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The Impact of Dementia and Extremity Injuries on the Plasticity of Long-term Care Demand

An Analysis of Counterfactual Projection Scenarios Based on German Health Insurance Routine Data*

Alexander Barth

Abstract: Although demand for long-term care (LTC) in Germany is expected to increase over the coming decades, the LTC sector will struggle to provide sufficient capacity. Evaluating the impact of different risk factors on future LTC demand is necessary in order to make informed policy decisions. With regard to LTC need, dementia and lower extremity injuries (LEI) are common risk factors. Both are used to demonstrate their maximum attainable efficacy in mitigating the future increase in overall LTC need, both at home and in nursing homes.

We use a multi-state projection model for which the estimation of the underlying transition and mortality rates is based on longitudinal health claims data from AOK, Germany's largest public health insurance provider, between 2004 and 2010. We project six different scenarios of LTC for ages 75+ in Germany for the period from 2014 to 2044, including counterfactual scenarios that remove the effects of LEI, dementia, or both. Our multi-state projections distinguish between home-based and institutional LTC.

Removing the effect of LTC risk factors mitigates the increase in total LTC demand and postpones demand until a later age. Removing dementia markedly shifts future care demand from institutional LTC to LTC at home and even increases demand for LTC at home at older ages beyond the baseline projection due to the dual function of dementia as a risk factor for both LTC demand and mortality. Removing LEI has less of an effect on overall and sectoral LTC demand. Removing both risk factors at the same time results in the greatest impact, which is even more marked than that of both individual scenarios combined, thus indicating a synergistic relationship between dementia and LEI on LTC risk.

The type of LTC demand (home-based or institutional) shows considerable plasticity when specific risk factors are removed. We demonstrate the degree to which

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LTC demand can be affected in favour of LTC at home, using dementia and LEI as examples of potentially modifiable risk factors, and thus show how the efficacy of potential intervention targets for policy-makers can be assessed.

This study provides evidence on the degree of plasticity of future long-term care demand at home and in institutions that would hypothetically be attainable when completely removing specific cognitive or physical risk factors of care need (dementia or lower EI). It is based on large-scale health claims data, which contain longitudinal individual level data on morbidity and long-term care status. A close link exists between the cognitive risk factor of dementia and the type of LTC, as its absence shifts care demand to home-based care at older ages. The study also demonstrates the usefulness of counterfactual projections based on health claims data in assessing the hypothetical maximum efficacy of different intervention strategies.

Keywords: Long-term care · Counterfactual projections · Dementia · Extremity injuries

1 Introduction

Increasing life expectancy and declining fertility are driving population ageing in developed countries. Across OECD states, the share of people aged 80 years and older is expected to triple from 2005 to 2050, causing a marked increase in LTC demand (*Fujisawai/Colombo* 2009; *Comas-Herrera et al.* 2006). Ageing nations need to manage this increase, e.g. by providing opportunities for informal care, giving professional assistance to informal caregivers or by increasing capacity in nursing homes. The growth rate in LTC expenditure was the highest among all healthcare sectors (*OECD* 2017) and total LTC expenditure is expected to increase from 1 percent to up to 4 percent of GDP between 2005 and 2050 (*Fujisawai/Colombo* 2009). Between 2030 and 2050 in particular, LTC demand is expected to increase markedly, as large baby boomer cohorts born between the mid-1950s and 1960s will reach ages at which LTC becomes prevalent (*Doblhammer* 2012; *Rothgang et al.* 2012b). As both personnel and funding in the LTC sector are in short supply, further strategies to mitigate increases in LTC demand are of vital interest.

Since LTC dependency often arises due to illnesses (*Koller et al.* 2014; *Barth et al.* 2016), lowering either the prevalence of a disease or its impact on LTC demand could mitigate the increase in demand. However, most studies focus on total future LTC demand or labour supply (*Doblhammer* 2012; *Fujisawai/Colombo* 2009). Evidence on the efficacy of specific conditions is sparse. This article therefore uses counterfactual projections that remove either dementia, lower extremity injuries (LEI), or both to assess their efficacy in mitigating the increase in total and sectoral LTC demand.

This study uses a large sample of German statutory health insurance routine data, which provide morbidity, mortality and LTC status. It allows all transition risks that are required for the counterfactual projections to be modelled based on the

same source. In terms of LTC, dementia is a greater risk factor than LEI (*Barth et al.* 2016), which leads us to hypothesise that its overall mitigating effect will be greater. Since dementia often requires a higher degree of care, its removal should result in a marked reduction in institutional LTC demand. Because health insurance routine data cover all diseases and are available in many countries, this approach could also be applied to different diseases or countries.

2 Background

2.1 Individual level LTC risk factors

In order to examine trends in population health, health expectancy measures such as healthy, active or disability-free life expectancy are common, which divide the number of remaining life years into unimpaired and impaired years. While results largely depend on the exact measure in question, findings generally show that a compression of morbidity occurs. Against the background of increasing life expectancy, this means that the life years gained are mostly spent in good health. These gains pertain in particular to serious conditions, while for minor impairments, a dynamic equilibrium (additional life years distributed evenly) or even an expansion of morbidity can be found, which is characterised by multimorbidity and chronic impairments (*Unger/Schulze* 2013; *Christensen et al.* 2009). LTC dependency often arises due to chronic functional impairments when basic tasks cannot be performed alone. We focus on two common LTC causes: one related to mental health – dementia; and one related to physical mobility – lower extremity injuries (LEI).

Dementia is the primary cognitive cause of LTC and mostly occurs at the age of 75 and older. It describes a syndrome that subsumes different diseases that all cause a severe decline in cognitive functioning or affect personality traits. Most patients require assistance and supervision (*Doblhammer et al.* 2012). LEI are a major physical health risk factor as regards LTC. Mobility limitations are often caused by LEI such as a broken hip, often resulting from falls (*Barth et al.* 2016), which are common in older age and especially frequent among women (*Stevens/Sogolow* 2005). As mobility is a basic requirement for independence, LEI can cause LTC dependency. They can also act as a proxy for impairments that increase LTC risk. Falls are linked to age, because they are often caused by other age-related conditions like muscle weakness, problems with gait or balance, impaired vision or mild cognitive impairment. Restoring mobility after a LEI can be difficult, and future mobility may be reduced as a precaution after suffering a LEI (*Neuman et al.* 2014; *Guralnik et al.* 1995). A study comparing both risk factors found that dementia is more influential than LEI as far as individual LTC risk is concerned (*Barth et al.* 2016).

Dementia and LEI can also be causally related (*Barth et al.* 2016; *Lautenschlager et al*. 2008). LEI can make performing daily tasks or maintaining an active lifestyle difficult, thus undermining the protective effect that such a lifestyle can have against dementia (*Wang et al.* 2002) and making LEI a risk factor for dementia *(Barth et al.* 2016). Mobility impairments like gait instability can be a predictor of cognitive de-

cline. Delirium can occur after a LEI, which in turn can cause dementia (*Krogseth et al.* 2011). Dementia is often found in older fracture patients (*Bruijn et al.* 2013; *Hamer/Chida* 2009; *Zhou et al.* 2016) because it shares direct and intermediate risk factors with fractures. Dementia can negatively affect gait and balance, and its treatment can increase fracture risks (*Friedman et al.* 2010). If dementia and LEI are present concurrently, they can synergistically increase LTC risk (*Barth et al.* 2016; *Inagawa et al.* 2013).

Looking at trends of years lived with disability (YLD) as a result of these conditions helps to contextualise their importance with regard to LTC demand. Worldwide, YLD due to falls, which are the primary cause of LEI in older age, have increased by 46 percent from 1990 to 2010. Falls account for 2.5 percent of all YLD, making them the 10th most frequent cause of YLD globally and the 3rd most frequent cause in Western Europe. YLD due to dementia increased by 80 percent, thus being responsible for 0.9 percent of all YLD worldwide. Globally, dementia is the 24th most frequent cause of YLD, and the 10th most frequent cause in Western Europe. While the increases in total YLD due to both conditions are driven in part by population ageing, YLD rates per 100,000 persons have also increased by more than 12 percent in the case of falls, and by more than 38 percent for dementia (*Vos et al.* 2012).

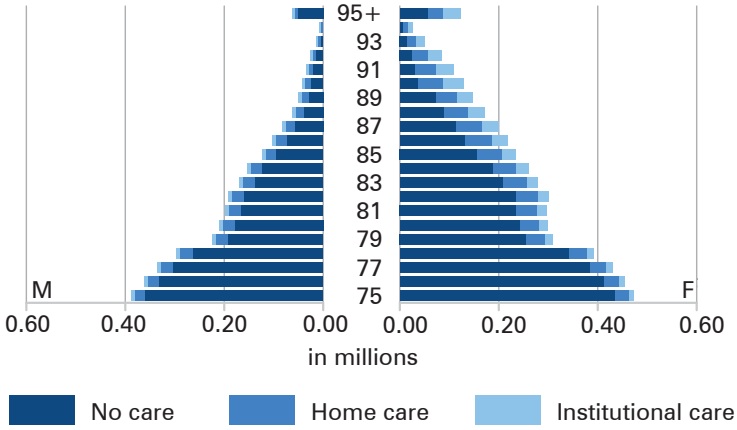
In terms of disability-adjusted life years (DALYs) lost, which weight and combine life years lived with health impairments with those lost due to premature mortality, and looking at the population aged 60 years and older, both dementia and falls are among the fifteen most frequent causes. Dementia accounts for 1.7 percent (9th most frequent cause), and falls for 2.2 percent (7th most frequent cause) of all DALYs lost in 2010 (*Prince et al*. 2015). Along with population ageing, dementia and falls are therefore increasing in importance as causes of YLD.

