers of users of private domestic help	745	846	993	1,231	65.2%
Numbers of users of any non-residential service[6]	1,532	1,653	1,935	2,416	57.7%
Numbers of people in residential care homes	238	257	293	373	57.1%
Numbers of people in nursing homes	134	145	168	213	59.1%
Numbers of people in institutions	397	430	493	627	57.8%
Public long-term care expenditure (£ billion)	7.5	8.8	11.4	16.3	117.4%
Private[7] long-term care expenditure (£ billion)	4.1	5.0	6.3	8.9	120.2%

[6] Local authority home care, district nursing, day centre care, meals or private domestic help

Total long-term care expenditure (£ billion)	11.6	13.8	17.7	25.3	118.4%
Total long-term care expenditure as a % of GDP	1.46%	1.42%	1.44%	1.64%	12.3%

Source: model estimates.

The model produces projections of future long-term care expenditure based on a specified set of base case assumptions. This set of assumptions seems plausible but is clearly not the only possible set. A substantial part of the PSSRU study of long-term care projections has involved the investigation of the sensitivity of the projections to changes in the assumptions made in the model, which is discussed below.

Finally, it is important to point out that the expenditure projections obtained using the model do not constitute the total costs of long-term care to society. That would require inclusion of the costs of a wider range of services to a wider range of public agencies and service users and the opportunity costs of informal care. It should also be stressed that no allowance has been made for changes in public expectations about the quality, range or level of care.

3.4. Sensitivity analysis in the PSSRU model: the effect of changes in the key assumptions

This section examines the model's sensitivity to any changes in the key assumptions, with particular regard to changes relating to the future numbers of older people, dependency rates, the availability of informal care, patterns of formal care and the unit costs of care.

Future numbers of older people

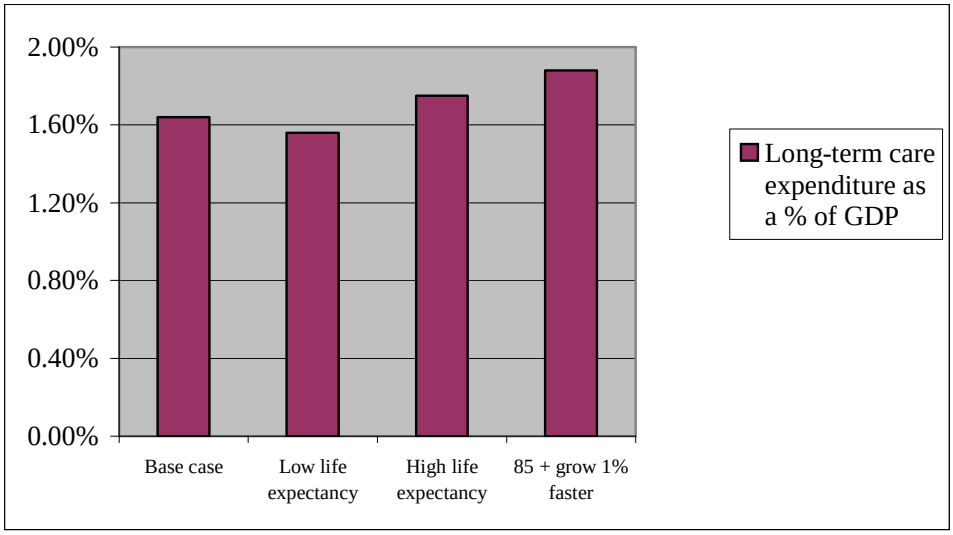
The Government Actuary's Department (GAD) population projections for England produce a rise of 54 per cent in numbers of people aged 65 or more between 2001 and 2031, while numbers of those over 85 will rise by 81 per cent.

Mortality rates in old age are the key factor affecting the projected number of older people, and numbers of very old people in particular. As the proportion of older people with dependency rises sharply with age, the model's projections are very sensitive to the assumptions about the numbers of very elderly people. Figure 2 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions. The assumptions are: the GAD's low and high life expectancy 2000-based population projection variants, and an assumption according to which the numbers of people aged 85 or more would rise faster than projected by the GAD's principal projection, by 1% more per year. This assumption has been chosen because it corresponds roughly to the extent of past under-estimation of the numbers of very elderly people (Shaw, 1994). According to data gathered by Robine (2003), the official population projections of most European countries have consistently underestimated the future numbers of older people, specially of the very old. It is debatable whether the most

[7] Includes user fees and co-payments.

recent UK projections, based on a changed approach (Shaw, 2000), will still prove to be under-estimates.

Figure 2: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about changes in life expectancy

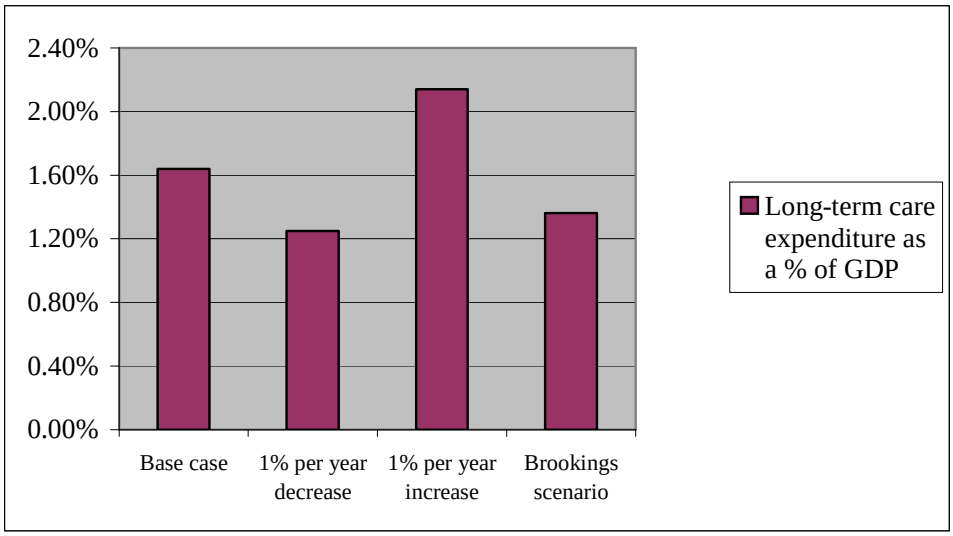


Dependency

If falling mortality rates were accompanied by falling rates of dependency, this would (at least partially) offset the impact of demographic pressures on demand. Constant dependency rates could be regarded as a pessimistic assumption. The 'Brookings scenario' is a less pessimistic assumption that moves the age-specific dependency rate up by one year for each one-year increase in life expectancy.

While there are differing views about whether age-specific dependency rates can be expected to rise, fall or remain much the same, projections of demand for long-term care are highly sensitive to assumptions about dependency. Figure 3 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions: a 1% increase and decrease per year in the prevalence rates of dependency, and the 'Brookings scenario'.

Figure 3: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about dependency trends.



Availability of informal care

The GAD marital status projections imply that there is likely to be an increase in spouse carers of dependent older people, at least until 2020 (see Wittenberg et al, 2001 for more details). The PSSRU model base case takes this into account, but does not take into account other possible changes in the availability of informal care.

The proportion of older people living with an adult child in Great Britain declined from 42 per cent in 1962 to 14 per cent in 1986, and has subsequently declined still further (Grundy 1995, Grundy and Glaser 1997). If by 2031 fewer older people receive informal care from children living in the same household, it could be assumed that more people may move into residential homes. In addition, it is possible that more older married couples may also require admission to residential care, if there is a decline in informal care by children.

Various scenarios have been developed to test the impact on the model's projections for formal services of a decline in informal care. Compared to the base case, all of these produce varying degrees of increases in public expenditure and increased numbers of those in institutional care. But much depends on the size of the decline in informal care and on the extent to which such care is substituted by residential care or by moderate packages of domiciliary services.

Future patterns of care

The model can be used to explore the impact of changes in the patterns of services. The scenarios explored assume a shift in the balance of care from institutional to domiciliary, a change in the eligibility criteria for home care and an increase in support for informal carers.

The first scenario considered here assumes that projected numbers in nursing and residential homes would by 2020 be 10 per cent lower than the base case, and that

people 'diverted' from nursing homes would receive an average of eight hours' home care and 1.5 community nurse visits a week while those 'diverted' from residential homes would receive eight hours' home care. This follows a similar scenario in the National Beds Inquiry for England (Department of Health, 2000b).

The second scenario investigated the potential impact of introducing a national entitlement to free formal care for all older people with moderate to severe dependency (two or more ADLs) whether or not they were receiving informal care. (This scenario mirrors, to a certain extent, the entitlement to long-term care in Germany). This scenario assumes 5.75 hours of formal home care a week and 100 per cent take-up.

The GAD marital status projections suggested that in future there was likely to be an increase in spouse carers of dependent older people. However, many spouse carers are elderly and in need of support themselves. The third scenario looked at providing support to the most heavily burdened carers (defined as those providing personal care to older people living in the same household) and explores the implications of making the same services available to those living with others as those living alone: the 'carer-blind' approach.

In the first scenario, projected public spending was lower than in the base case as the packages of domiciliary care were less costly than institutional care. The national entitlement scenario, however, had substantial cost implications with numbers of those using home help nearly doubling. Under the 'carer-blind' scenario projected long-term care expenditure would also be higher than under the base case.

Unit costs and economic growth

Spending on long-term care is highly sensitive to relatively small changes in future unit costs. The base case of the model assumes that real unit costs will rise in line with historical trends in input pay and prices: one per cent per year for social care and 1.5 per cent a year for health care. GDP is assumed to rise by 2.25 per cent a year.

Residential care, home care and day care are all highly labour intensive. An alternative scenario investigates the impact of assuming that future unit costs will rise in line with projected rises in earnings. This scenario is based on the Treasury's long-term assumptions, published in the 2003 Budget (HM Treasury, 2003), for productivity growth (as an indicator of possible future rises in care staff earnings) and for growth in GDP. In this scenario, spending on long-term care would rise to nearly £31bn compared to £25bn under the base case.

Overall findings of the sensitivity analysis

Overall, the sensitivity analysis shows that projected future demand for long-term care services for older people in the UK is sensitive to assumptions about the future numbers of older people and about future prevalence rates of dependency. It is also sensitive to assumptions about the future availability of informal care. Projected future expenditure on long-term care for older people is also sensitive to assumptions

about future rises in the real unit costs of services, such as the cost of an hour's home care. The sensitivity of the model to changes in the assumptions made means that the projections should not be regarded as forecasts of the future.

