The Present and Future Dementia Burden in China: Kinship-Based Projections and Global Comparisons

Abstract

China has the largest number of patients with dementia in the world, and the rate of growth is expected to escalate further as the population ages. The majority of dementia patients rely on their families for care and assistance. Using demographic models of kinship, we provide quantitative estimates of the burden of dementia, from 1990 up to 2050, by illustrating the number of kin accessible to dementia patients, the dementia prevalence among kinship networks, and the dependency ratio of kin with dementia to working-age kin without dementia. We then compare the estimates of dementia burden across 194 countries and territories, accounting for historical trends in, and future projections of, mortality, fertility, and dementia prevalence. Our findings suggest that, unlike other aging societies, China's aging crisis is exacerbated by the fact that, in addition to the alarming rise in the number of older adults in need of care, the number of potential family caregivers is also dropping at an unprecedented pace. The increase in dementia dependency ratio is expected to exceed the increases in most other countries across East Asia, Western Europe, and the United States. These findings have important implications for understanding the evolution of care networks for older adults in China over time and from a cross-country comparative perspective.

Introduction

Alzheimer's disease and related dementias (hereafter referred to as dementia) constitute an enormous challenge for patients, their caregivers and family members, and society as a whole. At a population level, numerous studies have documented the causes and consequences of dementia, its variation across time and place, and its growing impact on the economy and healthcare systems (Baumgart et al. 2015; Nichols et al. 2022; Pedroza et al. 2022). Dementia profoundly changes the lives of patients and those of their families and relatives (Schulz and Martire 2004). Those effects depend, among other things, on the structure of kinship networks: the numbers, age distributions, and social roles of the relatives of a person with dementia.

Following the framework developed by Freedman et al. (2024), we study how demographic transitions affect the dynamics of kinship structure and how structural changes in kinship networks influence dementia caregiving. Specifically, we estimate the dementia prevalence and the availability of potential caregivers for an *average* individual in the historical past and projecting them into the future. Our primary focus is on China, and we then contextualize the China case through a global comparison. China has the largest number of dementia patients in the world, and this number is expected to grow rapidly in the coming years due to the unprecedented pace of population aging. The number of those living with dementia has increased over fourfold in the past three decades, from 3.68 million in 1990 to 15.33 million in 2019, and this number is expected to triple to 45.54 million in 2050 (Nichols et al. 2022). While a significant amount of research has documented the increased rate of dementia cases and the associated economic costs at the national level (Chan et al. 2013; Jia et al. 2020; Nichols et al. 2019; Sohn 2023), the familial implications of dementia in kinship networks have yet to be fully explored.

Of particular importance is the number of potential family caregivers available to individuals with dementia, as well as the number and relations of one's family members who may potentially experience dementia throughout their lifetime. Thus, the burden of dementia (and many other diseases) in China, and in rapidly aging populations worldwide, is fundamentally a kinship problem. The kinship network determines the number of potential family caregivers, and how many families and relatives are affected by the occurrence of dementia among their kin. For example, an individual may, in young adulthood, have a grandmother with dementia, have a parent with dementia in middle age, and have a spouse or a sibling with dementia in their own older age. This age pattern may vary across population subgroups stratified by kin type, gender, race, socioeconomic status, and place of residence, and it will likely have significant consequences for social inequality (Alburez-Gutierrez et al. 2022; Chung and Hepburn 2018; Feng, Song, and Caswell 2024; Friedman, Freedman, and Patterson 2023; Jiang 1995; Song and Caswell 2022; Verdery and Margolis 2017; Zhou, Verdery, and Margolis 2019). While the availability of relatives is not the sole determinant of the provision of care (which also depends on the health care system, the costs and access to institutional care facilities, and the cultural norms of family responsibilities) all those factors must operate within the context of the kinship network. That network is crucial for both the care needs of older adults and the support of caregivers, as consistently emphasized in previous demographic analyses (Cheng et al. 2013; Cleary et al. 2022; Freedman et al. 2024; Reyes, Schoeni, and Freedman 2021).