2.2 Long-term care in Germany

LTC dependency is defined in accordance with German statutory public LTC insurance ("Pflegeversicherung"), which was introduced in 1995. Benefits are granted based on one of three dependency levels, which are assigned by an objective assessment that focuses on limitations in activities of daily living (ADL). For care level one, a minimum of 90 minutes of assistance are required, at least half of which must relate to basic care tasks. Level three is assigned when five hours are required, four hours of which must relate to basic care tasks. Thus, not everyone in need of assistance is covered. The higher the care level, the more time and skill are required by the caregivers. Payments can be used for professional care at home, in institutions or at the discretion of the recipient, e.g. for informal caregivers, utilities or renovations. The benefits do not cover all care-related costs. Institutional care in particular causes cost-benefits gaps (*Rothgang et al.* 2012b).

In 2014, more than 2.6 million people received benefits, around two thirds of whom were female. Figure 1 shows the age structure by care type at age 75 and older. More than half of all LTC recipients are at least 80 years of age, and more than one third are aged 85 years and older. Over two thirds are in ambulatory care. For

Fig. 1: Population aged 75 and older by care need in 2014



Source: Long-term care statistics ("Pflegestatistik"), own design.

two thirds of recipients, care was provided on an informal basis by relatives. Informal care at home is thus the most frequent type of care, which is best suited for a lower level of care need. Professional care services provide either partial or full care for the remaining recipients living at home. Less than 30 percent of LTC recipients live in institutions, and about half are 85 years or older (*Statistisches Bundesamt* 2015b).

2.3 Influences on future long-term care supply

Both LTC sectors face difficulties in the coming decades. Informal care depends on partners, spouses, daughters or in-laws (*Doblhammer/Scholz* 2010). The share of older people living with a partner is expected to increase slightly up to 2030, due to a sharper increase in the life expectancy of males compared to females (*Schulz* 2010; *Pötzsch* 2011). As a result, no decrease in partner-based care potential is expected to arise until then. Even if couples are living together longer, home care might be too demanding when the need exceeds the partner's potential to give care. Between the 1937-1942 and 1963-1967 birth cohorts, the share of childless women has nearly doubled to 20 percent, leading to a reduction in the care provision potential by own children or their spouses (*Statistisches Bundesamt* 2015a) from the late 2030s onwards when the latter cohort begins to reach age 75 and older.

Informal care depends on the labour market participation of caregivers, because working full-time jobs restricts available time. Since most informal care is provided by females (*Dukhovnov/Zagheni* 2015; *OECD* 2017), female labour market participation is a key factor. Female labour market participation between the ages of 50 and 65 is expected to increase from 44 percent to 61 percent (2003-2050). In absolute terms, however, the number of women will decline due to lower fertility and a higher prevalence of childlessness, which both decrease the care potential of females

(*Schulz* 2010). When informal caregivers are themselves parents, they also have to care for their young children (*Dukhovnov/Zagheni* 2015). Providing care requires the caregiver to live close to the recipient. Job-related mobility might increase distances, especially in rural areas which younger people leave to move elsewhere, while their parents remain behind (*Maretzke* 2016).

A decreasing population, fewer people of working age and fewer young people entering the labour market indicate that the recruitment of care workers will prove challenging over the next few decades (*Geerts et al.* 2012; *OECD* 2017; *Rothgang et al*. 2012a). Between 2010 and 2030, the working age population will decrease by nearly three million, and the economically active population will decrease by 1.4 million (*Bundesministerium für Arbeit und Soziales* 2013). The level of job vacancies in the care sector is already more than twice as high as the overall average (*Bundesministerium für Gesundheit* 2015). All sectors will compete for fewer potential employees, and care is currently not one of most appealing career choices due to low wages and the high demands placed on carers. The shortage of LTC staff is expected to total between 140,000 and 200,000 full-time jobs by 2025 (*Bundesministerium für Gesundheit* 2015) and exceed 500,000 by 2030 (*Vereinigung der Bayerischen Wirtschaft* 2012).

2.4 Projection of long-term care need for Germany

A number of scientific or administrative LTC projections are available (*Doblhammer* 2012; *Doblhammer/Scholz* 2010; *Pfaff* 2010; *Geerts et al.* 2012; *Doblhammer/Ziegler* 2010; *Schulz* 2010; *Rothgang et al.* 2012a). They are based on population scenarios that are combined with different variants or trends of age-specific prevalence of total or sectoral LTC demand, or which incorporate determinants of LTC use such as household composition. They vary in their definition of care need, with some using the objective LTC insurance definition, and others using self-reported criteria, sometimes based on survey data like SHARE (*Geerts et al.* 2012). The focus lies mostly on the number of LTC recipients. Some projections differentiate between care settings at home and in institutions (*Geerts et al.* 2012; *Rothgang et al.* 2012a). Because care need depends on the size of the cohorts reaching older ages, the primary source of uncertainty is the trend in life expectancy, while assumptions on the cohorts' health status are the second key factor. Despite their methodological differences, all projections agree on a marked increase in LTC demand ranging from 22 percent to 62 percent between 2005 and 2030, and from 45 percent to 123 percent between 2005 and 2050. Health improvement scenarios assume that the increase in demand for LTC will be reduced by between 400,000 and 600,000 individuals in 2030, and by around one million in 2050 (*Doblhammer* 2012). Age structure therefore dictates a marked increase in LTC demand that no realistic degree of compression of morbidity can compensate. LTC demand will increase markedly, but the increase can be mitigated by health improvements.

2.5 Aim of this study

Increasing LTC demand as a result of population ageing does not allow macro level interventions besides making changes to legislation regarding entitlement. Individual level risk factors such as diseases are potentially modifiable, which shifts the focus on their efficacy in mitigating future LTC demand. Our first goal is to assess the plasticity of future LTC demand that is achievable by removing one or both of the two risk factors, namely dementia and LEI. First, we assess the impact on the total number of LTC recipients and second, on whether care demand arises at home or in institutions. The third aim is to demonstrate the general use of counterfactual projections based on claims data for the assessment of interventions and to show their use for policy planning.

Germany is a good example of a country where LTC demand is growing. With Japan and Italy, Germany is one of the three countries most advanced on the path of population ageing and already has an age structure that other countries will be reaching (*United Nations, Department of Economic and Social Affairs, Population Division* 2017). Germany's mandatory public LTC insurance system has been established over 20 years ago, meaning sufficient real life experience has been gained and is available for analysis in routine data. Germany has a high and expanding capacity of institutional LTC beds per 1,000 people aged 65 and over, surpassed only by a few countries such as the Netherlands or Sweden (*Statistisches Bundesamt* 2017; *OECD* 2017). Informal and institutional LTC demand can therefore be studied using data for Germany. Recent LTC reforms included persons formerly below the threshold for the lowest care level, which shows that providing care to those who require it remains important for policy-makers (*Straub* 2018). Given its status as a country where population ageing is at an advanced stage and continuing, Germany is a good example for retrospective studies and was also used as example to comparatively study the costs of establishing national entitlement to LTC at home in different countries (*Pickard et al.* 2007).

3 Methods

3.1 Definition of long-term care

Everyone with at least care level one is defined as LTC dependent. This study does not distinguish between care levels, but between LTC settings. LTC recipients not living in an institution are defined as receiving home care whereas beneficiaries living in an institution are defined as institutional LTC recipients. The remainder of the population is considered as non-LTC dependent.

3.2 Definition of dementia

Dementia is defined as one or more of the following: Alzheimer's disease (ICD-10 codes F00/G30), vascular dementia (F01), Lewy body dementia (G31.82), circum-

scribed brain atrophy (G31.0), dementia as a side-effect, e.g. of Parkinson's disease (F02, F05.1, G23.1), or other/unspecified dementia (F03). To ensure validity, only diagnoses flagged as "verified" for outpatients or "discharge" for inpatients are considered. Second, at least two diagnoses issued in the same quarter either by an inpatient and an outpatient physician or from different outpatient specialists are required: inpatient diagnosis and neurological specialist, inpatient and general physician, inpatient and other type of specialist, neurological specialist and general physician, neurological specialist and other type of specialist, or other type of specialist and general physician. Alternatively, at least two verified diagnoses at different quarters from inpatient care, an outpatient neurological specialist, a general physician or other specialist are required. In these cases, the diagnosis is deemed valid from the time of the first diagnosis onwards. If the first verified diagnosis occurs in the last observed quarter, it is also deemed valid. Dementia is coded as being present from the first validated occurrence onwards.

3.3 Definition of lower extremity injury

Lower extremities are defined from the hip downwards. Relevant injuries are fractures, wounds, luxations, contusions, burns, frostbites and amputations (ICD codes S70–S99, relevant parts of T). LEI is coded as being present from the first occurrence onwards.

3.4 Population projection

Population projections often use the cohort-component method, which projects the population by age and sex. Multi-state projections like those used here extend this method and share many characteristics. Age is divided into groups of equal size, in this case single years. The projection steps are of the same length as the age groups. The highest age group is open-ended, in our case 95 years and older. The projection requires a starting population that is specified by age and sex for the first year, and parameters of population development, i.e. fertility, migration and mortality. The subgroups defined by age and sex are projected into the future for each step forward in time – in this case, single calendar years – by applying mortality, fertility and migration rates.

In this case, fertility is disregarded because the interest of this study lies in the projection of LTC demand of cohorts that have already been born. According to the German Federal Statistical Office, between 2000 and 2018 migration of persons in the 75 and older age group contributed between 0.3 percent and 0.8 percent to total annual immigration, and between 0.8 percent and 1.4 percent to total emigration. This corresponded to annual net totals of between +1,200 and -6,500 persons, or between 0.01 percent and 0.09 percent of the entire population in this age group, which increased from nearly 6 to 9.5 million persons. All variants of the most recent 14th official coordinated population projection also assume net migration of similarly small amounts in the highest age group going forward. The impact of migration on population change at older ages is considered to be of minor importance and

is thus disregarded here. Our focus lies on assessing the effects of health changes on LTC demand: including concurrent migration flows would act as a confounding factor. Further, data to estimate age, sex and LTC-type-specific migration rates for older people are not available.