A recent international study[8] investigated the sensitivity of projections of long-term care expenditure for older people to assumptions on trends in the key drivers of demand for care (Comas-Herrera and Wittenberg, 2003). This comparative study investigated the key factors that are likely to affect future expenditure on long-term care services in Germany, Spain, Italy and the United Kingdom. The approach involved investigating how sensitive long-term care projections are to assumptions made about future trends in different factors, using comparable projection models.

The sensitivity analysis showed that projections of long-term care expenditure in all four countries are sensitive to assumptions about future mortality and dependency rates. They are also highly sensitive to assumptions about future real rises in the unit costs of care. They are sensitive to scenarios involving a relative decline in informal care where this results in greater use of residential care. They are somewhat less sensitive to assumptions about changes in the patterns of formal care.

3.5. Projections of long-term care expenditure due to dementia

As discussed in section 3.4, future demand for long-term care and associated expenditure are very sensitive to changes in the assumptions made about trends in dependency of older people. The definition of dependency used in the PSSRU model is based on the ability to perform instrumental activities of daily living (IADLs) and activities of daily living (ADL). One of the causes of difficulties in the performance of IADLs and ADLs is dementia. Most of those with dementia who require long-term care are likely to have difficulties with IADLs or ADLs. It is unlikely that a model of long-term care demand that uses IADLs and ADLs would omit large numbers of older people requiring long-term care. Nevertheless, , there are important reasons for having a model that can distinguish between those who have functional dependency only and those who have functional dependency and suffer from dementia.

The first reason is that there are important differences in the patterns of care for people with and without dementia given the same ADL problems, specially for those with severe cognitive impairment. People with severe cognitive impairment are more likely to rely on formal care and, in particular, are more likely to be institutionalised (Bauld et al, 2000, Boersma *et al*, 1997, and Netten *et al*, 2001b). If the future numbers of people with dementia were to rise at different rates than the future numbers of people with ADL problems due to other causes, projections made using a model that only used an overall ADL definition would not be appropriate to plan the future services required for people with dementia.

Another reason why it is important to have a model that takes specific account of dementia is that it would permit an investigation of the potentially cost-saving impact

[8] Funded by the European Commission.

of new drugs for people with Alzheimer's Disease. This would be an important issue to explore.

PSSRU[9] developed a version of their model to make projections, for the next 30 years, of future numbers of older people with cognitive impairment, their demand for long-term care services and the future costs of their care under a range of specified assumptions (Comas-Herrera et al, 2003b). The term cognitive impairment is used here to describe one of the manifestations of dementia.

The study set out to explore the impact of factors that are likely to affect future long-term care expenditure associated with cognitive impairment, in particular changes in the future prevalence rates of mild and severe cognitive impairment. The study also investigated the impact of changes in the patterns of care specific to those with dementia, for example, increasing support to informal carers.

The study found that, under the base case, the numbers of people with cognitive impairment would increase faster between 1998 and 2031 than the numbers of people with functional disability only (66% and 58% respectively). This implies that demand for long-term care will rise at a faster rate among those with cognitive impairment than would be suggested by projections of the overall demand for long-term care based on functional disability. For example, between 1998 and 2031, the number of people with cognitive impairment in institutional care is projected to increase by 63%, compared to a projected 52% increase in the total number of older people in institutions. These results show that, when planning future service requirements for older people with cognitive impairment, it would be important to have specific projections.

The results of the model also showed that, unless more effective treatments for cognitive impairment are developed and made widely available, the numbers of older people with cognitive impairment will rise significantly over the next 30 years. This means that substantial rises in formal services will be required. The implication is that there is a need to develop, and make widely available, better treatments to slow down the progressive decline associated with dementia.

4. Conclusion: recommendations on making long-term care projections

4.1. Choosing the methodological approach

When designing a long-term care projections model, the first step is to be clear on the purpose of the modelling. Key questions are whether the aim is to produce aggregate projections of the future numbers of older people requiring long-term care and of long-term care expenditures, or to investigate the impact of alternative financing mechanisms on different groups. The purpose will influence the choice of type of model, for example, whether to construct a cell-based or microsimulation model.

[9] Funding from the Alzheimer's Research Trust and access to MRC CFAS data (MRC CFAS, 1998) are gratefully acknowledged.

Another key aspect to be clear about is the coverage of the model. Important questions include: will the model include only older people? Will it cover both public and private expenditure or just public long-term care expenditure? Will it include informal care by family and friends or only formal services?

The second step is to investigate all the available sources of data. The ideal situation would be to find a nationally representative survey covering the health, dependency, household situation, income, assets and long-term care use of people in the community and in care homes and hospitals. Single surveys with all the relevant information are not available in most countries. As a result, a variety of sources containing information on some of the aspects need to be used. The description of the UK's PSSRU long-term care model in section 3 explains how various sources of information were used to obtain an overall picture (in terms of data) of long-term care in the UK. The quality of the data used and the construction of a baseline that represents as accurately as possible the current long-term care arrangements is crucial for the reliability of the projections.

Determining the architecture of the model is a complex exercise. In the case of cell-based models it is necessary to balance the need for sufficient cells to address the range of policy issues with the need for a model simple enough to be useable. The greater the breakdown into more cells, the greater the flexibility of the model; but too many cells could render it unduly complex to build and use.

If opting for a cell-based model, it is also important to consider whether there are existing microsimulation models that already model the income and assets (as well as other characteristics) of older people. If so, it may be possible to combine a cell-based model of long-term care projections with a microsimulation model that investigates the impact of different funding mechanisms over time and between different groups.

4.2. Choosing the base case set of assumptions

Projections models generally need to incorporate initial assumptions on future levels of key variables. These may be that key variables will remain constant over time, change in line with past trends or change in line with expert views. Long-term care models need to incorporate assumptions about future trends in the main drivers of demand for long-term care and long-term care expenditure.

It is useful to choose a core set of assumptions about future trends to form a 'base case' that can act as a reference case against which the effect of changes in the different assumptions can be investigated. The approach taken in the UK's PSSRU model has involved taking account within the base case of expected changes in factors exogenous to long-term care policy[10], such as trends in the numbers of older people by age, gender and marital status, and holding constant factors endogenous to long-term care policy, such as patterns of care and the funding system.

[10] The definition of exogenous and endogenous factors use here should be interpreted in relative terms rather than absolute terms: all factors could be at least partly endogenous in the sense that they could be affected by policy changes in the long-term.

The factors affecting the future numbers of dependent older people requiring long-term care are mainly exogenous to long-term care policy. They include demographic change and dependency rates. These two factors affect the overall need for long-term care. There are other important exogenous factors that also affect demand for long-term care, either by influencing the propensity to seek care or by influencing the type and amounts of care that will be sought. These factors include individual preferences, which may reflect age, gender, income and other personal characteristics but which are difficult to model. Demand for formal care is also crucially affected by the availability of informal care.

As well as the exogenous factors mentioned above, the receipt of long-term care is influenced by factors endogenous to long-term care policy, such as the availability and accessibility of formal services, the funding system, and the policy incentives or disincentives to the provision of informal care.

Future long-term care expenditure is determined not only by changes in the volume of services demanded but also by rises in the unit costs of long-term care, such as the cost of an hour's home care. Since long-term care services are labour-intensive services, trends in the unit costs of care will depend largely on trends in the earnings of care staff. The future affordability of long-term care depends also on how much the economy grows in the future.

The PSSRU model aims, as discussed above, to use base case assumptions that reflect "expected changes" in the main exogenous factors. However, there is not always consensus on what assumptions reflect those "expected changes". While using the official population and marital projections as base case assumptions is not very contentious, the choice of a base case assumption for trends in dependency and in unit costs is less straightforward as there is no consensus in the literature about future dependency rates and long-term economic trends. It is important to keep the base case assumptions under review in the light of new evidence.

4.3. Carrying out sensitivity analysis and interpreting the projections

Given the great degree of uncertainty about future trends in the drivers of demand for long-term care, it is very important to carry out sensitivity analysis to investigate the impact of changing each of the base case assumptions of the models.

The importance of the results of the sensitivity analysis lies in the fact that it is beyond the present state of knowledge to set probabilities for future trends in the factors examined. Yet it is important for policy and planning purposes to demonstrate the extent of sensitivity of future long-term care expenditures to assumptions about these trends. The findings of the PSSRU and other models suggest that policy-makers need to plan for uncertainty in future demand for long-term care for dependent older people. Future mortality and prevalence rates and rises in unit care costs, which are inevitably uncertain, have substantial implications for future demand for long-term care and associated expenditure.

It is also important to recognise that most models will not have taken account of the

impact of rising expectations, as their likely impact would be very difficult to measure and quantify. It seems plausible that rising real incomes will be accompanied by rising expectations for more and better quality care.

The approach taken by the PSSRU study of long-term care projections has been to emphasize that the model makes projections based on assumptions, rather than forecasts. That means that, instead of asserting what the future demand for long-term care and expenditure will be, the model's projections show what the future demand and expenditure would be like given the assumptions specified.

Acknowledgements

Most of the research reported here has been carried out as part of the Personal Social Services Research Unit's long-term research programme, financed by the Department of Health. Bleddyn Davies and Robin Darton have contributed to some of the research reported in this paper. All views reported here are those of the authors. The report does not purport to represent the views of the Department of Health.

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Making projections of long-term care: examples and methodological issues

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PSSRU Discussion paper 2004

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1. Introduction:

As the numbers of older people rises throughout the world, there have been concerns about the future affordability of public expenditure, particularly on pensions, health care and long-term care. In this context, the European Union's Economic Policy Committee (EPC) conducted a study of the impact of ageing on future public expenditure on pensions, health and long-term care and how it would affect the fiscal sustainability of public finances (Economic Policy Committee, 2001).

Projected increases in the numbers of users of long-term care, and concerns about the future availability of care provided by the family and other informal carers, have attracted more attention to the issue of the provision and financing of long-term care. There have been debates about how to provide and finance long-term care in most of Europe. These debates have concentrated, mainly, on the extent to which long-term care is an individual, family or state responsibility; the balance between care provided by families and public and private sector providers; financing arrangements, especially the balance between public finance and private payments; whether to provide care in-kind or cash payments; and the boundaries between health and social care (see, for example, Ikegami and Campbell 2002, Glendinning 1998, Karlsson 2002, OECD 1996).