The expected kinship network of a focal individual is an outcome of the mortality and fertility schedules to which the population is subject. The recent development of kinship models allows us to analyze these demographic trends and predict how kinship structures might evolve (Caswell 2019; Caswell and Song 2021). We use the time-varying version of this kinship model to project kinship structure based on observed and projected changes in mortality and fertility schedules from 1950 to 2050. China's rapidly changing demography makes this time-varying approach particularly useful (Wang 2011; Peng 2011).

By applying the age-specific dementia prevalence rates to the age distributions of various kin types, we calculate the burden of dementia care for individuals. This burden varies depending on a person's age, their kin's ages, and their relatedness to different kin types. In general, older cohorts will face a greater burden than younger ones. We introduce an index called the dementia dependency ratio (DDR), which calculates the ratio of the number of kin with dementia to the number of kin without dementia who are potential caregivers. The DDR is an individual property. To evaluate the burden of dementia at the population level, we average the age-specific DDR over the age distribution of the population. After computing results for China, we compare the index across a wide range of countries.

Our results show that China will experience among the fastest-growing dementia burdens in the world in the next three decades. In 2050, China's age-weighted DDR is projected to rise to approximately 18 times its 1990 level, marking one of the most rapid increases ever recorded, surpassed only by Singapore's expected climb of roughly 24 times. This trend is largely driven by rising numbers of dementia cases and shrinking kinship networks. Given China's immense population size and its relatively underdeveloped public health support system, the challenges faced by China will be substantially more formidable than those of many other countries. The results also underscore the need for future research to redirect its focus from merely the total count of dementia cases to a more comprehensive assessment of dementia burden from a demographic perspective. The kinship approach offers new insights into the economic and healthcare impacts of dementia in a rapidly aging context.

Background

Population Aging and Dementia in China

China's population is aging at an unprecedented rate. Its three-and-a-half decade long history of the One-Child Policy, along with its remarkable economic take-off following the 1978 economic reforms, has led to a sustained fertility decline and a rapid increase in life expectancy (Cai and Feng 2021; Chen and Liu 2009; Wang 2011). This ongoing demographic transition will eventually turn China's population pyramid upside-down. Even assuming, against the trend, a gradual and moderate recovery of fertility, the proportion of the population aged 65 years and above is expected to increase from 191 million in 2020 to 395 million in 2050, eventually accounting for 30.1% of the total population (United Nation 2022). This accelerated aging of the population will lead to substantial pressures on the fiscal capacity and the social welfare system in China. Cai, Wang, and Shen (2018) estimated that maintaining an average social welfare generosity at the 2014 level, public health spending will more than double and pension spending will more than triple from 2015 to 2050. Assuming that China manages to maintain its economy at the 2020 level, the spending on public health and pension alone would consume as much as 82.8% of the government revenue by 2050. The impact that the COVID-19 pandemic has had on China's birth rate and economy would only precipitate the tipping point of the potential fiscal crisis.

The increasing prevalence of dementia is one of the greatest challenges facing China's aging population. China has the largest population of dementia patients (Jia et al. 2020), with many of them undiagnosed (Lang et al. 2017), and this number is expected to climb as the population ages. In 2017, dementia became the fifth leading cause of death in China, following stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer (Zhou et al. 2019). There is no effective cure for dementia, and sufferers eventually require assistance as the disease progresses. The disease thus poses a heavy economic and healthcare burden on patients and their families. A 2015 survey of 81 representative hospitals, nursing homes, and care facilities across 30 provinces in China reported an average annual cost of dementia care per patient of $19,144.36, amounting to a national total of $167.74 billion annually (Jia et al. 2018). Indirect costs, such as financial loss sustained by patients themselves or their informal caregivers account for 51.9% of the total cost, while the direct medical costs (such as medication and hospitalization) and non-medical costs (such as costs of transportation and healthcare equipment) account for 32.5% and 15.6%, respectively.