Multi-state projections divide the population by age, sex and several functional states. We distinguish different LTC types using the states healthy (no LTC), LTC at home and LTC in an institution. Transitions (mobility between states) are possible from healthy to LTC at home (1st transition path) and to institutional LTC (2nd), and additionally from LTC at home to institutional LTC (3rd). Each state can lead to death (4th-6th).

While transitions from any care to no care or from institutional to home care are possible, they are very rare. *Ehing et al.* (2015) show that the yearly transition probabilities to either a lower care level or from institutional to home care are very low, and *Rothgang et al.* (2017) describe the absolute number of changes from institutional to home care per year as marginal compared to the overall institutional care demand. The possibility of decreasing care need is thus disregarded and all transitions are considered as irreversible.

Multi-state projections require all parameters of the cohort-component method for each functional state. Assumptions on the age- and sex-specific transitions into every other accessible state are required, too. The additional data we require for a multi-state approach consist of age-, sex- and state-specific parameters of mortality, and age- and sex-specific parameters for transitions between different LTC states. For all transitions in all scenarios, age- and sex-specific transition and mortality rates were estimated separately using parametric survival regressions with age and age-squared as covariates with an exponentially distributed baseline hazard (Stata procedures *streg* and *predict*) and calendar time as process time, with $h(t\backslash age) = e^{ß_0+ß_1*age+ß_2*age^2}$ used to estimate all required rates. For counterfactual scenarios, only data spells before the onset of the respective conditions are used: e.g. the dementia-free scenario only uses spells before the onset of dementia. Each model was run separately for both sexes.

The estimated transition rates are applied unchanged for the entire projection time span, while mortality rates are reduced by 1.5 percent each year to account for increasing life expectancy. For Germany, a reduction of this amount is congruent with the decrease in mortality observed for ages 75 and over in the past decade.

The 2014 starting population is based on the general population structure at the end of 2014 (census) and LTC statistics. It consists of males and females by age in all states (no care, care at home or care in institutions).

3.5 Health insurance routine data

All parameter estimates are based on longitudinal health insurance routine data. A random sample was drawn, of 250,000 individuals who were at least 50 years old in the first quarter of 2004 and were insured with Germany's largest public health insurance provider AOK ("Allgemeine Ortskrankenkasse"). Besides ICD-10 records of medical diagnoses, information on age, sex, LTC status and date of death are

included. Claims data is process-generated and used for the reimbursement of outpatient practitioners and inpatient clinics. The AOK covers about one third of the population aged 50 years and older, with this proportion increasing to as much as 50 percent among people of older ages. AOK data are not completely representative of the German population, as there are differences regarding socio-economic and health status compared to other public sickness funds, and especially to private health insurance schemes (which cover about 11 percent of the population). The literature indicates that on average, compared to other public or private health insurance providers, AOK members tend to be slightly older, have a lower socio-economic position and exhibit a somewhat higher prevalence of common conditions like hypertension, diabetes or cardiovascular diseases (*Neubauer et al.* 2017; *Hoffmann/Icks* 2012). The sample was drawn from all insured persons, including those in nursing homes, regardless of whether they were seeking treatment and includes data up to the end of 2010 with one data spell per quarter. After data cleaning, consistency checking, removal of interrupted observations (e.g. due to a change of insurance provider) and the implementation of a two-year validation period for incident dementia, there remained around 122,000 individuals aged 65 and older at the first quarter of 2006.

3.6 Scenarios

Table 1 gives an overview of the properties for all scenarios. Each scenario covers the period from 2014 to 2044. Three counterfactual scenarios (2A-4A) are used to assess plasticity of LTC demand when removing specific risk factors: without dementia (2A), without LEI (3A) and the absence of both (4A). The status quo scenario 1A is the baseline for comparison. It shares the mortality decline with all counterfactual scenarios without removing any LTC risks. Two additional status quo scenarios with alternative mortality assumptions are used to compare the impact of removing risk factors with the effect of different rates of mortality decline (1B, 1C). Results are shown for the population in the relevant age group for LTC (75 years and older). All scenarios were calculated using the PDE Population Module tool (*International Institute for Applied Systems Analysis (IIASA)* 1997). The PDE project files, which include all necessary transition rates for all scenarios and variants presented here, as well as the base year population, are available as an online data appendix.

3.7 Use of counterfactual scenarios

In order to assess the impact on LTC plasticity of potentially modifiable risk factors, we use counterfactual projections that eliminate the respective risk factors. All differences between a counterfactual scenario and the baseline are caused by the elimination of the specific risk factor. The counterfactual scenarios do not strive to be realistic but are instead tools used to assess different options. They show the maximum degree to which the increase in LTC demand can be mitigated.

Tab. 1: Overview of assumptions of all projection scenarios and variants

	A	B	C
1. Status Quo	Mortality rates -1.5 % each year Includes dementia & LEI cases	Mortality rates -1 %each year Includes dementia & LEI cases	Mortality rates -2 % each year Includes dementia & LEI cases
2. No Dementia	Mortality rates -1.5 % each year Excludes dementia cases		
3. No Lower Extremity Injuries	Mortality rates -1.5 % each year Excludes LEI cases		
4. No Dementia or Lower Extremity Injuries	Mortality rates -1.5 % each year Excludes dementia & LEI cases		

Source: Own design

3.8 Hypotheses

3.8.1 General considerations

Removing a LTC risk factor should mitigate future LTC demand. The amount of plasticity is likely to depend on the strength of the risk factor in question. The effect on total LTC demand of conditions that markedly increase the risk of LTC should be greater than that of weaker factors. Different risk factors can affect LTC risk differently depending on age, sex or care setting. As a result, LTC plasticity can be observed in terms of total or sex-specific demand, age structure of LTC recipients and setting. LTC risks are also mortality risks. Their removal also increases life expectancy without and with LTC need due to other causes. The removal of a specific LTC risk can thus counterintuitively increase LTC demand due to other causes. Removing an LTC risk can lead to greater relative increases in older-age LTC demand compared to the baseline scenario. As the mortality decrease of 1.5 percent per year is the same for all counterfactual scenarios, an increase in older-age LTC demand is expected as a global effect for all main scenarios (1A-4A).

3.8.2 Dementia (2A)

(1) Total demand
Dementia is a risk factor for LTC. Its removal should decrease total demand compared to the baseline. As dementia is a greater LTC risk than LEI, it should have a greater effect on total demand.
(2) Sectoral demand
Dementia is strongly linked to institutional LTC. Its removal should decrease institutional demand compared to the baseline.
(3) Older-age demand
Institutional older-age LTC demand is expected to decrease due to the strong link between dementia and institutional LTC. Total older-age demand should increase compared to the baseline, because dementia's removal should decrease mortality and cause later entry and longer life in LTC.

3.8.3 LEI (3A)

(1) Total demand
LEI are a risk factor for LTC. Their removal should decrease total demand compared to the baseline, but not as much as dementia, since LEI are the risk factor which has less of an impact. Since LEI are more frequently found among women, their removal is likely to affect overall LTC demand among females in particular.
(2) Sectoral demand
LEI are less of a risk for institutional LTC than dementia; accordingly a minor decrease in institutional demand is expected.
(3) Older-age demand
A shift from older-age institutional demand to LTC demand at home is expected, although to a lesser extent than without dementia. Total older-age demand should increase compared to the baseline as removing LEI ought to decrease mortality, delay entry into LTC and enable longer life in LTC.

3.8.4 Dementia & LEI (4A)

(1) Total demand
When present concurrently, dementia and LEI act synergistically and increase LTC risk to a disproportionate degree. In the absence of both factors, total demand should be markedly lower than in the baseline and also lower than in both individual scenarios combined.
(2) Sectoral demand
Due to the removal of dementia, a marked shift towards LTC at home is expected.
(3) Older-age demand
A strong shift to older-age LTC at home is expected. Total demand should increase more than in any other scenario due to lower mortality, and is ex-

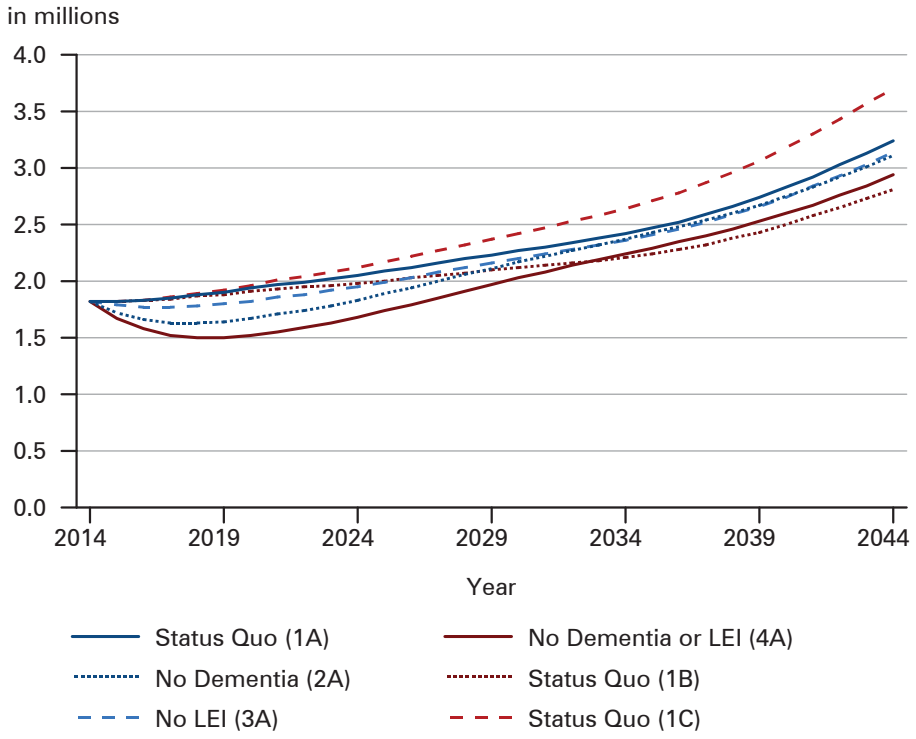
pected to be even higher than in both individual counterfactual scenarios combined.