These debates about the sustainability of public finances and how to provide and finance long-term care raise many questions. How many older people are likely to require long-term care services in the coming decades? How much are these services likely to cost? Will the cost to public funds prove affordable? In order to address these issues, it is useful to have reliable projections of future demand for long-term care and associated future long-term care expenditure.

Projections of long-term care demand can also be valuable as aids to planning. They can be used to illustrate the growth in supply of care required as the numbers of older people grow, and the impact that changes in the patterns of care could have on the volumes of services required.

This paper discusses various methodological approaches to making projections of future long-term care demand and expenditure. Section two discusses and, provides examples of, the main two approaches: cell-based models and microsimulation models. Section three discusses in detail the methodological approach chosen in the development of a specific model: the Personal Social Services Research Unit (PSSRU) long-term care model. Projections made with the PSSRU model are presented, as well as a discussion of the sensitivity of long-term care projections to various factors. Finally, section four concludes with some recommendations on making long-term care projections.

2. Critical analysis of different long-term care projections models

Projections of long-term care demand and expenditure can be produced in many different ways. Which method is best depends very much on two factors: what is the purpose of the projections, and what data are available. The main purposes of long-

term care projections tend to be, as discussed in the introduction, to assist in the planning of long-term services; to investigate the future affordability of long-term services; and to estimate the future implications of possible changes in patterns of care or funding mechanisms.

The availability of suitable data is, in most countries, an important limiting factor, when considering how to make long-term care projections. Long-term care has historically accounted for only a small proportion of public expenditure, especially compared to health care. As a result, few countries have systematically collected much data on long-term care provision and expenditure.

There are broadly two main approaches to making projections: cell-based (or macrosimulation) models and microsimulation models. The main feature that distinguishes the two types of model is that microsimulation models have as their unit of analysis individual people, families or households, while cell-based models have, as their unit of analysis, aggregates of individuals grouped by their characteristics (such as age and gender). Most long-term care models are cell-based, not only because it is a much simpler method of making projections, but also because very few countries have the data required to produce microsimulation models.

This section describes some examples of both cell-based and microsimulation models. It discusses the advantages and disadvantages of both approaches, and concludes with an example of the combination of a macro and a microsimulation model, and some recommendations on choosing an approach. A useful discussion outlining the differences between the two methods and their advantages and disadvantages is available in Wittenberg *et al*, (1998, p. 28). Spilauer (2002) has also compared both approaches in his review of microsimulation models.

2.1. Cell-based (or macrosimulation) models

Most models used to make projections of future demand for long-term care or of future expenditure are cell-based models that, as stated before, have as a unit of analysis groups of people rather than individuals. Most cell-based models are built using a spreadsheet. While it is possible to develop sophisticated systems of scenarios, the models tend to be relatively straightforward from a computing point of view.

In cell-based models the overall population is represented by an aggregated cross-classification table, in which the cells represent each possible combination of the characteristics considered. The number of cells grows with the number of characteristics and too many cells could make the models unwieldy. Most long-term care cell-based models (partly as a result of lack of data) only consider a limited number of variables and a result the number of cells does not become a problem. The model developed by the Personal Social Services Research Unit (PSSRU model) in the UK, which does have a considerable number of variables, deals with the potential explosion in the numbers of cells by limiting the number of variables used to those that are relevant in each part of the model. For further details, see section 3 of this paper.

There are several different types of cell-based models. The purpose for which the projections are made, the long-term care systems that they represent and the

availability of data determine to a great extent the design and complexity of the models. Below are descriptions of various long-term care cell-based models. An attempt has been made to classify them according to the factors they take into account.

Expenditure profile modelling:

The simplest form of long-term care projections model, which is also one of the most frequently used, consists in applying the current average costs of care for people of each age (and sometimes gender) group to the future numbers of people in that age (and gender) group. These average costs for each age and gender group are often called "expenditure profiles".

This method of making projections has the advantage of very low demands in terms of data and computing, and is widely used. It has been used in international comparisons by the OECD and, more recently, the European Union's Economic Policy Committee (EPC, 2001). As long as the data on the costs of care have been calculated using similar methods and coverage in the different countries, the projections obtained using this method are, in principle, highly comparable.

With regards long-term care, however, not all countries have even such basic data readily available. In the EPC study, while all EU countries (except Luxemburg) were able to provide age and gender specific health expenditure profiles, only ten countries provided them for long-term care. The lack of basic data partly reflects the absence in many countries of information systems to compile data on long-term care use and expenditure.

The main limitation of the "expenditure profile" projections is that they make the implicit assumption that the only factors that affect future long-term care expenditure are demography and inflation. However, there are many factors other than age that will determine future demand of long-term care and expenditure. Age is effectively just an imperfect proxy for need in such models.

The sensitivity of projections produced using this type of model can be investigated in respect of alternative demographic projections and alternative inflation assumptions. The sensitivity of these projections to changes in the prevalence of disability, the proportion of older people living alone or patterns of care cannot be readily investigated.

In the UK, the Department of Health model (House of Commons Health Committee, 1996, see also the review by Wittenberg, 1999) used age-specific expenditure profiles as its starting point, but adjustments were then made for assumed changes, under varying scenarios, in real costs of care, age-specific disability rates and some other factors.

Models that allow the exploration of dependency trends:

A slightly more sophisticated approach, used by Lagergren and Batljan (2000) in Sweden, is to calculate the long-term care costs of people with different degrees of

dependency. The model then applies prevalence rates of functional dependency to the projected future population in order to obtain the future numbers of people with dependency and, finally, their long-term care costs. This approach makes it possible to investigate separately the impact of changes in mortality and dependency on the future costs of long-term care.

A review by Wittenberg of models of long-term care projections (Wittenberg, 1999) identified, in Britain, two cell-based models that also went beyond age and gender expenditure profiles. The Institute of Actuaries' model (Nuttall et al, 1993, now partly updated by Rickayzen and Walsh, 2002) made projections of the future numbers of disabled people and of the costs of caring for them on varying assumptions about changes in age-specific mortality and disability rates. Hours of care demanded were estimated by assigning an assumed number of hours per week for each level of disability. The London Economics and the Institute for Public Policy Research (Richards et al, 1996) study effectively used the Institute of Actuaries central scenario, with some minor changes in assumptions, as its starting point on projected numbers of disabled people for each year to 2030. It then concentrated on estimating the breakdown of the aggregate level of care demanded between informal care, publicly funded care and privately funded care. The review by Wittenberg (1999) describes these models in detail.

Models that allow the exploration of changes in patterns of care:

A recent international study (Comas-Herrera and Wittenberg, 2003) investigated future long-term care expenditure in four different countries (Germany, Spain, Italy and the United Kingdom) and their sensitivity to factors such as demography, changes in the prevalence of dependency, changes in the balance between informal and formal care, changes in the balance between domiciliary and institutional care, and in the rates of growth of the unit costs of care. The study used existing models in Germany and the UK. A model for Spain was substantially expanded for use in the study, and a new Italian model was developed for the project. Three of those models are described below. The UK model, developed by the Personal Social Services Research Unit (PSSRU model), is described in more detail in section 3 of this paper.

The Spanish model is based on an earlier simpler model developed by Casado (Casado and Lopez Casasnovas, 2001). It was further developed by Patxot and Costa-Font as part of the European study (Patxot and Costa-Font, 2003). Their model calculates the future numbers of people with dependency by applying current dependency rates to the projected population. It then applies, to the future numbers of dependent older people, the current utilisation rates of services. The model can be used to investigate changes in mortality, dependency trends, utilisation of services and the future unit costs of care.

The Italian model was developed specifically for the European study by Comas-Herrera, Di Maio, Gori and Pozzi (2003). The model uses a similar structure as the Spanish model described above. There was only a short amount of time available to develop the model and the team were not able to explore all the possible sources of data. This model is currently being reviewed and improved by Vanara and Gori (?).

The German model was developed by Rothgang (Rothgang, 2003) to make projections of the future numbers of beneficiaries of public long-term care insurance, and of the future contribution rates for public long-term care insurance, under a number of scenarios. Rothgang's model applies the prevalence rates of the various degrees of dependency (that determine entitlement to insurance benefits), by age and gender, to the future numbers of older people. The model then calculates long-term care insurance expenditure by applying the value of the benefits to the numbers of recipients. This projected expenditure is then applied to a simple labour force and pensions model to calculate the future contribution rates necessary under various scenarios.

The value of the benefits in the German model depends not only on the severity of dependency but also on the type of benefits chosen. There is a choice between cash-benefits, in-kind care in people's own home, a mixture of cash and in-kind benefits, and institutional care. The model's base case assumes that the proportion of people by age, gender and dependency that choose the different types of benefits remains unchanged. Sensitivity analysis can be used to investigate the expenditure impact of changing the choice of benefits (as well as the impact of different assumptions about future mortality, dependency and changes in the real unit costs of care). A change in the choice of benefits would result, effectively, in a change in patterns of care.

None of the models described above consider whether older people live alone or with others, or whether they have access to an informal carer. They also do not consider the socio-economic status of care users. These are important factors in the demand for long-term care services, as changes in household composition or the economic situation of older people will affect their future demand for long-term care services. The UK's PSSRU model (and a nearly identical replica done for Catalonia, see Lopez-Casasnovas, Casado and Comas-Herrera, 2003) is, as far as the authors know, the only long-term care cell-based model that takes household type and economic situation (housing tenure) variables into account.

2.2. Microsimulation models

Microsimulation models can be defined as models that use simulation techniques and that take micro-level units (that is, in the case of long-term care models, the individual, family or household) as the basic units of analysis. They permit a more detailed consideration of distributional factors than cell-based models. A useful review of microsimulation methods in health care modelling can be found in Spilauer (2002).

Dynamic (as a opposed to static) microsimulation models simulate changes over time and in response to context changes. Monte-Carlo simulation, using information on transition rates between states, is used to determine transitions of micro-units from one state to another at each time period. Such transitions could include mortality, onset of dependency or admission to residential care.

Dynamic microsimulation models have the advantage of allowing the consideration of events over the lifetime. They can be used, for example, to simulate how long a person can expect to live in each of a number of health or dependency states. They can also be used to simulate a link between contributions to a pension or other

saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle.

Dynamic microsimulation models are potentially useful for the purposes of modelling future demand for long-term care and expenditure. The reason that there are not many such models (besides the substantial investment in data analysis and computing involved) is that the data they require is not available in most countries. A dynamic microsimulation model of long-term care would require a longitudinal data collection from which to draw information on transitions in health (or dependency) states and other variables including the use of long-term care.