As the demand for dementia care rises, the traditional family structures that have long supported care for older adults in China are also undergoing significant changes. Despite the long history of preference for large families and intergenerational co-residence in China, the average household size has shrunk from 4.41 in 1982 to 3.44 in 2000 and 2.62 in 2020 (China National Bureau of Statistics 2021). Moreover, with a total fertility rate of 1.3 in 2020, China now has one of the lowest fertility rates, similar to its East Asian neighbors (China National Bureau of Statistics 2021). The three-and-a-half-decade-long strict One-Child Policy and the changing fertility preferences have significantly altered the kinship network (Wang, Cai, and Gu 2013; Wang, Gu, and Cai 2016). Scholars have long warned that the One-Child Policy would significantly weaken family and kin structures in Chinese families, leading to the disappearance of many kin ties for the most affected generations (Bongaarts and Greenhalgh 1985). For example, an only child has no siblings, and the children of two only-child parents have no aunts or uncles. Additionally, a significant number of parents may be left without a surviving child in old age if their only child passes away prematurely.

These demographic shifts have profound implications for the future of caregiving in China. Microsimulation studies and formal demographic models have predicted an unavoidable decline in both family size and kin availability(Hammel et al. 1991; Jiang 1995; Verdery 2019; Yang 1992). Verdery (2019) shows that China has reached an era of peak family, in which the number of extended family members remains high but is projected to drop in the coming years. By the year 2050, two-fifths of the population under 50 will be only children. The kinless population, defined as those without spouses or children, will reach around 25 million (Verdery 2019). Moreover, massive rural-to-urban migration has split families, as many adult children have migrated to metropolitan regions for better opportunities, leaving their older parents behind in rural villages (Liang 2016; Lin and Tang 2023; Wang and Mason 2007). The percentage of individuals over 65 living alone is expected to increase to 14% in rural areas and 11% in urban areas in 2050 (Zeng et al. 2008). Overall, the number of dementia cases is expected to rise due to population aging, at the same time that the number of available family caregivers, particularly those who are not in old age themselves, decreases.

The Demography of Dementia Caregiving

Family plays a key role in caring for older adults worldwide, especially those with dementia (Jia et al. 2020; Livingston et al. 2017; Wang et al. 2019). According to a large-scale survey from China, about 84.9% of dementia patients were cared for by family members, 8.3% lived alone, 4.9% received care from hired nannies, and only 2% were receiving formal care in nursing homes or hospitals(Jia et al. 2016). Several factors contribute to the low utilization of formal care in China. First, formal care provided by nursing homes or hospitals is often not covered by medical insurance, making it financially inaccessible for many families (Wang, Cheung, and Leung 2019). Second, dementia care services are often inadequate and fragmented. While home care in developed urban areas is supplemented by community-based services, such support is scarce in rural and underdeveloped regions, further restricting access to formal care (Quail et al. 2020). Furthermore, cultural norms rooted in filial piety also discourage families from using nursing homes, as it is seen as a departure from traditional caregiving (Chang, Schneider, and Sessanna 2011). These intertwined factors collectively contribute to the limited use of formal care services and the enduring significance of family care within kinship networks in the context of dementia care in China.

Most people with dementia receive informal care at home primarily from their spouses and children (Wang et al. 2019). Using the China Health and Retirement Longitudinal Study (CHARLS), Hu and Ma (2018) found that among those over 60 receiving informal care, 41.7%

were cared for by a spouse only, and 27.0% by children only. For those who were never married, divorced, separated, or widowed, 70.9% received care exclusively from children (Hu and Ma 2018). Caregiving expectations also remain strong even for those who do not currently require care. Among the general population of older adults, 60.3% expect long-term support from their children when needed, nearly double the rate in the U.S (Cheng 2017). Extensive research from various contexts highlights that dementia caregiving places a significant strain on families, leading to physical, psychological, and emotional stress for caregivers (Brodaty and Donkin 2009; Chan 2011; Freedman et al. 2022; Ory et al. 1999; Patterson et al. 2023). This challenge is especially pronounced for caregivers in low- and middle-income countries like China, where support systems, as well as knowledge and skills related to dementia care, are limited (Chan 2011; Wang et al. 2019). However, there is relatively little knowledge about the prevalence of dementia within kinship networks from a caregiver perspective, or the expected probability of having a family member with dementia based on an individual's age or other socio-demographic characteristics—information that is crucial for anticipating caregiving needs, guiding public health planning, and informing social policies to support family caregivers.