4 Results

4.1 Total long-term care demand

The plasticity of LTC demand that is attainable when removing dementia, LEI or both can be shown from different perspectives. Figure 2 shows the total demand over time, by scenario. Figure 3 subdivides the total demand by LTC type. Table 2 shows the endpoints of all scenarios in total, by care type as well for the younger (75-84) and older (85+) age group and by sex. Figure 4 shows the sex-specific population age structure by LTC type at the endpoint of each scenario.

Fig. 2: Total number of LTC recipients in millions over time, all scenarios



Source: Own calculations

The benchmark for all counterfactual scenarios is the main status quo scenario (1A). In this scenario, LTC demand increases by 78 percent in total, from 1.82 to about 3.24 million people, between 2014 and 2044 (Fig. 2, Table 2) with LTC demand

among males more than doubling and female demand growing by 64 percent. Like the status quo scenario (1A), all counterfactual scenarios also show increasing demand over time, indicating that no counterfactual scenario can mitigate the increase caused by population ageing. Beyond this demographically-driven increase, mitigating plasticity is visible.

Figures A1-A4 (appendix) show the respective base year transition probabilities for scenarios 1A-4A. Figure A1 indicates that without LTC need, the transition to LTC typically starts with home care, the probability of which doubles roughly every six years. The probability that recipients of LTC at home will transition into institutional LTC also increases with age, although not as rapidly as seen for the transition into LTC at home for persons without LTC dependency. Direct transition from no LTC dependency to institutional LTC dependency is far less common. The removal of LTC risk factors decreases the probability of transitioning into LTC, and also from LTC at home to institutional LTC. Removing individual LTC risk factors in the counterfactual scenarios (2A-3A) therefore slightly mitigates the increase in overall long-term care demand compared to the baseline scenario. The lower the probability of transition into LTC, the greater the mitigating effect on total LTC demand will be at each endpoint.

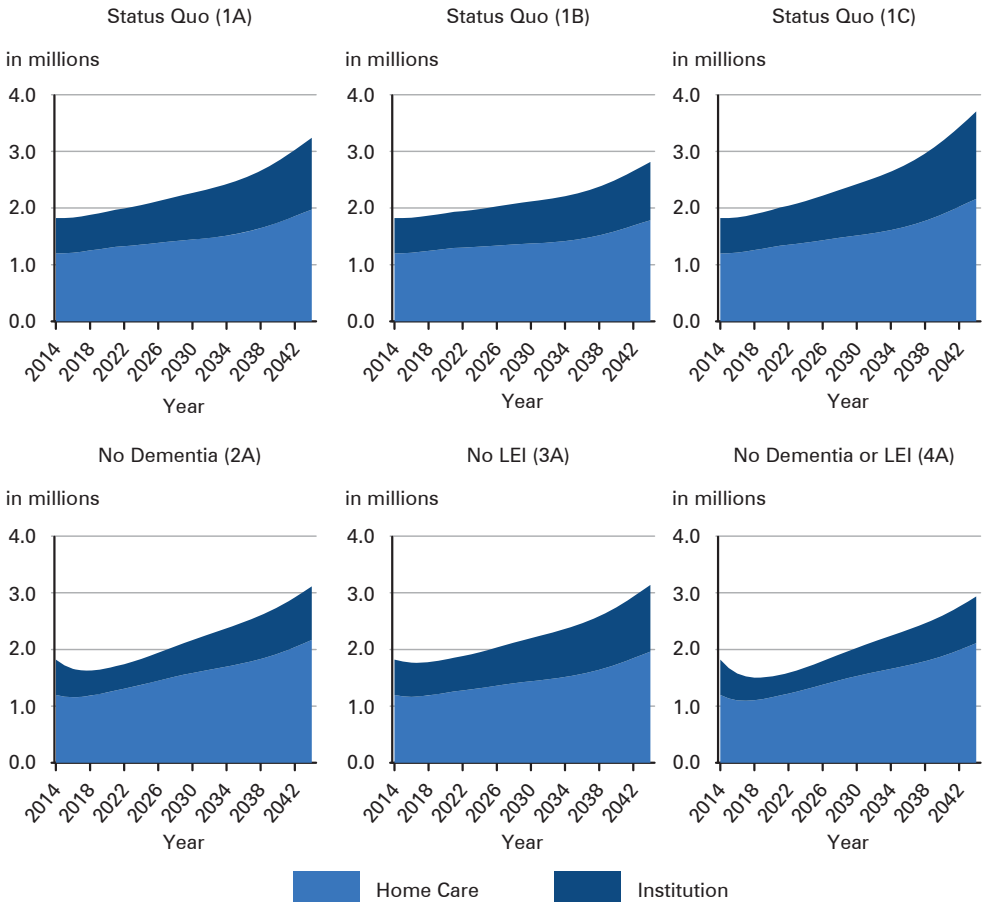
Changes in the transition probabilities to LTC are smallest in the LEI-free scenario (3A), where they are more apparent for females than males (Fig. A3). Mitigation of LTC demand in this counterfactual scenario, which results in a 72 percent increase in total LTC demand compared to 78 percent in the baseline scenario, is primarily attributable to female LTC demand (Table 2). The dementia-free scenario (2A) shows a more considerable decrease in LTC transition probabilities from no care to home care, and especially from home care to institutional LTC (Fig. A2) and results in a slightly more marked mitigation of future overall LTC demand, with an increase of 71 percent. The dementia and LEI-free scenario (4A) shows the biggest reduction in the transition probabilities into LTC (Fig. A4) and thus results in a marked mitigation of the increase in total LTC demand to 61 percent, compared to 78 percent in the baseline. These findings support hypotheses 2A-1, 3A-1 and 4A-1 concerning the impact on total LTC demand. The more pronounced increase in male than female LTC demand is consistent in all scenarios. The alternative status quo scenarios, which assume faster (1C, 103 percent increase in total LTC demand) and slower (1B, 54 percent) mortality decreases without eliminating a specific LTC risk factor, indicate that the future mortality trend is a more important factor than individual LTC risks, because its effect on future LTC demand is greater.

4.2 Sectoral long-term care demand

Figure 3 shows LTC demand by type over time. It illustrates that the major differences between the counterfactual scenarios are found in their effects on LTC setting.

The dementia-free (2A) and the dementia- and LEI-free counterfactual scenarios (4A) indicate that removing dementia affects LTC type, because these scenarios markedly decrease the transition probabilities to institutional LTC and thus show a shift towards LTC at home compared to the baseline scenario 1A (Fig. 3, A2, A4).

Fig. 3: Total number of long-term care recipients (millions) by care type over time, all scenarios



Source: Own calculations

Compared to a 103 percent increase in institutional LTC within 30 years, which equates to about 1.3 million people, the dementia-free scenario (2A) reduces by half the increase in institutional demand, to 51 percent, and the dementia- and LEI-free variant (4A) lowers the increase to 32 percent (Table 2). At the status quo endpoint, 39 percent of LTC recipients are institutionalised, while the dementia- and LEI-free scenario (4A) and the dementia-free scenario (2A) show that 28 percent and 30 percent respectively of LTC is provided in institutions. In turn, home care is more frequent than in the baseline. Without dementia, LTC at home increases by 81 percent (2A), and without dementia and LEI (4A) by 76 percent, while the baseline indicates a 65 percent increase. Removing dementia markedly shifts demand from LTC at institutions to LTC at home, coupled with a small decrease in total LTC demand growth. This supports hypotheses 2A-2 and 4A-2. The LEI-free scenario (3A) does not show

such a marked shift to LTC at home, because the growth in institutional demand which it projects (88 percent) is only 15 points less than the 103 percent increase in the baseline, which tends to support hypothesis 3A-2. The LEI-free scenario (3A) is an exception, as it primarily mitigates the increase in female LTC demand in both care settings; the other effects on care setting are largely identical for both sexes. Of the two conditions considered, a marked mitigation of total and institutional LTC demand is only achievable by targeting dementia.

4.3 Older-old and younger-old long-term care demand

Table 2 shows all scenario endpoints separately for younger (75-84 years) and older (85 years and older) LTC recipients. The relative increase in older-age demand compared to the baseline scenario (1A) is generally greater than for the younger group. The reasons are the same in all scenarios: large cohorts reach this age group and mortality risk progressively decreases in all scenarios. For instance, the baseline scenario (1A) shows an increase in total LTC demand of 69 percent for the younger and 86 percent for the older group. The plasticity when removing risk factors primarily lies in shifting the majority of the increase in demand to the older age group. For instance, removing dementia (2A) shows an increase in younger total LTC demand of 27 percent, and of 111 percent for the older age group. Larger relative increases of this kind in counterfactual scenarios are accompanied by a greater LTC demand in absolute terms for the older age group. For instance, the absolute difference in total demand between the endpoints of the baseline (1A) and the dementia-free scenario (2A) for the 85 and older age group is close to 250,000 individuals. Thus, for both genders and overall, more people reach the highest ages in the counterfactual scenarios due to the removal of conditions that also act as mortality risks. The share of institutional LTC recipients among those larger older cohorts is smaller than in the baseline due to the removal of LTC risk factors.