The following sections describe three microsimulation models. Two of them are from the US and the third one investigates charging for long-term care in the UK.

US models

The Brookings Institution and Lewin-VHI Inc, and the Urban Institute, have developed Long-Term Care models using microsimulation techniques. In the US longitudinal data on health states, disability and use of long-term care is available from the National Long Term Care Survey and other surveys. The health state, family circumstances, incomes and other characteristics of a sample of individuals are simulated year by year to their deaths. The outputs of the microsimulations are grossed up to match official population projections by age and gender. These models have been described in some detail and compared with cell-based models by Wittenberg (1999).

The Brookings Institution and Lewin-VHI Inc. Long-Term Care Financing Model was originally developed in 1986-7 but updated and refined in 1988-9 using new data. This model projects the size, financial position, disability status, and nursing home and home care use and expenditures of elderly people through the year 2020. Expenditures are further extrapolated on a broader basis to the year 2050. The model has been used to simulate the effects of changes in the system for financing long-term care in the USA (Wiener et al, 1994). The model starts with a nationally representative sample of the adult population, with a record of each person's age, gender, income, assets, and other characteristics. It then simulates changes to each individual from 1986 to 2020. The changes simulated include onset and recovery from disability and commencement and termination of receipt of long term care services.

The Brookings Institution Lewin-VHI study assigns a source of funding for all elderly people who have been modelled to receive home care or nursing home care. Medicare funding is considered before payment from other sources. Where a person is admitted to non-Medicare nursing home care, the costs are attributed to the person's income and then non-housing assets. When the person's assets have been spent down to the Medicaid threshold, Medicaid is assumed to pay the difference between the person's income (less a personal allowance) and the Medicaid payment rate. In this way the Medicare and Medicaid systems are simulated.

The Urban Institute's Dynamic Simulation of Income Model (DYNASIM) was used to project the elderly population's characteristics, incomes, and needs to the year 2030 (Zedlewski et al, 1990). The study considers the future numbers of elderly people with

different levels of disability, incomes and other characteristics, under varying assumptions about future mortality and disability rates. It does not include projections of long-term care expenditure.

Both studies consider future trends in marital status and numbers of children as part of their simulations but do not investigate sensitivity to alternative assumptions. Marriage, divorce and widowhood are included in the microsimulations as is child-birth. Official data are used on marital status and on fertility. The related issue of the proportion of elderly people living alone is also considered in both models. The studies do not, however, make a link between living arrangement, as opposed to marital status, and probability of receipt of long term care.

Both studies consider income and assets in some detail in their simulations. The Urban Institute model was designed specifically to look at incomes, while the Brookings Lewin-VHI Long Term Care Financing Model is based on the Lewin-VHI Pension and Retirement Income Simulation Model (PRISM).

The studies modelled receipt of home care and receipt of residential care separately as functions of individual characteristics such as age, gender and dependency. The relationship between these characteristics and receipt of care is assumed to remain constant over time, at least as a base case. The Brookings Institution model gives the user a facility to simulate an increase in home care use and/or in nursing home use by adjusting the estimated probabilities of service receipt by a factor assumed for induced demand.

Informal care is not directly covered in either model. They take actual propensities to receive care in a base year as their starting point for projections. The Brookings study considers the impact on the balance between public and private expenditure of potential changes in real incomes and assets.

The Nuffield Community Care Studies Unit model

The Nuffield Community Care Studies Unit (NCCSU), in the UK, has developed a microsimulation model to simulate long-term care charges under different charging regimes (Hancock, 2000). It contains detailed information on the incomes, wealth, housing and other relevant characteristics of sample members, sufficient to make good estimates of their liability for care charges. The model permits analysis of the distributional consequences of different long-term care funding options.

The NCCSU model simulates what each older participant in the UK's Family Resources Survey would have to pay towards care home fees should he or she need long-term care. The model performs simulations for single people currently aged 65 and over, and for the older partner in couples where at least one partner is aged at least 65 years. The simulations are performed for a base year and for future years. Simulations for future years involve: ageing the sample of those currently aged 65 or more, allowing for deaths and the consequent effects of widowhood; modelling the evolution of their incomes and capital under certain assumptions; and making assumptions about future costs of care and the care charging, social security benefit and income tax regimes which will be in place for the year of interest. The model

makes a number of simplifying assumptions such as, for example, in predicting death there is no allowance for differences in mortality by income, social class or housing tenure.

Because it is more difficult to predict the future incomes of people who are not yet retired than it is for those who are already drawing pensions, the base year sample is not 'refreshed' as it is aged. This restricts the years and age ranges for which the model produces projections.

The microsimulation model does not predict how many or which older people will need care. It simply calculates what each person in a representative sample of older people would be required to contribute to the costs of residential or nursing home care should he or she need it, and how much would be contributed from different parts of the public purse. British data shows that, controlling for age, residents in care homes are, in comparison with older people generally, disproportionately likely to have lived alone and to have rented rather than owned their homes (Netten et al, 1998). Housing tenure and whether living alone are also both characteristics which affect liability for long-term care charges as well as probability of admission to care homes.

The NCCSU and PSSRU[1] jointly produced projections of future long-term care expenditure through an innovative linkage of their two models. This involved using outputs from the NCCSU microsimulation model as inputs to the PSSRU cell-based model. The NCCSU model produced projections of the future proportions of older people eligible for public funding should they require residential care and of their future contributions to the costs of their care under different funding arrangements. The PSSRU model produced projections of total public and private expenditure on long-term care to 2051 on the basis of the NCCSU projections and assumptions about future trends in life expectancy, dependency, real unit costs and patterns of care (Wittenberg et al, 2002 and Hancock et al, forthcoming).

2.3. Advantages and disadvantages of both approaches

Microsimulation models would offer some advantages for making projections of long-term care for older people, compared to cell-based models. One advantage, specially relevant for models that look at financing long-term care, is that they permit a more detailed consideration of distributional factors than cell-based models. An example would be the way in which different funding systems affect different income groups. In cell-based models the investigation of distributional issues is restricted to distribution by the variables used to define the cells.

A second advantage of microsimulation models is that, as discussed above, they can also be used to simulate a link between contributions to a pension or other saving/insurance scheme at one stage in the life cycle with expected benefits at a later stage in the life cycle. This is important where a contributions-based insurance system is under consideration.

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[1] This research was financed by the Institute of Public Policy Research (IPPR), UK.

A further advantage is that the number of cells in cell-based models grows with the number of characteristics and too many cells could make the models unwieldy. In practice, most long-term care cell-based models (partly as a result of lack of data) consider only a limited number of variables and the number of cells does not in practice become a problem.

While there are many advantages to microsimulation (and in particular dynamic microsimulation) models, it is important to be aware that constructing a microsimulation model is a complex and time-consuming task. As discussed in Wittenberg et al (1998, p. 130), "... such work is not likely to be cost-effective unless there is a policy interest in the types of question that can only be answered through microsimulation; suitable data – generally longitudinal data- are available; and the expertise and resources are available".

Unfortunately, in most countries suitable data is not available, which is a key reason why cell-based models are more widely used. A useful approach to enable the investigation of distributional issues is to combine a cell-based model for long-term care with an existing microsimulation model of the incomes and assets of older people, as discussed above and in Hancock et al (forthcoming).

3. The PSSRU model

The PSSRU long-term care projections model was constructed as part of a project on long-term care finance, funded by the English Department of Health since 1996. The project is concerned with two related policy issues on the funding of long-term care for older people. The first is whether expenditure, and specifically public expenditure, on long-term care will remain sustainable over the coming decades, despite demographic pressures and potentially rising expectations. The second is what should be the balance between public and private expenditure on long-term care.

A detailed account of the long-term care projections model and of the data and assumptions and the methodology used can be found in Wittenberg *et al* (1998), a report that describes the first version of the model. The model has been regularly updated and expanded. A paper exploring sensitivity of an updated version of the model to various assumptions was published in Health Statistics Quarterly in 2001 (Wittenberg *et al*, 2001). The latest version of the model is described in Comas-Herrera et al (2003a).

The initial model was used to provide projections for the Royal Commission on Long-Term Care[2] (1999). More recently, new versions of the model have been used to provide projections for the HM Treasury Health Trends Review (Wanless, 2002) and for the Institute of Public Policy Research (Wittenberg *et al*, 2002 and Hancock *et al*, forthcoming). The latter involved innovative linkage between the PSSRU model and a microsimulation model developed by the Nuffield Community Care Studies Unit (NCCSU), as discussed above.

[2] A high level group set up by the Government to review the financing of long-term care and make recommendations about its future financing.

As well as the main model, other versions of the model have been developed. One of them investigates the future long-term care costs of cognitive impairment (Comas-Herrera et al 2003b), using MRC CFAS data (MRC CFAS, 1998). This enabled separate projections to be made of services for older people with cognitive impairment under a range of assumptions about future prevalence rates of cognitive impairment. This version of the model will be further described in section 3.5. Versions of the model have been developed for the National Assembly for Wales (Comas-Herrera et al, 2003c) and for the Catalan regional Government (Lopez-Casasnovas et al, 2003).

This section contains a discussion of the methodological issues addressed in designing the PSSRU model, in particular with regards the modelling of demand. It then provides a detailed description of the model, the assumptions made, and the base case projections.

3.1. Methodological choices in modelling demand and supply of long-term care

The PSSRU model aims to make projections of three key variables: the future numbers of dependent older people, the likely level of demand for long-term care services for elderly people and the costs associated with meeting this demand. The model covers public and private services and expenditure. It is cell-based (a macro-simulation model) and takes the form of a spreadsheet. An in-depth discussion of the methodological approach adopted in designing the model is available in Wittenberg et al (1998). This section summarises some of the main points.

The first, crucial point is that *the model does not make forecasts about the future.* It makes projections on the basis of specific assumptions about future trends. The approach involves simulating the impact on demand of specified changes in demand drivers, such as demographic pressures, or specified changes in policy, such as the introduction of free personal care. It does not involve forecasting future policies or future patterns of care.

The second important point is to clarify the concept of demand in this context. Demand generally refers to the quantity of a good of service that people want to purchase at a given price. The demand by a person for goods or services is generally taken to be a function of the person's income, the price of the good, the price of other goods that may be close substitutes or complements, and the person's tastes. The latter may in turn be a function of the person's age, gender, occupation, health state, and other personal characteristics.