Although extended family members are not the primary caregivers for individuals with dementia, their role cannot be overlooked (Furstenberg 2020; Furstenberg et al. 2020). They often serve as important substitutes, stepping in when primary caregivers are unavailable or during emergencies (Reed et al. 2023; Sun 2014). According to CHARLS, 6.4% of old adults receiving informal care were cared for exclusively by relatives other than a spouse or children, while 12.3% received care from a combination of other relatives along with a spouse or children. In the absence of children or a spouse, extended family members can take on the primary caregiving role. Among single older adults who received informal care, 29.1% were cared for by other relatives (Hu and Ma 2018). The anticipated importance of extended family members grows as the rates of childlessness, unmarried individuals, and domestic and international migration continue to rise (Sun 2014; Verdery 2019; Zhou, Verdery, and Margolis 2019). Furstenberg (2020) argues that kinship has been a "neglected topic" in recent decades, partly because of the lack of availability of data on patterns and the frequency of contact and exchanges among kin.

In this study, we address the question of how changing kinship networks and dementia prevalence combine to reshape the dementia burden landscape in China. We calculate both the expected burden experienced by an *average* individual and the potential availability of family caregivers. Our analyses span both past trends and future projections and consider both primary and extended kin. China presents a compelling case not only due to its large and rapidly growing population of dementia patients but also because of the rapid demographic transitions resulting from family planning policies and economic development, which have fundamentally reshaped its kinship structure. We then situate China within a global context, demonstrating how its unique demographic changes have created a significant gap in dementia care demands. Before presenting our results in detail, we outline our analytic approach in the next section.

Projecting the Kinship Network and the Dementia Burden

Changes in kinship structures impact caregiving arrangements and the well-being of older adults (Freedman et al. 2024; Murphy 2010; Schulz et al. 2016; Wachter 1997; Wolf 1994). These shifts in family dynamics play a pivotal role in determining how older adults receive care and support as they age. To analyze the dementia burden, formal demographic models offer a valuable framework for quantifying the implications of these changes in terms of kinship networks. These models leverage data on mortality, fertility, and other demographic rates to calculate and understand the dynamics of kinship. Below we describe the analytical framework that characterizes the evolving landscape of caregiving for older adults.

The Kinship Network of Individuals

Notation The following notation is used throughout this paper. Matrices are denoted by upper case bold characters (e.g., $\mathbf{U}$) and vectors by lower case bold characters (e.g., $\mathbf{a}$). Vectors are column vectors by default; $\mathbf{x}^{\mathsf{T}}$ is the transpose of $\mathbf{x}$. The bold vector $\mathbf{1}$ is a vector of ones, and the matrix $\mathbf{I}$ is the identity matrix. When necessary, subscripts are used to denote the size of a vector or matrix; e.g., $\mathbf{I}_\omega$ is an identity matrix of size $\omega \times \omega$. The notation $\|\mathbf{x}\|$ denotes the 1-norm of $\mathbf{x}$, that is, the sum of the absolute values of the entries of $\mathbf{x}$.

The matrix kinship model on which we rely has been presented in a series of papers, each of which extends the demographic processes that can be incorporated (Caswell 2019, 2020, 2022; Caswell and Song 2021; Caswell, Margolis, and Verdery 2023). Because we are interested in *changes* in kinship, beginning in the past and continuing into the (projected) future, our analysis is based on the version of the model that incorporates time-varying demographic rates.

The model describes the kinship network of an individual, referred to as Focal. The model treats each type of kin as a population. As Focal ages, her kinship network develops through the births and deaths of each type of kin. Our one-sex definitions of kin include mother, grandmother, great-grandmother, daughter, granddaughter, great-granddaughter, sisters, cousins, aunts, and nieces.

The age structure of each type of kin is projected using the matrix formulation of rates of survival and fertility. The population of any type of kin is subsidized; that is, new members of the population of one type of kin come not from the reproduction of those kin, but from the reproduction of some other type of kin (e.g., new sisters of Focal arise not from the reproduction of her current sisters, but from the reproduction of her mother).