The differences between the development of younger and older-age LTC demand are also apparent for the different LTC settings. Compared to the status quo (1A), where older-age institutional demand increases by 119 percent and demand for LTC at home by 64 percent, the older-age demand in the counterfactual scenarios resembles the setting-specific effects seen for overall demand: the removal of LTC risk factors mitigates the increase in institutional demand compared to the baseline scenario (1A) at the cost of more recipients of home care, due to both mitigation and postponement of the increase in LTC transition probability (Fig. A1-A4). Removing dementia (2A) mitigates the increase in institutional demand to 94 percent, while demand for LTC at home increases to 122 percent, double the increase seen in the status quo scenario. The dementia and LEI-free scenario (4A) shows even stronger plasticity: it extenuates the increase in institutional demand even more (70 percent), but shows the largest increase in home care demand of any particular scenario (129 percent). The LEI-free scenario (2A) shows the smallest degree of plasticity, which supports hypotheses 2A-4, 3A-4 and 4A-4. These outcomes occur in largely similar fashion among both genders, except for the LEI-free scenario (3A), where no

Tab. 2: Overview of scenario results by sex, care type, age group and in total

	Male					
	Home Care	%	Institutional	%	All Care	%
All Results (75+)						
2014	379,061		135,684		514,745	
Status Quo (1A)	764,203	102	332,710	145	1,096,913	113
No Dementia (2A)	809,016	113	239,982	77	1,048,998	104
No LEI (3A)	754,897	99	335,201	147	1,090,098	112
No Dem. or LEI (4A)	775,677	105	237,137	75	1,012,814	97
Status Quo (1B)	668,933	76	256,566	89	925,499	80
Status Quo (1C)	862,926	128	423,509	212	1,286,435	150
75-84						
2014	236,473		73,116		309,589	
Status Quo (1A)	434,471	84	146,819	101	581,290	88
No Dementia (2A)	364,164	54	64,868	-11	429,032	39
No LEI (3A)	410,410	74	131,733	80	542,143	75
No Dem. or LEI (4A)	328,809	39	56,366	-23	385,175	24
Status Quo (1B)	387,602	64	118,075	61	505,677	63
Status Quo (1C)	481,827	104	179,195	145	661,022	114
85+						
2014	142,588		62,568		205,156	
Status Quo (1A)	329,732	131	185,891	197	515,623	151
No Dementia (2A)	444,852	212	175,114	180	619,966	202
No LEI (3A)	344,487	142	203,468	225	547,955	167
No Dem. or LEI (4A)	446,868	213	180,771	189	627,639	206
Status Quo (1B)	281,331	97	138,491	121	419,822	105
Status Quo (1C)	381,099	167	244,314	290	625,413	205

mitigation, but instead an even greater increase in older-age male institutional LTC demand occurs.

Consequently, the most substantial effect is that in the case of the younger group, both LTC types see a mitigated increase in demand in all counterfactual scenarios compared to the baseline, whereas for the older group, decreases in institutional demand growth come at the cost of increased demand at home. This indicates that removing LTC risk factors delays entry into any type of LTC and also delays transitioning from home to institutional LTC. The results for older-age LTC demand show that the total demand cannot be mitigated, because decreases in institutional demand always come at the cost of more recipients of LTC at home. However, the sector where higher increases in LTC demand occur can be influenced by targeting specific risk factors, as the dementia-free (2A) and, in particular, the dementia- and LEI free (4A) scenarios demonstrate.

Tab. 2: Continuation

	Female					
	Home Care	%	Institutional	%	All Care	%
All Results (75+)						
2014	818,263		489,398		1,307,661	
Status Quo (1A)	1,208,259	48	934,980	91	2,143,239	64
No Dementia (2A)	1,359,754	66	705,818	44	2,065,572	58
No LEI (3A)	1,206,675	47	842,629	72	2,049,304	57
No Dem. or LEI (4A)	1,336,821	63	587,928	20	1,924,749	47
Status Quo (1B)	1,114,848	36	771,747	58	1,886,595	44
Status Quo (1C)	1,299,872	59	1,117,975	128	2,417,847	85
75-84						
2014	386,858		167,286		554,144	
Status Quo (1A)	597,527	54	279,258	67	876,785	58
No Dementia (2A)	530,333	37	134,828	-19	665,161	20
No LEI (3A)	544,103	41	230,525	38	774,628	40
No Dem. or LEI (4A)	472,033	22	113,215	-32	585,248	6
Status Quo (1B)	561,031	45	242,396	45	803,427	45
Status Quo (1C)	632,364	63	317,628	90	949,992	71
85+						
2014	431,405		322,112		753,517	
Status Quo (1A)	610,732	42	655,722	104	1,266,454	68
No Dementia (2A)	829,421	92	570,990	77	1,400,411	86
No LEI (3A)	662,572	54	612,104	90	1,274,676	69
No Dem. or LEI (4A)	864,788	100	474,713	47	1,339,501	78
Status Quo (1B)	553,817	28	529,351	64	1,083,168	44
Status Quo (1C)	667,508	55	800,347	148	1,467,855	95

5 Discussion

5.1 Summary

The ageing of large baby boomer cohorts will increase the demand for LTC services in the coming decades (*Nowossadeck et al.* 2016; *Doblhammer* 2012). To ensure that the LTC system will be able to respond to this challenge (*Bundesministerium für Gesundheit* 2015; *Fujisawai/Colombo* 2009), policy-makers require tools to assess the efficacy of interventions aimed at mitigating the increase in LTC demand. Counterfactual projections that eliminate specific health-related risk factors can be used to assess the maximum degree of plasticity attainable with specific conditions. This study investigates the efficacy of dementia and LEI in mitigating the increase in LTC demand, thus using one physical and one cognitive health-related determinant of

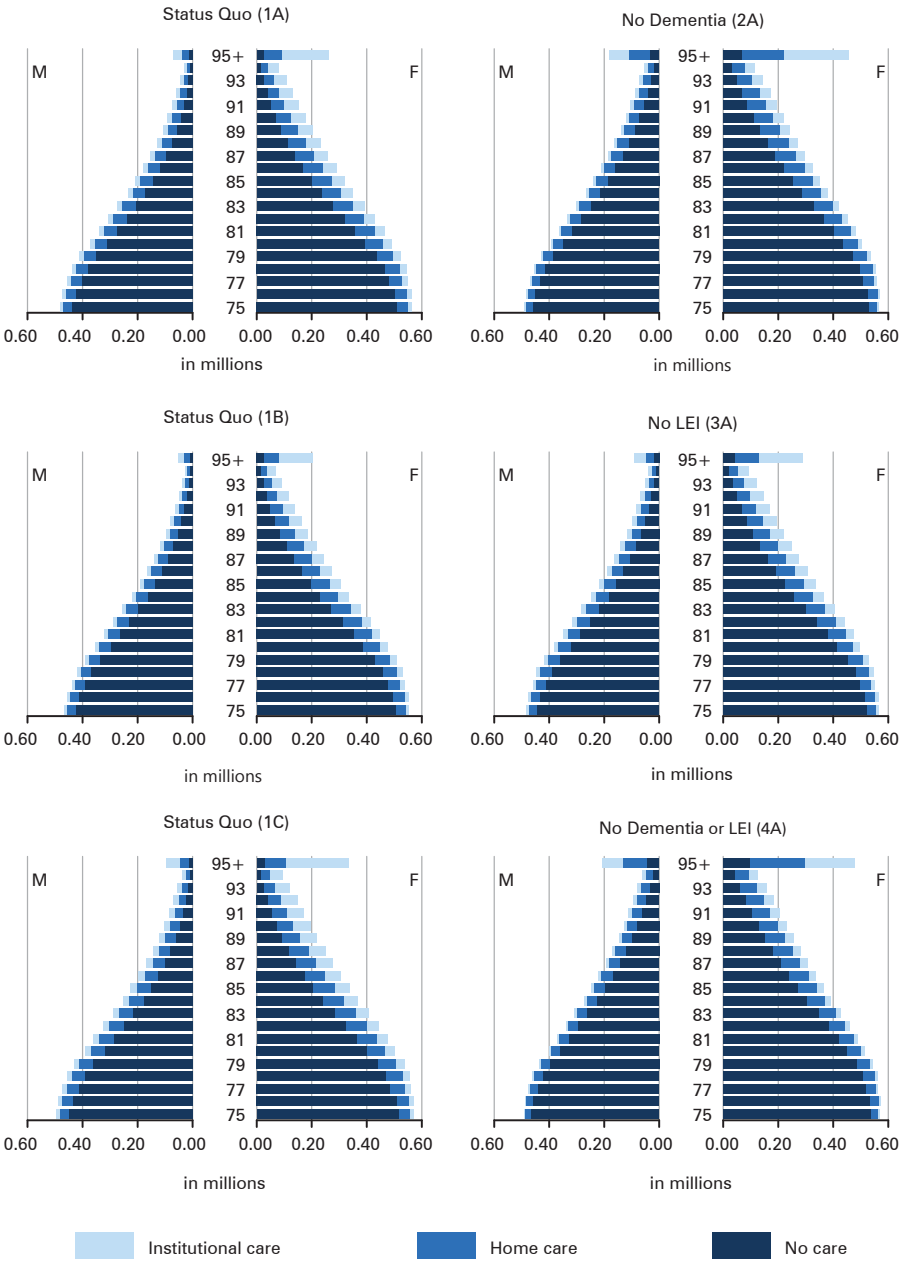
Tab. 2: Continuation

	Home Care	%	Total Institutional	%	All Care	%
All Results (75+)						
2014	1,197,324		625,082		1,822,406	
Status Quo (1A)	1,972,462	65	1,267,690	103	3,240,152	78
No Dementia (2A)	2,168,770	81	945,800	51	3,114,570	71
No LEI (3A)	1,961,572	64	1,177,830	88	3,139,402	72
No Dem. or LEI (4A)	2,112,498	76	825,065	32	2,937,563	61
Status Quo (1B)	1,783,781	49	1,028,313	65	2,812,094	54
Status Quo (1C)	2,162,798	81	1,541,484	147	3,704,282	103
75-84						
2014	623,331		240,402		863,733	
Status Quo (1A)	1,031,998	66	426,077	77	1,458,075	69
No Dementia (2A)	894,497	44	199,696	-17	1,094,193	27
No LEI (3A)	954,513	53	362,258	51	1,316,771	52
No Dem. or LEI (4A)	800,842	28	169,581	-29	970,423	12
Status Quo (1B)	948,633	52	360,471	50	1,309,104	52
Status Quo (1C)	1,114,191	79	496,823	107	1,611,014	87
85+						
2014	573,993		384,680		958,673	
Status Quo (1A)	940,464	64	841,613	119	1,782,077	86
No Dementia (2A)	1,274,273	122	746,104	94	2,020,377	111
No LEI (3A)	1,007,059	75	815,572	112	1,822,631	90
No Dem. or LEI (4A)	1,311,656	129	655,484	70	1,967,140	105
Status Quo (1B)	835,148	45	667,842	74	1,502,990	57
Status Quo (1C)	1,048,607	83	1,044,661	172	2,093,268	118