The demand for long-term care is complicated by at least three issues. First, it is important to consider the relationship between need and demand, which is discussed below. Second, it is important to distinguish between demand for different types of care. In particular it seems important to differentiate between demand that could be met by either informal or formal care and demand for formal health and social services. Third, it is difficult to observe "demand" alone. What is observed from data on service use is a combination of demand and supply (Norton, 2000).

Relationship between need and demand

Need for long-term care may arise from a number of sources or combination of sources. It may arise from limitations in physical health and/or in mental health. It may arise from a combination of limitations in health and difficulties in the person's environment, such as poor or unsuitable housing. Demand is not the same as need. It takes account of the person's ability and willingness to purchase the good or service. Demand for long-term care would arise if the person actually sought long-term care and was willing to pay, if required.

These considerations suggest that demand for long-term care can be regarded as a function of the following variables: age, gender, physical health, mental health, income, assets, preferences, and the costs of care (Evandrou and Winter, 1988; Davies et al, 1990 and Norton, 2000). A model of long-term care demand should in theory consider all of these. Preferences, however, are clearly intangible and changes in preferences or expectations are problematic to project.

Demand for different types of care

It is possible to distinguish three forms of long-term care in terms of costs to the care recipient. These are informal care by family and friends, publicly funded formal care, and privately purchased formal care. The first generally involves no financial cost to care recipients, the second may involve a cost depending on whether public support is subject to charges, and the third clearly involves a financial cost to care recipients or their families. This consideration, together with the potentially different nature of formal services and informal care, mean that the different types of care need to be considered as separate subsets of overall demand for long-term care.

Demand and supply of informal care

Demand for informal care could in principle be regarded as a function of the same variables as demand for long-term care generally. The concept of demand for informal care, however, has little meaning in practice in the absence of family or friends willing to supply such care; that is, in the absence of potential supply. Since a proportion of dependent people do not have a surviving close relative or friend, for some people informal care is not an option.

The supply of informal care depends on the availability of a potential carer. The most recent data on informal carers supplied by the General Household Survey (GHS) confirms that the majority of informal care is provided by spouses, children and children-in-law (Maher and Green 2002).

The supply of informal care depends not only on the availability of a potential carer but also on the potential carer's ability and willingness to provide care. The carer's ability and willingness to provide care may be affected by the carer's health and other commitments, including employment and child-care responsibilities. It may also be affected by the carer's income. People with higher incomes may prefer to purchase care

for their elderly relative, as the cost of any employment lost, that is, the opportunity cost of caring, would be higher.

The supply of informal care is clearly central, yet it cannot be considered independently of demand. Not all informal care is supplied to people with a need for care in the sense that they are dependent or disabled in some way. There is evidence that much informal care for elderly people is supplied to people who do not have disabilities and that carers often give care irrespective of need (Daatland 1983, Wenger 1992). This again relates to a fundamental characteristic of informal care. It is not just that people who need care do not necessarily receive it from the informal sector, it is also that caregivers often give care irrespective of need. If, then, the concern is with the support of dependent elderly people, not all the informal care supplied is relevant.

To consider the factors influencing whether or not an older person receives informal care, it is necessary to bring together the factors affecting demand and supply. This suggests that the provision of informal care to an individual is a function of the person's dependency, income, preferences, and availability of a partner, child or possibly other relative living nearby, and also of the potential carer's health, income, employment status, marital status, child-care responsibilities and preferences.

The PSSRU model treats the receipt of informal care as a function of the person's dependency (as an indicator of need) and of the person's household type (as an indicator of the likely availability of informal care). The former may be regarded as a demand variable and the latter as a supply variable. The function is thus a reduced form[3] that seeks to model actual receipt of informal help rather than a demand or a supply function.

Relationship between formal and informal care

It is important to consider the nature of the relationship between formal and informal care. An important issue is whether the amounts of formal and informal care provided are determined jointly, or whether the amount of formal care provided can be considered as a function of the amount of informal care. Joint determination implies that both informal and formal care are determined at the same time, with the level of informal and formal care jointly determined by the parties involved. Consecutive determination implies that formal care follows informal care sequentially and that informal care is taken into account when formal services are provided.

The approach to informal care adopted by service providers in the UK, certainly prior to the community care changes of the early 1990s, has been characterised by a model that treats carers as a resource and provides formal services very much in response to the amount of informal care received (Twigg and Atkin 1994). This is reflected in the importance of household composition as a variable determining receipt of formal services, since household composition to a large extent reflects the amount of informal care (Evandrou et al 1986, Evandrou 1987, Evandrou and Winter, 1988).

[3] By a "reduced form" function is meant the summarisation in one equation of a reciprocal inter-relationship between variables requiring two or more equations to describe in full. The single equation takes the perspective of the influence on one only of two causally interdependent variables.

For this reason, the PSSRU model has a sequential form. In the model, household type is one of the variables that determines receipt of informal care. Indeed, so close is the relationship between household type and informal care that the most recent version of the PSSRU model treats household type and informal care as a single variable with five categories: living alone without informal help, living alone with informal help, single living with others, married/cohabiting living with partner only and married/cohabiting living with partner and others. Receipt of informal care/household type, in turn, is one of the variables that determines receipt of formal care in the model.

Demand for formal care

This discussion of the relationship between formal and informal care suggests that the demand for formal care should be treated as a function not only of the variables affecting overall demand for long-term care but also of the provision of informal care. This is on the basis that formal care can and does sometimes substitute for informal care, especially when it is unavailable, and that informal care provision is often determined before formal care. The demand for formal care can, therefore, be regarded as a function of the person's age, gender, physical health, mental health, income, assets, preferences, and receipt of informal care, and of the costs of care.

For those with no informal carers, the overall demand for long-term care is effectively a demand for formal services. For those receiving informal care, the demand for formal services may be regarded as a demand for additional types of care or additional hours of care that remain unmet. Alternatively, or additionally, there may be a demand for formal services to provide respite for informal carers. This suggests that carer stress may be a further relevant factor.

The role of supply constraints in observed demand

The supply of formal services also requires discussion. Demand for long-term care alone is difficult to observe and the data used on service use is, in fact, a combination of demand and supply. The overall supply of publicly funded care is affected by policy decisions at central and local level about priorities for public expenditure. In modelling demand for formal care, these policy decisions need to be treated as exogenous to the model. This is on the basis that the purpose of the modelling is to inform decisions on public expenditure by providing information on projected changes in demand. To take account of policy constraints on supply in a model aiming to inform policy decisions on supply of public funds would be circular.

Market constraints on supply are also very important. A key constraint is the need to retain the inputs to formal care, especially care staff. Expenditure projections need to incorporate assumptions about unit costs of care and about rises in the real costs of care. These could be understood as assumptions about the real rises in wages and other payments for inputs to care that are necessary to ensure that supply is sufficient. Expenditure projections would thus effectively assume that supply of formal care will adjust to match demand for formal care and that demand will be no more constrained by supply in the future than in the base year. This is on the basis of an appropriate assumption about real rises in care costs.

Other methodological choices

The model contains a relatively large number of variables that, when combined in a cross-tabulation, create a relatively large number of categories (cells), as discussed below. This can cause a problem when using data from sample surveys, as the number of observations that relate to people in each category (cell) in the cross-tabulation may become too small. The PSSRU model deals with this problem by using multivariate (logistic regression) analysis to determine which variables, such as age, gender and dependency, are statistically significant in explaining the use of different services. The fitted values from the analysis are used as the probability of receipt of services for people in each category.

Another important feature of the design of the model is that it has been built in a way that allows the testing of alternative hypotheses about trends in the key factors affecting future demand for long-term care and expenditure. A nearly automated menu of alternative assumptions about trends in key factors has been developed that allows almost any combination of assumptions for the different factors to be tested.

3.2. Description of the model

The model described below seeks to model the demand for formal long-term care services, as a function of some of the key variables discussed in this section. These include not only the elderly person's age, dependency and other characteristics but also the person's receipt of informal care. The latter is a function of demand and supply factors relating to informal care.

The model does not seek to incorporate variables concerning the supply of formal care. It does not seem appropriate to do so, since one of the purposes of the model is to inform policy decisions concerning the supply of publicly funded care. Supply considerations are not, however, absent from the model. Assumptions are made about future rises in the real costs of care. These need to be sufficient to retain the inputs, especially staff, required to provide the levels of care demanded.

The description of the model provided here was first published in Comas-Herrera et al (2003a). The model consists of four main parts. The first part estimates the numbers of older people with different levels of dependency by age group, gender, household type and housing tenure. The second part estimates the levels of long-term care services required, by attaching a probability of receiving health and social care services to each cell. The third part of the model estimates total health and social services expenditure, and finally, in the fourth part, total expenditure is allocated to the various sources of funding.

Part One: Projected numbers of older people

The first part of the model classifies the projected numbers of older people into subgroups (or cells), according to age bands, gender, dependency and other key characteristics. The model uses the Government Actuary's Department (GAD 2003

and Shaw 2003) 2001-based interim population projections as the basis for the numbers of people by age band and gender in each year under consideration until 2031.

The projected older population by age band and gender are separated into dependency groups. The model uses as a measure of dependency the ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Four dependency groups have been used in the model (Box One). Information from the 1998/9 General Household Survey (GHS) was used to break down the private household population into the four groups.

BOX ONE
DEPENDENCY GROUPS USED IN THE PSSRU MODEL

The four dependency groups used in the model are as follows:

1. People able to perform ADL (personal care) tasks and IADL (domestic care) tasks without difficulty.
2. People with difficulty with IADL but not ADL tasks.
3. People with difficulty with one ADL task.
4. People who live in the community and have difficulty with two or more ADL tasks, and people who are in institutional care (hospital, nursing home or residential care home).

Another key factor in the receipt of long-term care is household type. Household type is an important structural correlate of informal care (Pickard *et al.* 2000). Informal care is combined with household composition in a five-fold classification: living alone without informal help; living alone with informal help; *de facto* single, living with others; married/cohabiting couple; and married/cohabiting couple, living with others. Household types where older people live with others, including married/cohabiting couples, have not been broken down between those with and without informal carers because all older people living with others have a potential carer and most of those who are dependent have an actual carer. In the 1998/9 General Household Survey (GHS), over 90% of dependent older people living with others received informal help with domestic tasks.