Let $\mathbf{k}(x,t)$ denote the age distribution for a generic type of kin:

$$\mathbf{k}(x,t) = \text{ kin of type } \mathbf{k} \text{ at age } x \text{ of Focal at time } t \tag{1}$$

The kin vector is projected from time t to $t+1$ by a survival matrix $\mathbf{U}_t$ and a fertility matrix $\mathbf{F}_t$, both of dimensions $\omega \times \omega$ (i.e., the number of age groups). The survival and fertility rates may vary with time. For example with three age classes, so that $\omega = 3$, we have

$$\mathbf{U}_t = \begin{pmatrix} 0 & 0 & 0 \\ p_{1t} & 0 & 0 \\ 0 & p_{2t} & [p_{3t}] \end{pmatrix} \qquad \mathbf{F}_t = \begin{pmatrix} f_{1t} & f_{2t} & f_{3t} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{2}$$

where p_{it} is the survival probability and f_{it} the fertility rate of age class i at time t.[1]

The kin at age $x+1$ of Focal at time $t+1$ include the survivors of the kin of age x at time t. These survivors are obtained by multiplying the age distribution $\mathbf{k}(x,t)$ by the survival matrix $\mathbf{U}_t$. New individuals are produced according to a recruitment vector $\boldsymbol{\beta}(x,t)$ such that

$$\mathbf{k}(x+1,t+1) = \mathbf{U}_t\mathbf{k}(x,t) + \boldsymbol{\beta}(x,t) \qquad x = 0,\ldots,\omega \quad t = 0,\ldots,T \tag{3}$$

The recruitment vector $\boldsymbol{\beta}(x,t)$ has one of two forms. For some kin (e.g., older sisters of Focal), there is no recruitment of new members after the birth of Focal, so that

$$\boldsymbol{\beta}(x,t) = \mathbf{0}. \tag{4}$$

For some types of kin,

$$\boldsymbol{\beta}(x,t) = \mathbf{F}_t\mathbf{k}^*(x,t) \tag{5}$$

which applies the fertility at time t to the age structure vector of the kin $\mathbf{k}^*$ that provides the subsidy. For example, younger sisters ($\mathbf{n}$) of Focal are produced by reproduction of the mothers ($\mathbf{d}$) of Focal, so

$$\mathbf{n}(x+1,t+1) = \mathbf{U}_t\mathbf{n}(x,t) + \mathbf{F}_t\mathbf{d}(x,t) \tag{6}$$

The model must specify a set of two boundary conditions. One gives the kinship network of Focal, over all ages, at the earliest time point in the projection. The other specifies the kinship network of Focal at her birth over all time points. For some kin the latter boundary condition is

1. The optional (ω,ω) cell in $\mathbf{U}_t$ describes an open final age interval.

zero (e.g., Focal can have no children at birth), for others, it is not (e.g., Focal may have older sisters at birth). For details on these conditions, see Caswell and Song (2021).

Selection of Kin Types. Defining what constitutes a kinship network is challenging due to the growing diversity of family structures and cultural variations (Furstenberg 2020; Goody 1996). While the matrix kinship model can be extended to include any chosen set of kin types, we limit our analysis to those blood-related ties that are both the most common and most likely to be present for the focal individual during her lifetime. This includes first-degree kin (children and parents), second-degree kin (grandchildren, grandparents, and siblings), and third-degree kin (great-grandchildren, great-grandparents, aunts, uncles, nieces, and nephews). As will become clearer in the results section, we present the kin structure and dementia prevalence within kinship networks by kin type. In constructing the dementia dependency ratio, we provide two methods of aggregation: one aggregating all the common kin types mentioned above, and another aggregating only parents and their children (including the focal individual).