Source: Own calculations

LTC as two examples which are responsible for significant shares of life years lived in disability in Western Europe and worldwide, and whose importance will only increase further as population ageing continues (*Vos et al.* 2012). We analyse their effects on both total and sectoral LTC demand at home and in nursing homes. The results indicate the varying efficacy of dementia and LEI in mitigating the increase in total, sector-specific and age group-specific LTC demand, and show that their outcomes are broadly similar for both genders. Only in the LEI-free scenario (3A) do some results differ by sex, with the increase in female LTC demand mitigated primarily. This indicates that, in line with the literature, LEI affect older women much more frequently than they affect older men (*Stevens/Sogolow* 2005; *Ismail et al.* 2002).

Fig. 4: Population aged 75 and older by care type at end points, by scenario



Source: Own calculations

Dementia is a more influential risk factor than LEI, both in terms of its impact on total as well as on sectoral and age group-specific LTC demand. In the status quo scenario that is used as the baseline, the relative increase in institutional LTC demand is nearly double the increase in LTC demand at home. The removal of dementia shifts the majority of the increase in LTC from institutions to LTC at home, and also results in a modest mitigation of the increase in total LTC demand. Additionally, the removal of dementia causes a later onset of and a longer life with LTC dependency. Both circumstances contribute to most of the increase in LTC demand shifting from the 75-84 to the 85 and older age group.

Less institutional LTC dependency in the younger age group comes at the cost of higher demand for LTC at home for the 85 and older group. Mitigating the increase in total LTC demand by removing a specific risk factor does not therefore necessarily translate into a mitigation for all age groups or for all sectors, but can be a composite effect of trends differing by both age group and LTC type.

The efficacy of LEI in mitigating the increase in total LTC demand is smaller than the effect seen when removing dementia, and its impact on sectoral LTC demand is different. The removal of LEI mitigates the increase in institutional LTC demand in comparison with the baseline, yet the figure is higher than if dementia is removed. The increase in demand for LTC at home is not significantly affected. As a result, the efficacy of LEI lies almost completely in mitigating the increase in institutional LTC demand, albeit to a lesser degree than dementia. Eliminating LEI also results in a larger increase in LTC demand for the 85 and older age group while the mitigation of the increase in LTC demand for the 75-84-yearold age group is modest. This is the same general pattern as seen for dementia, although to a lesser degree.

The largest impact on the plasticity of LTC demand is seen as a consequence of the concurrent removal of both dementia and LEI. This scenario not only retains the core characteristics of both individual counterfactual scenarios, but also shows that both conditions are linked synergistically (*Barth et al.* 2016). When both are removed at the same time, the mitigation of the increase in LTC is even more pronounced than could be expected by combining both individual scenarios, both in terms of plasticity of total LTC demand, and regarding the shift in LTC setting from institutions to the home.

5.2 Strengths and weaknesses

The main strength of this study is that all input parameters are estimated using the same reliable and large-scale longitudinal empirical data that include medical diagnoses, sex, age and type of LTC. It is unaffected by typical survey biases like unit-nonresponse or recall uncertainty, which would have been particularly problematic for dementia patients. The data covers the whole population, including those in nursing homes. It should be reiterated that AOK data cannot be entirely representative of the German population, as those insured with AOK tend to be in slightly worse health and occupy lower socio-economic positions than members of other public or private health insurance schemes (*Neubauer et al.* 2017; *Hoffmann/Icks* 2012). Basing our estimates on a group that is in a somewhat less favourable posi-

tion might cause our findings to be slightly biased in two ways. First, in terms of overestimating the risk (or mitigating effect) that dementia and LEI (or their absence) exert on people's LTC need, e.g. because they might develop dementia at a younger age or to a more severe degree or be more likely to fall and sustain a severe injury than persons insured elsewhere, who might be healthier or have a more protective lifestyle in terms of compensatory cognitive reserves or dementia or fall risk factors. This could affect both the absolute size as well as the sectoral distribution of future LTC demand in the counterfactual scenarios. Second, persons in higher socio-economic positions might have greater financial reserves, which could mean that they are able to avoid or delay having to apply for LTC benefits, or institutionalization in cases where the care need is severe, and remain without formal LTC status or in home care longer. This would result in a slight reduction in the transition from no care to home care, or the marked sectoral shift from institutional to home care in dementia-free scenarios.

One weakness that affects our projections of LTC is its definition, which has changed since the data we used was collected. In the timeframe covered by our data, dementia played a special part in the assessment of official LTC dependence. Until 2008, persons with dementia who did not meet any of the ADL dependency requirements were not formally eligible for LTC insurance benefits. In 2008, LTC dependence level 0 was introduced to include dementia as a criterion for LTC dependency, but this is not available in our data. Thus, not everybody with dementia as the sole impairment may have been registered as being LTC dependent. However, the likelihood of receiving LTC benefits as a dementia patient is high, especially for older patients (*Barth et al.* 2016; *Doblhammer et al.* 2012; *Fink/Doblhammer* 2015; *Rothgang et al.* 2012b). Since 2015, after the observation period of the data used here, dementia became a criterion for LTC dependency, which means that more people with dementia as their sole limitation are eligible for LTC benefits (*Straub* 2018). Under these terms, the efficacy of dementia in mitigating the increase in future LTC demand might therefore be even higher than our results indicate. The assumptions of future developments of mortality are central to the results. This is the same for any projection, and we showed different scenarios to account for this.

5.3 Future research questions

This paper explores the impact of two conditions on the plasticity of total, sectoral and age-specific LTC demand and finds distinct effects and differences. Dementia and LEI are important cognitive and physical health risk factors, but are only examples. Further research should investigate the effects of more diseases that are common in older age. The distinction of different LTC settings and the differentiation of younger and older-age LTC demand should be upheld, because, as the results for dementia indicated, significant differences might occur. In this case, they were caused by a decreased risk of transitioning from home to institutional LTC. Further research could thus not only consider the risk of requiring any kind of LTC, but also focus on factors for the increase in care need, i.e. the transition from LTC at home to institutional LTC or to a higher care level. Going beyond health-related risk factors

for LTC, other potentially modifiable determinants of LTC demand, e.g. individual living conditions, individual lifestyle factors or social interactions, could be incorporated.

Household composition is an important aspect of living conditions that should be taken into account. It is not only important for the possibility of receiving care from the partner. Living alone in older age is also a risk factor for LTC need. Compared to households with more than one resident, people living alone in older age are often in poor health, have problems performing ADL tasks, have lower levels of physical activity, are at greater risk of being isolated and suffer falls more often – all of which are risk factors for care need and for determinants of care need, like dementia (*Kharicha et al*. 2007). It is plausible that for a comparatively milder LTC risk factor, a dependent person living alone has a higher institutionalization risk than one living with a partner. Consequently, the inclusion of household composition in models used to estimate LTC transition risks would be desirable. However, we were unable to consider it in this paper because information on household structure is not included in health insurance routine data.

Each country's care regime and their definitions of care need are unique. How diseases or impairments translate into LTC entitlement, how access to LTC is regulated, whether LTC support is means-tested, which level of government organises LTC provision, whether care is provided on a public or private basis or a mixture of the two, how LTC demand is related to specific care settings and what level of quality is aimed for all depend on the LTC regime (*Riedel/Kraus* 2011). Future research could also assess whether our findings are unique to the German LTC regime between 2004 and 2010, or if and to what degree they can be generalised.

5.4 Conclusion

The total demand for LTC services will continue to increase across developed countries over the coming decades (*Fujisawai/Colombo* 2009; *Comas-Herrera et al.* 2006). We show that the amount of the increase in total and sector-specific LTC demand can be mitigated by targeting potentially modifiable risk factors. In particular, the removal of dementia and, to a lesser degree, the removal of LEI, significantly mitigate the increase in institutional LTC dependency at the cost of additional increases in LTC at home. Because nursing homes are both cost-intensive and labour-intensive, identifying effective intervention strategies is important for policy-makers striving to decrease LTC costs and provide sufficient care services when faced with a potential shortage in professional LTC staff (*Fujisawai/Colombo* 2009; *Geerts et al.* 2012). According to the German Federal Ministry of Health, up to 214,000 jobs for care professionals will be vacant in 2025 due to insufficient labour supply (*Bundesministerium für Gesundheit* 2015), while another projection indicates half a million vacant full-time jobs by 2030 (*Vereinigung der Bayerischen Wirtschaft* 2012). Due to smaller cohort sizes in recent decades, the total number of people of working age is decreasing and will continue to do so well into the 2030s (*Bundesministerium für Arbeit und Soziales* 2013). Policy-makers have already taken action to make the care sector more competitive, for instance by campaigning for higher wages or

underlining high job security (*Bundesministerium für Gesundheit* 2015; *Fujisawai/Colombo* 2009).