Projections of informal care/household composition in the PSSRU model are driven by the 1996-based GAD marital status and cohabitation projections (Shaw 1999, Shaw and Haskey 1999). The two marital status groups (those who are *de facto* married and those who are *de facto* single) are broken down into five household types using the 1998/9 GHS. The projections assume a 'steady state' regarding the propensity within marital status groups to live with others.

The model includes, for those living in private households, a simple breakdown by housing tenure, between those living in owner-occupied tenure and those living in rented accommodation. One reason for the inclusion of housing tenure is that it can be regarded as a simple proxy for socio-economic group. Another is that it is

relevant, in the case of older people living alone, to the division between those who fund their own residential or nursing home care and those who are funded by their local authority or health authority. The current means test for public support in residential or nursing home care generally takes account of the value of the person's home (unless it is occupied by their spouse or an older or disabled relative). This means that older home-owners who live alone generally need to fund their residential or nursing home care privately, while older tenants and older home-owners living with their spouse are often eligible for public funding.

The model divides the population into 440 cells. 40 of these relate to the institutional population by age (5 bands), gender, previous household type (2 categories) and previous housing tenure (2 categories), and 400 to the household population by age (5 bands), gender, dependency (4 groups), household type/informal care (5 categories) and tenure (2 categories).

It is important to point out that, as discussed in section 3.1, the 440 cells is the maximum number of combinations that the variables and categories used yield. In practice, the model does not use all the variables and categories simultaneously.

Part Two: Projected numbers of service recipients

The second part of the model projects the volumes of services demanded by combining the output of the first part of the model (the projected numbers of older people by dependency, household type/informal care and other characteristics) with functions that assign receipt of services to each sub-group of the older population. The services covered include a range of health and social services relevant to meeting long-term care needs.

The probability of receipt of each non-residential service, such as home care, day care, and community nursing, was estimated through multivariate (logistic regression) analysis of the 1998/9 GHS data. The independent variables were age, gender, dependency, marital status, household type/informal care and housing tenure. Separate analyses were undertaken for dependent and non-dependent older people, as few non-dependent older people received services other than chiropody and private domestic help. For non-dependent people, age was statistically significantly associated with probability of receipt of each service and gender, marital status and tenure with receipt of some services. For dependent people, age, severity of dependency and marital status or household type were statistically significantly associated with probability of receipt of most services, and gender and housing tenure with receipt of some services.

Demand for domiciliary services was calculated by using the fitted values from the logistic regression models as the estimated probabilities of receipt of each service by age band, gender, dependency and the other factors described above. These fitted values were then multiplied by the projected numbers of older people within each cell by age band and other needs-related circumstances to produce estimates of the numbers of service recipients.

Finally, these estimates of numbers of service recipients were multiplied by estimates of the average intensity of service receipt, i.e. the average number of home help hours or district nursing visits per recipient week. Information on intensity of service receipt by dependency was also obtained from the 1998/9 GHS.

The probability of receiving residential, nursing home or long-stay hospital care was estimated using a combination of data. Official national statistics were used on the total numbers in residential care homes and nursing homes (Department of Health, 2000a). A proportionate breakdown of care home residents by age band, gender, previous household type and previous housing tenure was derived from PSSRU surveys of residential care (Netten *et al*, 1998) and applied to the totals. This approach enabled the proportion of older people in residential care and nursing home to be estimated by age band, gender, household type and housing tenure. Hospital Episode Statistics data on the numbers of older patients by age and gender with stays exceeding 55 days were used as estimates of the numbers in long-stay hospital care. In the absence of data on this group's previous household type and housing tenure, a breakdown from the PSSRU survey data on nursing home residents was applied to hospital residents.

In summary, the numbers of recipients (*SERNO*) of each service (*j*) was estimated as:

$$SERNO_j = \sum_{i=1}^{440} p_{ij} \cdot n_i ,$$

where p_{ij} is the probability of a person in cell *i* (i=1 to 440) receiving service *j* (j=1 to 9) and n_i is the number of older people in cell *i*.

Part Three: Projected aggregate expenditure on long-term care services

The third part of the model projects the total expenditure on the formal services demanded applying unit costs of formal care, drawn from a PSSRU study (Netten *et al.* 2001a) and from Laing and Buisson (2001), to the volume of services projected in the second part of the model. The unit costs were uprated to 2001 prices using the health and social services deflators available from Netten *et al* (2002). The model covers the costs to the health service, social services and users of services, for those services included in the model. Estimated expenditure on home care and community nursing services has been grossed up broadly to match official data.

In summary, the model estimates total expenditure on long-term care (E_t), for each year (*t*), as the sum across all formal health and social services considered, *j* (j = 1 to 9) of the following: projected number of service recipients in year *t* ($serno_{jt}$) multiplied by the intensity of service receipt in terms of hours/visits per week (int_j) and multiplied by the unit cost of care inflated to the year to which the projection year relates (c_{jt}). This can be shown as:

$$E_t = \sum_{j=1}^{10} serno_{jt} \cdot int_j \cdot c_{jt}$$

Part Four: Projected breakdown of expenditure between funders

The fourth part of the model breaks down projected aggregate expenditure by source of funding: NHS, social services and service users. The costs of the health services included are assigned to the NHS. The costs of the social services are divided between personal social services and service users. As there are no national data on the quantities of privately funded care, the projections for privately funded care, especially on non-residential care, need to be treated with caution as it is not possible to verify that all privately funded care is captured by the model.

Residents of residential care and nursing homes are divided into privately and publicly funded residents. The breakdown for 2000 is based on Laing & Buisson data (Laing & Buisson, 2001) for independent sector homes and 1996 PSSRU survey data (Netten *et al*, 1998) for local authority homes. The Laing & Buisson estimates for the proportion of residents who are privately funded were reduced by two percentage points to take account of the changes to the funding system introduced in April 2001. The future trend in this proportion is derived from the projected rise in home-ownership by older people who live alone.

Expenditure on local authority funded residential care, home care, day care and meals is divided between local authority social services and users on the basis of Department of Health data on the proportion of gross costs of social services met by user charges. The proportion of costs met by users is held constant for future years. The full costs of privately funded residential and nursing home care and private domestic care, and a proportion of the costs of all other social services, are thus assigned to users.

3.3. Base case assumptions and projections

The PSSRU model produces projections on the basis of specific assumptions about future trends in the key drivers of demand for long-term care. The main assumptions used in the base case of the model are summarised in Box Two below. The base case projections take account of expected changes in factors exogenous to long-term care policy, such as demographic trends. The base case projections hold constant factors endogenous to long-term care policy, such as patterns of care and the funding system. The base case is used as a point of comparison when the assumptions of the model are subsequently varied in alternative scenarios.

BOX TWO

KEY ASSUMPTIONS OF THE BASE CASE OF THE PSSRU MODEL

- The number of people by age, gender changes in line with the latest Government Actuary's Department (GAD, 2003) 2001-based population projections.
- Marital status changes in line with GAD 1996-based marital status and cohabitation projections.

- There is a constant ratio of single people living alone to single people living with others and of married people living with partner only to married people living with partner and others
- Prevalence rates of dependency by age and gender remain unchanged, as reported in the 1998/9 General Household Survey (GHS) for Great Britain.
- Home-ownership rates, as reported in the 1998/9 GHS, rise in line with the Anchor Housing Trust projections (Forrest *et al*, 1996).
- All dependent older people living with others receive informal care.
- The proportions of older people receiving informal care, formal community care services and residential and nursing home care services remain constant for each sub-group by age, dependency and other needs-related characteristics.
- Social care unit costs rise by 1% per year and health care unit costs by 1.5% per year in real terms. Real Gross Domestic Product would grow by 2.25% per year.
- The supply of formal care will adjust to match demand[4] and demand will be no more constrained by supply in the future than in the base year.

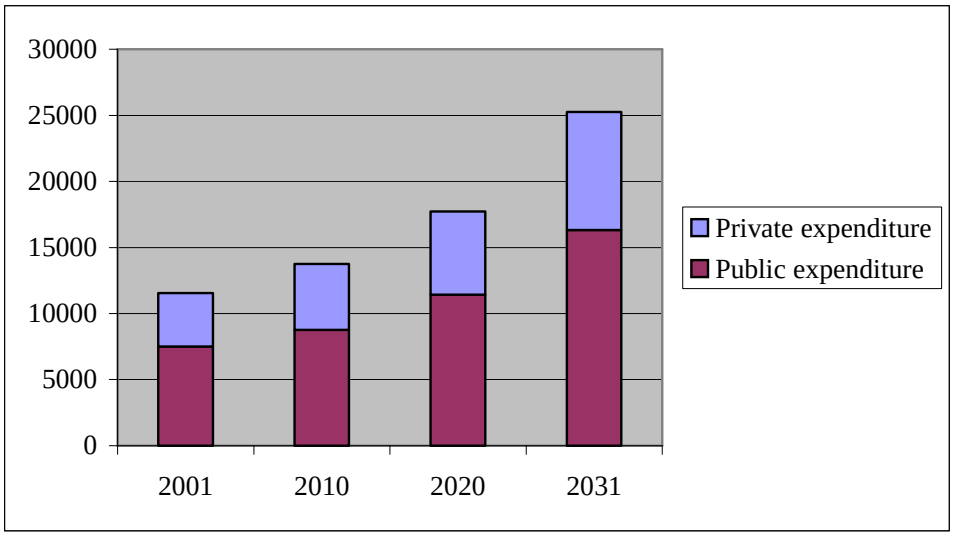
The GAD 2001-based principal population projections for England project that between 2001 and 2031 the numbers of people aged 65 or more will rise by 54%. The numbers of those aged 85 or more are projected to rise faster during this period, by 81%, from more than 950,000 to around 1,732,000. Much of this increase is a result of a projected rise in male life expectancy. Between 2001 and 2031, the numbers of men aged 85 or more are projected to rise by 155%, compared to a 52% rise in the number of women in that age group.

Under the base case assumptions, the numbers of dependent older people[5] would grow by 57% between 2001 and 2031, from 2,567,000 to 4,020,000. The numbers of users of non-residential formal services would rise by 58%, from 1,532,000, to 2,416,000. The numbers of older people in institutions would also rise by 58%, from nearly 400,000 to 627,000.

Figure 1: Projected expenditure (£m) by source of funding, England, 2001-2031, under base case assumptions.

[4] The model effectively assumes that the real rise in wages and other payments for care will ensure that supply is sufficient.

[5] Defined as having problems with at least one IADL or one ADL.