Approximating Male and Female Kin. The vector $\mathbf{k}(x,t)$ gives the age structure of female kin in maternal lines of descent. To fully compute the age distributions of both male and female kin through all lines of descent, would require a two-sex model incorporating both male and female mortality and fertility schedules (Caswell 2022). However, approximate results for both sexes can be obtained by treating males and females as identical, and multiplying the kin vectors $\mathbf{k}(x,t)$ by a set of factors suggested by Goodman, Keyfitz, and Pullum (1974), called the 'GKP factors' by Caswell (2022). In this approximation, daughters are multiplied by 2 to give childen, granddaughters multiplied by 4 to give grandchildren, mothers multiplied by 2 to give parents, grandmothers multiplied by 4 to give grandparents, sisters multiplied by 2 to give siblings, and so on. In the absence of full sets of male and female vital rates, the GKP factors offer the best alternative for approximating the full kin counts. Prior studies have shown that the

GKP factor approximation is largely comparable to the two-sex model or data from population registers. However, relying solely on female vital rates for kin population estimates can lead to overestimation due to females' relatively lower mortality rates (Alburez-Gutierrez, Williams, and Caswell 2023; Caswell 2022; Song and Caswell 2022).

The Dementia Dependency Ratio of an Individual

As an individual, Focal has kin both with and without dementia. The numbers of kin in these categories will differ among kin types because the age distributions differ among kin types, and change as Focal ages.

The number of kin with dementia is calculated from the age-specific prevalence of dementia in the population [2]. Let $\mathbf{\Psi}$ be a vector containing age-specific prevalences. The expected number of kin with dementia at age x of Focal at time t is

$$y(x,t) = \mathbf{\Psi}^{\mathsf{T}}(t)\,\mathbf{k}(x,t). \tag{7}$$

This calculation can be modified to give the number of kin with dementia within a specified age range (e.g., kin in the working ages from 16 to 64) by setting all elements of $\mathbf{\Psi}$ except those corresponding to those ages to zero.

From the numbers of kin with dementia, we calculate the probability that Focal, at age x and time t, has at least one relative with dementia, using a Poisson approximation [3], as in Song and Mare (2019) and Song, Campbell, and Lee (2015). If the expected number of kin with dementia at time t is $y(t)$, under the Poisson assumption the probability of having at least one such kin is

$$P(\text{at least one kin with dementia}) = 1 - e^{-y(t)}. \tag{8}$$

2. Since, in this study, the male kin population is approximated based on the female kin population, we apply the average of female and male dementia prevalence rates to the sum of the female and male kin population to obtain the number of kin with dementia.

3. The Poisson approximation assumes that having kin with dementia is rare and independent, but we acknowledge that this may underestimate the probability, as dementia can be genetic and not fully independent within a kinship network.

Focal has kin both with and without dementia, and the burden of dementia experienced by Focal is measured by a dependency ratio. The familiar demographic dependency ratio is calculated as the ratio of those not considered part of the labor force (younger than 15 or older than 65) relative to those considered to be part of the labor force (16–64) and thus supporting the dependant ages.

Here we calculate a corresponding dementia dependency ratio for each type of kin:

$$\text{DDR}(x,t) = \frac{\text{number with dementia}}{\text{number without dementia aged 16–64}} = \frac{y(x,t)}{(\mathbf{1} - \mathbf{\Psi}_{16-64})^{\intercal}\mathbf{k}(x,t)}. \tag{9}$$

The dementia dependency ratio can be interpreted as a measure of the burden that kin with dementia place on kin without dementia in working ages[4].

In our main results, we include all common kin types introduced in the previous section. We carried out an additional analysis that limits the types of kin to children and parents. The results show a similar significant rise of DDR in China when compared to other countries as those presented in Figure 6. We present these results in online Appendix Figures S2 and S3.

The Dementia Burden of a Population

The kinship network and the dementia dependency ratio are expected properties of a Focal individual at a given age x. A population is a collection of such individuals, of different ages, with an age structure given by, say, $\mathbf{n}(t)$.

The population dependency ratio is obtained by averaging the age-specific values over the age distribution.

Then the age-weighted, population dependency ratio is

$$\text{DDR}_{\text{pop}}(t) = \frac{\sum_x n_x(t)\text{DDR}(x,t)}{\|n(t)\|}. \tag{10}$$

4. Note that alternative measures of dependency can easily be imagined and are easily calculated. For example, Chung and Alexander (2019) proposed a similar Kin Dependency Ratio (KDR) index, which is defined as the ratio of the number of plausibly dependent kin at Focal age x to the number of plausibly non-dependent kin at Focal age x. Also note that this index can be calculated for any type of kin, or any combination of types of kin, as desired.