Even if the increase in institutional LTC demand were able to be mitigated by targeting risk factors like dementia, this would come at the cost of a marked increase in demand for LTC at home. Although this does not necessarily require care professionals, it depends on the availability of informal caregivers, primarily partners and children (*Dukhovnov/Zagheni* 2015). Relatively speaking, more older people will live with a partner in the future (*Pötzsch* 2011), so the availability of partner-based informal LTC potential is not the most serious problem for care needs that are classed as being non-severe. Children make up the other major group of informal caregivers. As far as the availability of informal care potential is concerned, increasing childlessness in particular might be a problem once cohorts that have seen a decline in fertility reach ages where LTC becomes prevalent by the end of the 2030s (*Statistisches Bundesamt* 2015a). Projections of informal care potential by adult children indicate a decrease of more than 30 percent between 2009 and 2040, and up to 40 percent by 2060 (*Dudel* 2015). This is not only a result of fewer children, but also of increasing labour-market participation, especially by middle-aged women (*Schulz* 2010), which reduces their availability as caregivers (*Bundesministerium für Arbeit und Soziales* 2013). This decline in informal care potential is estimated to be equal to 125,000 full-time care professionals in 2030 (*Vereinigung der Bayerischen Wirtschaft* 2012). Additionally, greater distances between where a dependent person and supporting child live might make the provision of informal care more difficult (*Nowossadeck et al.* 2016). As a result, professional LTC will be required above all by persons with LTC dependency who are single and childless, or whose children do not live close by. These factors should be taken into account when planning LTC services from a regional perspective. More flexibility in mixed work-care scenarios might help in enabling more children of working age to provide care to their parents. This also requires financial losses incurred as a result of fewer working hours to be partially compensated by transfer payments. Since most informal care is still provided by females (*Dukhovnov/Zagheni* 2015), efforts to promote more male provision of informal care could also help to recruit more informal carers.

Aside from trying to tap into all available informal care resources and increasing the attractiveness of the care sector, other areas could be explored. For instance, innovations in housing and technology could help LTC dependent persons to live at home longer (*Barth/Doblhammer* 2016; *Fujisawai/Colombo* 2009). New forms of living arrangements, such as shared apartments, could enable LTC recipients to assist each other as far as possible and split the use of informal or professional assistance between the remaining tasks. For home owners, re-mortgaging to finance LTC support is becoming more popular.

However, the most promising approach is the prevention or delay of primary risk factors for LTC need. Identifying influential health-related LTC risk factors and assessing their effects on the plasticity of total, sectoral and age-specific LTC demand is thus useful for policy planning. In this study, dementia was identified as a determinant that has a particularly big impact, especially in terms of mitigating the increase in institutional LTC demand. The results of counterfactual scenarios

cannot be interpreted as realistically achievable goals because they assume the population-wide, instantaneous elimination of a specific disease. However, they illustrate the maximum attainable impact and targeting the risk factors that have the biggest impact is a reasonable strategy. A risk factor identified as significant in a counterfactual scenario should also have a notable, albeit smaller impact in real life, where intervention is only partially successful. In the context of our results, this indicates that dementia should be a primary target, because its impact was so pronounced that even partly successful interventions would mitigate the increase in LTC demand to a greater extent than a completely successful intervention against less severe risk factors like LEI. Lesser risk factors should not be dismissed outright as possible intervention targets, because synergistic effects between risk factors should be taken into account. The effect of concurrent LEI and dementia, which disproportionately increases LTC risk, is a reason to target the lesser risk factor LEI, if assessed individually. Without LEI, LTC dependency can be slightly reduced directly, but its removal can also be helpful in the event of a later onset of dementia as it then prevents the disproportionately greater LTC risk.

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Appendix

Fig. A1: Base year transition probabilities for status quo scenario 1A

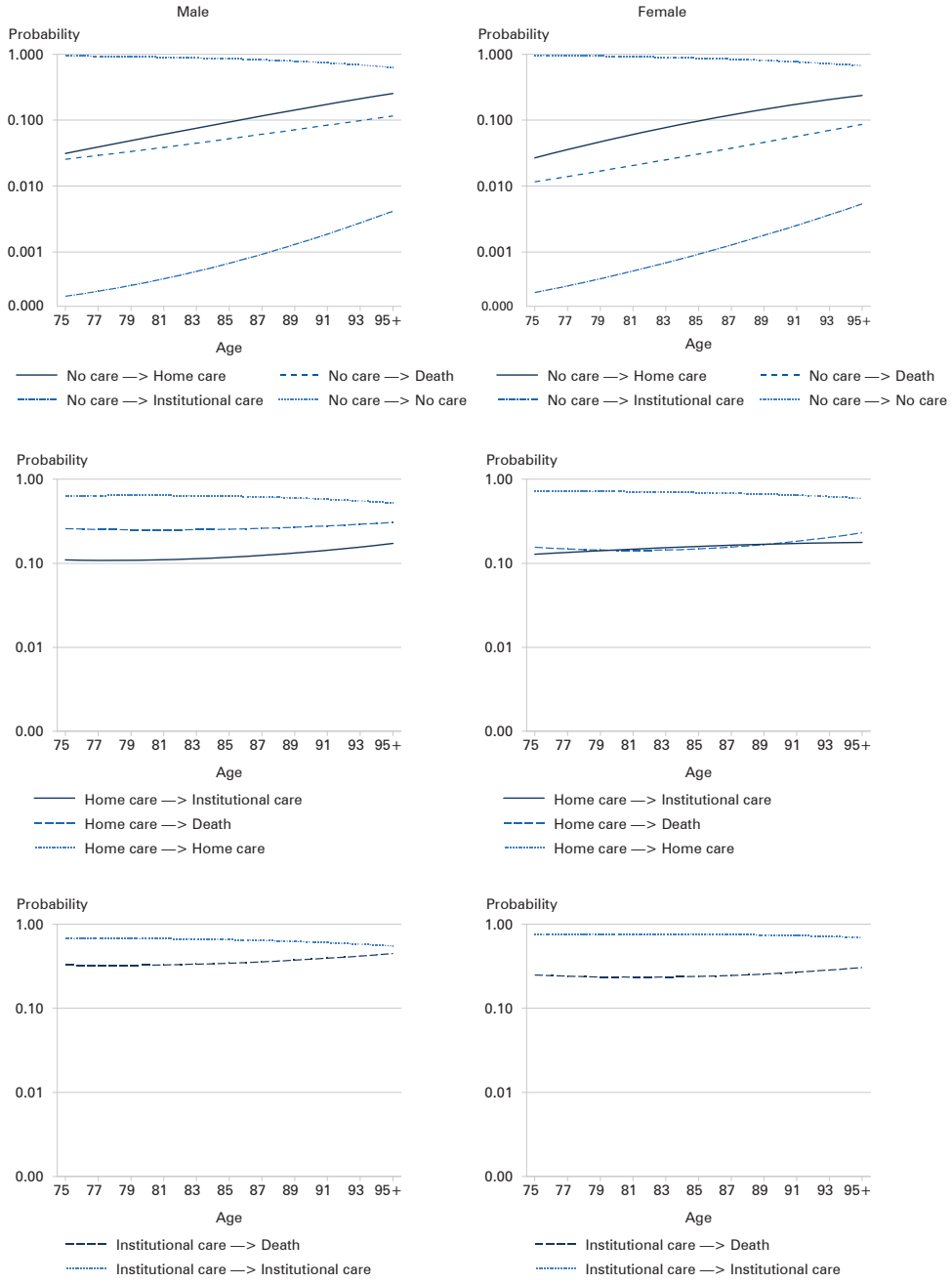


Fig. A2: Base year transition probabilities for dementia-free counterfactual scenario 2A