Projected long-term care expenditure would grow by 118%, from nearly 11.6 billion in 2001 to just above 25 billion in 2031 (figure 1). If Gross Domestic Product rose by 2.25% per year, long-term care expenditure would grow from 1.46% of GDP in 2001 to 1.64% in 2031. Table 1 shows these base case projections in greater detail.

Table 1: Projected numbers of older people (thousands), service recipients (thousands) and expenditure (£ billion) under base case assumptions, 2001 to 2031.

	2001	2010	2020	2031	% growth 2001 to 2031
Numbers of older people (aged 65 or more)	7,821	8,455	10,073	12,049	54.1%
Numbers of people aged 85 or more	957	1,127	1,313	1,732	80.9%
Numbers of older people with some dependency	2,567	2,773	3,258	4,020	56.6%
Numbers of users of local authority home help services	372	399	457	586	57.8%
Numbers of users of community nursing services	422	453	533	657	55.7%
Numbers of users of private domestic help	745	846	993	1,231	65.2%
Numbers of users of any non-residential service[6]	1,532	1,653	1,935	2,416	57.7%
Numbers of people in residential care homes	238	257	293	373	57.1%
Numbers of people in nursing homes	134	145	168	213	59.1%
Numbers of people in institutions	397	430	493	627	57.8%
Public long-term care expenditure (£ billion)	7.5	8.8	11.4	16.3	117.4%
Private[7] long-term care expenditure (£ billion)	4.1	5.0	6.3	8.9	120.2%

[6] Local authority home care, district nursing, day centre care, meals or private domestic help

Total long-term care expenditure (£ billion)	11.6	13.8	17.7	25.3	118.4%
Total long-term care expenditure as a % of GDP	1.46%	1.42%	1.44%	1.64%	12.3%

Source: model estimates.

The model produces projections of future long-term care expenditure based on a specified set of base case assumptions. This set of assumptions seems plausible but is clearly not the only possible set. A substantial part of the PSSRU study of long-term care projections has involved the investigation of the sensitivity of the projections to changes in the assumptions made in the model, which is discussed below.

Finally, it is important to point out that the expenditure projections obtained using the model do not constitute the total costs of long-term care to society. That would require inclusion of the costs of a wider range of services to a wider range of public agencies and service users and the opportunity costs of informal care. It should also be stressed that no allowance has been made for changes in public expectations about the quality, range or level of care.

3.4. Sensitivity analysis in the PSSRU model: the effect of changes in the key assumptions

This section examines the model's sensitivity to any changes in the key assumptions, with particular regard to changes relating to the future numbers of older people, dependency rates, the availability of informal care, patterns of formal care and the unit costs of care.

Future numbers of older people

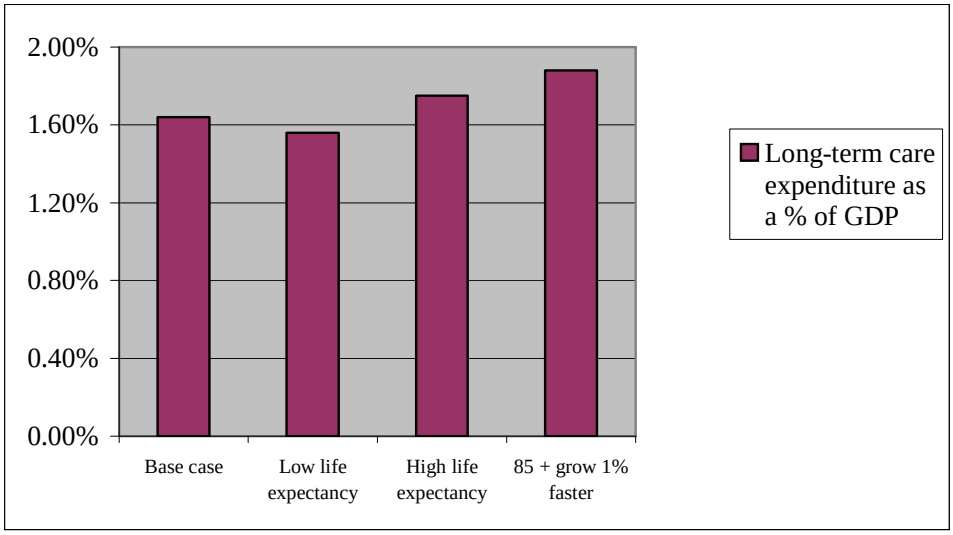
The Government Actuary's Department (GAD) population projections for England produce a rise of 54 per cent in numbers of people aged 65 or more between 2001 and 2031, while numbers of those over 85 will rise by 81 per cent.

Mortality rates in old age are the key factor affecting the projected number of older people, and numbers of very old people in particular. As the proportion of older people with dependency rises sharply with age, the model's projections are very sensitive to the assumptions about the numbers of very elderly people. Figure 2 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions. The assumptions are: the GAD's low and high life expectancy 2000-based population projection variants, and an assumption according to which the numbers of people aged 85 or more would rise faster than projected by the GAD's principal projection, by 1% more per year. This assumption has been chosen because it corresponds roughly to the extent of past under-estimation of the numbers of very elderly people (Shaw, 1994). According to data gathered by Robine (2003), the official population projections of most European countries have consistently underestimated the future numbers of older people, specially of the very old. It is debatable whether the most

[7] Includes user fees and co-payments.

recent UK projections, based on a changed approach (Shaw, 2000), will still prove to be under-estimates.

Figure 2: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about changes in life expectancy

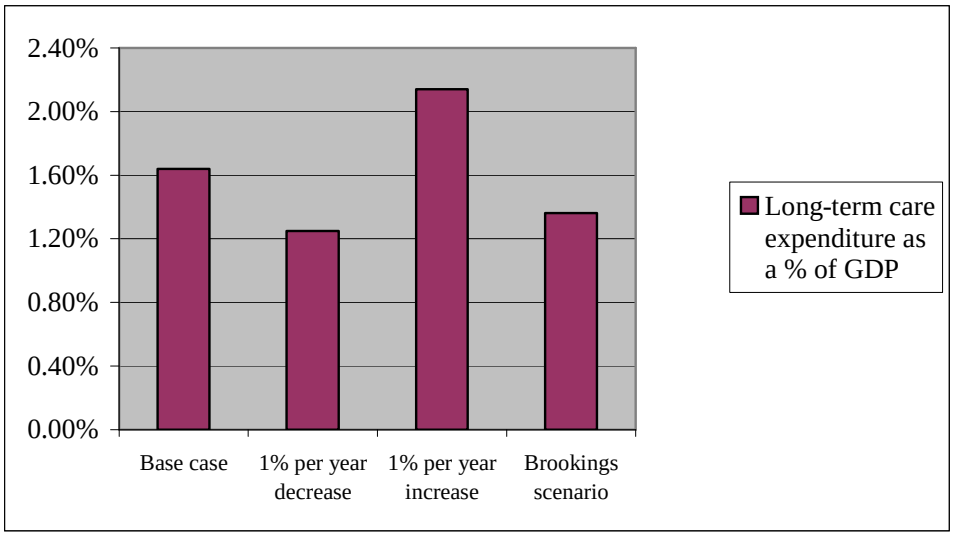


Dependency

If falling mortality rates were accompanied by falling rates of dependency, this would (at least partially) offset the impact of demographic pressures on demand. Constant dependency rates could be regarded as a pessimistic assumption. The 'Brookings scenario' is a less pessimistic assumption that moves the age-specific dependency rate up by one year for each one-year increase in life expectancy.

While there are differing views about whether age-specific dependency rates can be expected to rise, fall or remain much the same, projections of demand for long-term care are highly sensitive to assumptions about dependency. Figure 3 shows projected expenditure in 2031 as a percentage of GDP using a range of assumptions: a 1% increase and decrease per year in the prevalence rates of dependency, and the 'Brookings scenario'.

Figure 3: Projected expenditure as a % of GDP, England, 2031, under alternative assumptions about dependency trends.



Availability of informal care

The GAD marital status projections imply that there is likely to be an increase in spouse carers of dependent older people, at least until 2020 (see Wittenberg et al, 2001 for more details). The PSSRU model base case takes this into account, but does not take into account other possible changes in the availability of informal care.

The proportion of older people living with an adult child in Great Britain declined from 42 per cent in 1962 to 14 per cent in 1986, and has subsequently declined still further (Grundy 1995, Grundy and Glaser 1997). If by 2031 fewer older people receive informal care from children living in the same household, it could be assumed that more people may move into residential homes. In addition, it is possible that more older married couples may also require admission to residential care, if there is a decline in informal care by children.

Various scenarios have been developed to test the impact on the model's projections for formal services of a decline in informal care. Compared to the base case, all of these produce varying degrees of increases in public expenditure and increased numbers of those in institutional care. But much depends on the size of the decline in informal care and on the extent to which such care is substituted by residential care or by moderate packages of domiciliary services.

Future patterns of care

The model can be used to explore the impact of changes in the patterns of services. The scenarios explored assume a shift in the balance of care from institutional to domiciliary, a change in the eligibility criteria for home care and an increase in support for informal carers.

The first scenario considered here assumes that projected numbers in nursing and residential homes would by 2020 be 10 per cent lower than the base case, and that

people 'diverted' from nursing homes would receive an average of eight hours' home care and 1.5 community nurse visits a week while those 'diverted' from residential homes would receive eight hours' home care. This follows a similar scenario in the National Beds Inquiry for England (Department of Health, 2000b).

The second scenario investigated the potential impact of introducing a national entitlement to free formal care for all older people with moderate to severe dependency (two or more ADLs) whether or not they were receiving informal care. (This scenario mirrors, to a certain extent, the entitlement to long-term care in Germany). This scenario assumes 5.75 hours of formal home care a week and 100 per cent take-up.

The GAD marital status projections suggested that in future there was likely to be an increase in spouse carers of dependent older people. However, many spouse carers are elderly and in need of support themselves. The third scenario looked at providing support to the most heavily burdened carers (defined as those providing personal care to older people living in the same household) and explores the implications of making the same services available to those living with others as those living alone: the 'carer-blind' approach.

In the first scenario, projected public spending was lower than in the base case as the packages of domiciliary care were less costly than institutional care. The national entitlement scenario, however, had substantial cost implications with numbers of those using home help nearly doubling. Under the 'carer-blind' scenario projected long-term care expenditure would also be higher than under the base case.

Unit costs and economic growth

Spending on long-term care is highly sensitive to relatively small changes in future unit costs. The base case of the model assumes that real unit costs will rise in line with historical trends in input pay and prices: one per cent per year for social care and 1.5 per cent a year for health care. GDP is assumed to rise by 2.25 per cent a year.

Residential care, home care and day care are all highly labour intensive. An alternative scenario investigates the impact of assuming that future unit costs will rise in line with projected rises in earnings. This scenario is based on the Treasury's long-term assumptions, published in the 2003 Budget (HM Treasury, 2003), for productivity growth (as an indicator of possible future rises in care staff earnings) and for growth in GDP. In this scenario, spending on long-term care would rise to nearly £31bn compared to £25bn under the base case.

Overall findings of the sensitivity analysis

Overall, the sensitivity analysis shows that projected future demand for long-term care services for older people in the UK is sensitive to assumptions about the future numbers of older people and about future prevalence rates of dependency. It is also sensitive to assumptions about the future availability of informal care. Projected future expenditure on long-term care for older people is also sensitive to assumptions

about future rises in the real unit costs of services, such as the cost of an hour's home care. The sensitivity of the model to changes in the assumptions made means that the projections should not be regarded as forecasts of the future.

A recent international study[8] investigated the sensitivity of projections of long-term care expenditure for older people to assumptions on trends in the key drivers of demand for care (Comas-Herrera and Wittenberg, 2003). This comparative study investigated the key factors that are likely to affect future expenditure on long-term care services in Germany, Spain, Italy and the United Kingdom. The approach involved investigating how sensitive long-term care projections are to assumptions made about future trends in different factors, using comparable projection models.

The sensitivity analysis showed that projections of long-term care expenditure in all four countries are sensitive to assumptions about future mortality and dependency rates. They are also highly sensitive to assumptions about future real rises in the unit costs of care. They are sensitive to scenarios involving a relative decline in informal care where this results in greater use of residential care. They are somewhat less sensitive to assumptions about changes in the patterns of formal care.

3.5. Projections of long-term care expenditure due to dementia

As discussed in section 3.4, future demand for long-term care and associated expenditure are very sensitive to changes in the assumptions made about trends in dependency of older people. The definition of dependency used in the PSSRU model is based on the ability to perform instrumental activities of daily living (IADLs) and activities of daily living (ADL). One of the causes of difficulties in the performance of IADLs and ADLs is dementia. Most of those with dementia who require long-term care are likely to have difficulties with IADLs or ADLs. It is unlikely that a model of long-term care demand that uses IADLs and ADLs would omit large numbers of older people requiring long-term care. Nevertheless, , there are important reasons for having a model that can distinguish between those who have functional dependency only and those who have functional dependency and suffer from dementia.

The first reason is that there are important differences in the patterns of care for people with and without dementia given the same ADL problems, specially for those with severe cognitive impairment. People with severe cognitive impairment are more likely to rely on formal care and, in particular, are more likely to be institutionalised (Bauld et al, 2000, Boersma *et al*, 1997, and Netten *et al*, 2001b). If the future numbers of people with dementia were to rise at different rates than the future numbers of people with ADL problems due to other causes, projections made using a model that only used an overall ADL definition would not be appropriate to plan the future services required for people with dementia.

Another reason why it is important to have a model that takes specific account of dementia is that it would permit an investigation of the potentially cost-saving impact

[8] Funded by the European Commission.

of new drugs for people with Alzheimer's Disease. This would be an important issue to explore.

PSSRU[9] developed a version of their model to make projections, for the next 30 years, of future numbers of older people with cognitive impairment, their demand for long-term care services and the future costs of their care under a range of specified assumptions (Comas-Herrera et al, 2003b). The term cognitive impairment is used here to describe one of the manifestations of dementia.

The study set out to explore the impact of factors that are likely to affect future long-term care expenditure associated with cognitive impairment, in particular changes in the future prevalence rates of mild and severe cognitive impairment. The study also investigated the impact of changes in the patterns of care specific to those with dementia, for example, increasing support to informal carers.

The study found that, under the base case, the numbers of people with cognitive impairment would increase faster between 1998 and 2031 than the numbers of people with functional disability only (66% and 58% respectively). This implies that demand for long-term care will rise at a faster rate among those with cognitive impairment than would be suggested by projections of the overall demand for long-term care based on functional disability. For example, between 1998 and 2031, the number of people with cognitive impairment in institutional care is projected to increase by 63%, compared to a projected 52% increase in the total number of older people in institutions. These results show that, when planning future service requirements for older people with cognitive impairment, it would be important to have specific projections.

The results of the model also showed that, unless more effective treatments for cognitive impairment are developed and made widely available, the numbers of older people with cognitive impairment will rise significantly over the next 30 years. This means that substantial rises in formal services will be required. The implication is that there is a need to develop, and make widely available, better treatments to slow down the progressive decline associated with dementia.

4. Conclusion: recommendations on making long-term care projections

4.1. Choosing the methodological approach

When designing a long-term care projections model, the first step is to be clear on the purpose of the modelling. Key questions are whether the aim is to produce aggregate projections of the future numbers of older people requiring long-term care and of long-term care expenditures, or to investigate the impact of alternative financing mechanisms on different groups. The purpose will influence the choice of type of model, for example, whether to construct a cell-based or microsimulation model.

[9] Funding from the Alzheimer's Research Trust and access to MRC CFAS data (MRC CFAS, 1998) are gratefully acknowledged.

Another key aspect to be clear about is the coverage of the model. Important questions include: will the model include only older people? Will it cover both public and private expenditure or just public long-term care expenditure? Will it include informal care by family and friends or only formal services?

The second step is to investigate all the available sources of data. The ideal situation would be to find a nationally representative survey covering the health, dependency, household situation, income, assets and long-term care use of people in the community and in care homes and hospitals. Single surveys with all the relevant information are not available in most countries. As a result, a variety of sources containing information on some of the aspects need to be used. The description of the UK's PSSRU long-term care model in section 3 explains how various sources of information were used to obtain an overall picture (in terms of data) of long-term care in the UK. The quality of the data used and the construction of a baseline that represents as accurately as possible the current long-term care arrangements is crucial for the reliability of the projections.

Determining the architecture of the model is a complex exercise. In the case of cell-based models it is necessary to balance the need for sufficient cells to address the range of policy issues with the need for a model simple enough to be useable. The greater the breakdown into more cells, the greater the flexibility of the model; but too many cells could render it unduly complex to build and use.

If opting for a cell-based model, it is also important to consider whether there are existing microsimulation models that already model the income and assets (as well as other characteristics) of older people. If so, it may be possible to combine a cell-based model of long-term care projections with a microsimulation model that investigates the impact of different funding mechanisms over time and between different groups.

4.2. Choosing the base case set of assumptions

Projections models generally need to incorporate initial assumptions on future levels of key variables. These may be that key variables will remain constant over time, change in line with past trends or change in line with expert views. Long-term care models need to incorporate assumptions about future trends in the main drivers of demand for long-term care and long-term care expenditure.

It is useful to choose a core set of assumptions about future trends to form a 'base case' that can act as a reference case against which the effect of changes in the different assumptions can be investigated. The approach taken in the UK's PSSRU model has involved taking account within the base case of expected changes in factors exogenous to long-term care policy[10], such as trends in the numbers of older people by age, gender and marital status, and holding constant factors endogenous to long-term care policy, such as patterns of care and the funding system.

[10] The definition of exogenous and endogenous factors use here should be interpreted in relative terms rather than absolute terms: all factors could be at least partly endogenous in the sense that they could be affected by policy changes in the long-term.

The factors affecting the future numbers of dependent older people requiring long-term care are mainly exogenous to long-term care policy. They include demographic change and dependency rates. These two factors affect the overall need for long-term care. There are other important exogenous factors that also affect demand for long-term care, either by influencing the propensity to seek care or by influencing the type and amounts of care that will be sought. These factors include individual preferences, which may reflect age, gender, income and other personal characteristics but which are difficult to model. Demand for formal care is also crucially affected by the availability of informal care.

As well as the exogenous factors mentioned above, the receipt of long-term care is influenced by factors endogenous to long-term care policy, such as the availability and accessibility of formal services, the funding system, and the policy incentives or disincentives to the provision of informal care.

Future long-term care expenditure is determined not only by changes in the volume of services demanded but also by rises in the unit costs of long-term care, such as the cost of an hour's home care. Since long-term care services are labour-intensive services, trends in the unit costs of care will depend largely on trends in the earnings of care staff. The future affordability of long-term care depends also on how much the economy grows in the future.

The PSSRU model aims, as discussed above, to use base case assumptions that reflect "expected changes" in the main exogenous factors. However, there is not always consensus on what assumptions reflect those "expected changes". While using the official population and marital projections as base case assumptions is not very contentious, the choice of a base case assumption for trends in dependency and in unit costs is less straightforward as there is no consensus in the literature about future dependency rates and long-term economic trends. It is important to keep the base case assumptions under review in the light of new evidence.

4.3. Carrying out sensitivity analysis and interpreting the projections

Given the great degree of uncertainty about future trends in the drivers of demand for long-term care, it is very important to carry out sensitivity analysis to investigate the impact of changing each of the base case assumptions of the models.

The importance of the results of the sensitivity analysis lies in the fact that it is beyond the present state of knowledge to set probabilities for future trends in the factors examined. Yet it is important for policy and planning purposes to demonstrate the extent of sensitivity of future long-term care expenditures to assumptions about these trends. The findings of the PSSRU and other models suggest that policy-makers need to plan for uncertainty in future demand for long-term care for dependent older people. Future mortality and prevalence rates and rises in unit care costs, which are inevitably uncertain, have substantial implications for future demand for long-term care and associated expenditure.

It is also important to recognise that most models will not have taken account of the

impact of rising expectations, as their likely impact would be very difficult to measure and quantify. It seems plausible that rising real incomes will be accompanied by rising expectations for more and better quality care.

The approach taken by the PSSRU study of long-term care projections has been to emphasize that the model makes projections based on assumptions, rather than forecasts. That means that, instead of asserting what the future demand for long-term care and expenditure will be, the model's projections show what the future demand and expenditure would be like given the assumptions specified.

Acknowledgements

Most of the research reported here has been carried out as part of the Personal Social Services Research Unit's long-term research programme, financed by the Department of Health. Bleddyn Davies and Robin Darton have contributed to some of the research reported in this paper. All views reported here are those of the authors. The report does not purport to represent the views of the Department of Health.

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