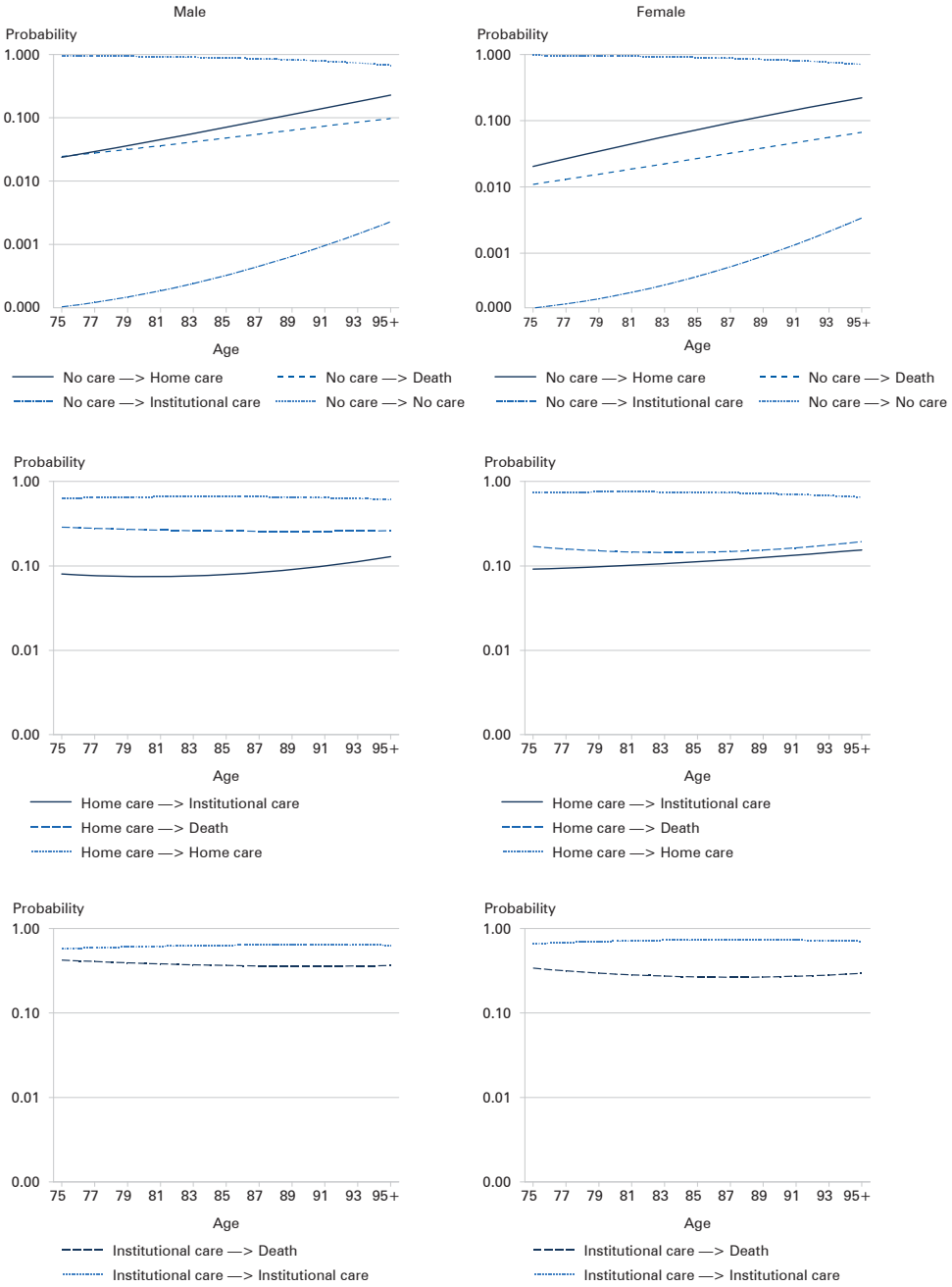


Fig. A3: Base year transition probabilities for lower extremity injury-free counterfactual scenario 3A

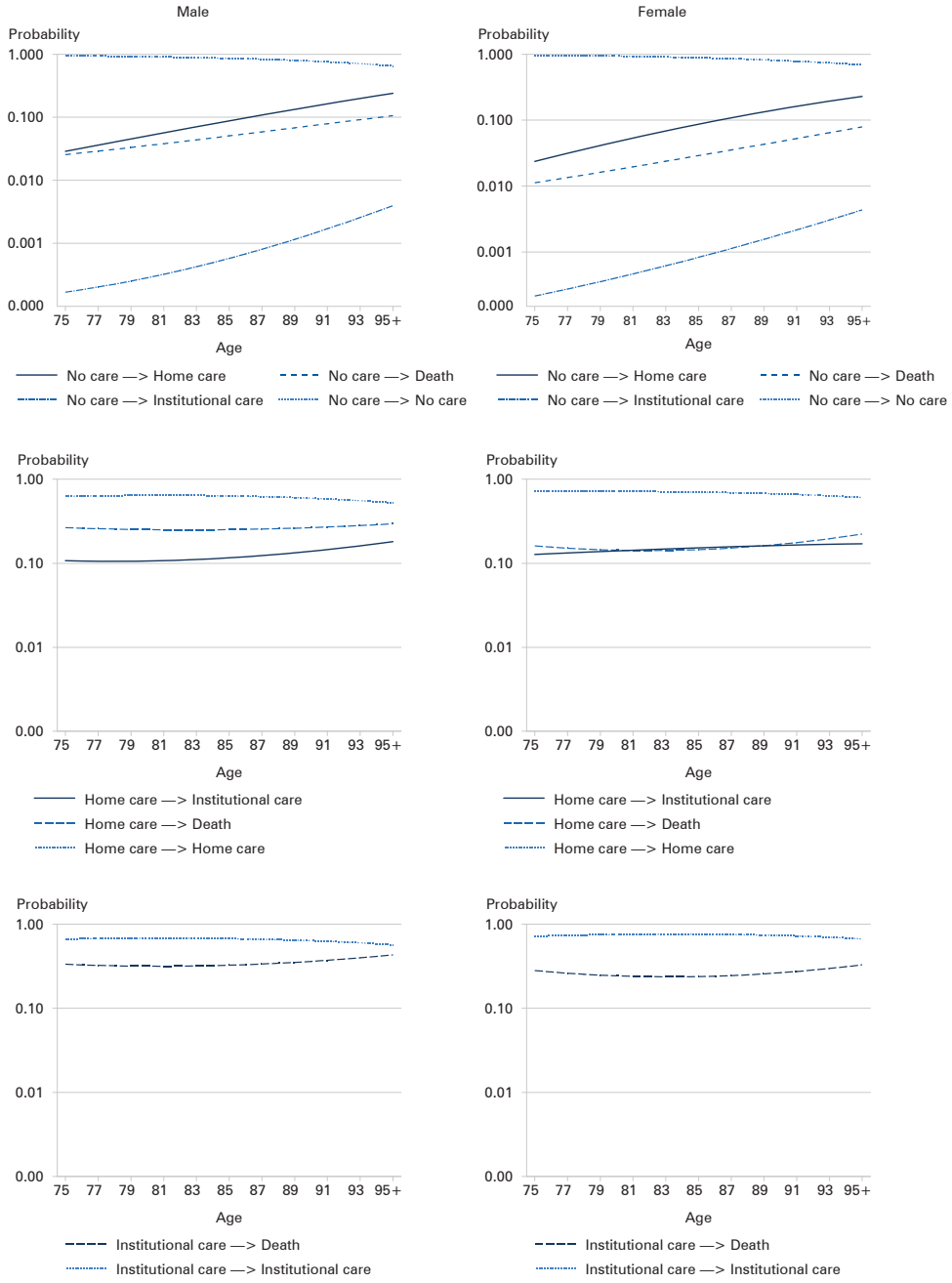
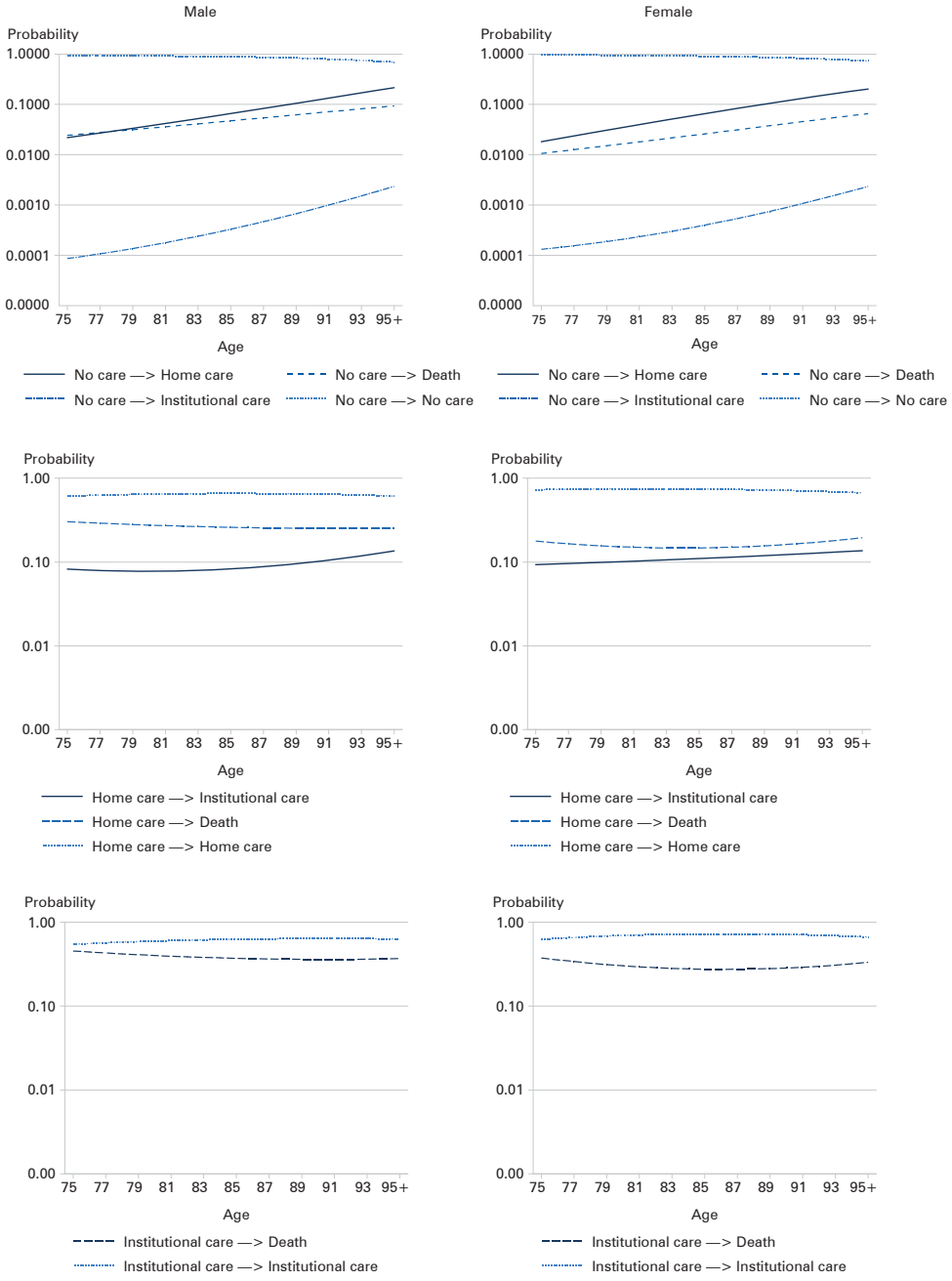


Fig. A4: Base year transition probabilities for dementia and lower-extremity injury-free counterfactual scenario 4A



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