This quantity is the expected dementia dependency ratio of an individual selected at random from the population.

The population ratio $\mathrm{DDR}_{\mathrm{pop}}(t)$ gives the expected dementia burden of the population at time t and permits comparison across populations of different countries and at different times. As is done with standardized mortality calculations, a standard age distribution could be used for $\mathbf{n}(t)$ across all countries. We do not explore this here.

Data Sources and Estimation

Our analyses are based on mortality and fertility schedules from the 2022 Revision of the United Nations World Population Prospects (UNWPP) (United Nation 2022), starting in the year 1950 and continuing from the year 2021 to 2050 as a projection of future rates. The time-zero boundary condition $\mathbf{k}(x, 0)$ was obtained by a time-invariant calculation using the rates of 1950 and the distribution of ages at maternity in 1950 based on the UN's estimate of births by age of the mother. The age-zero boundary condition specifies $\mathbf{k}(0, t)$ for each year; it was calculated from the appropriate kin at time $t - 1$ (see Table 1 of Caswell and Song 2021). Thus, when we report kinship results for a particular year (e.g., 1990), the results reflect the changing mortality and fertility schedules in China from 1950 up to that year.

We draw on period fertility and mortality estimates for China and 194 other countries from the year 1950 to 2021 documented in the 2022 UNWPP. The 2022 UNWPP provides age-specific fertility and mortality estimates for each single-year age group. For projected estimates up to the year 2050, we choose the medium-variant projections of fertility and mortality rates provided by the UN. The medium-variant projection refers to the median of several thousand distinct trajectories of each demographic component derived using the probabilistic model that takes into account the historical variability in fertility and mortality of each country (United Nation 2022). According to the medium fertility scenario, China's fertility is expected to rebound gradually and moderately to 1.4 from 2022 to 2050 after reaching a historical low of 1.2 in 2021.

To estimate the prevalence of dementia, we draw on data from the 2019 Global Burden of Disease (GBD 2019), which provide forecasted estimates of the prevalence rate of Alzheimer's disease and other types of dementia by age, sex, and year. The Global Burden of Disease uses a Bayesian meta-regression model to estimate age- and sex-specific prevalence rates and provides the mean value out of 1,000 draws from their model [5]. The Bayesian models provide a meta-analysis of 43 published studies on dementia in China. These data can be downloaded through GBD's Data Input Sources Tool. We did not use the public version of the GBD data as the data exclude dementia induced by other clinical disorders, including Down syndrome, Parkinson's disease, clinical stroke, and traumatic brain injury. Instead, we use updated dementia prevalence rates provided in Nichols et al. (Nichols et al. 2022) that include all forms of dementia. We use the mean-value dementia prevalence estimates throughout our analyses. Because the dementia prevalence rates were estimated in the five-year age group, we used linear interpolation to impute single-year age-specific prevalence rates. Table S1 in the online appendix summarizes sources, data types, time coverage, and age ranges for data used in our analyses.

We carried out our calculations using the `R` package `DemoKin` (Williams et al. 2022). This package implements the calculations developed in Caswell (2019, 2020, 2022) and Caswell and Song (2021), which are presented in those papers as MATLAB programs.

5. Four risk factors for dementia—high body mass index, high fasting plasma glucose, smoking, and years of education—have been included in the dementia projection (Nichols et al. 2022).

Results

Changing Kinship in China

Compared to 1990, Chinese people in 2019 are expected to have fewer grandchildren and great-grandchildren but are more likely to have living parents, grandparents, and great-grandparents. For instance, the average number of children for Focal aged 30 has decreased from 1.78 in 1990 to 1.20 in 2019 and is projected to decrease to 0.58 by 2050. In contrast, the estimated average number of grandparents for Focal age 30 has risen from 0.69 in 1990, to 1.70 in 2019, and is expected to reach 2.33 by 2050.

*** Figure 1 About Here ***

However, the change in the number of kin between 1990, 2019, and 2050 does not follow a monotonic trend for certain types of kin, especially among older individuals. For example, Focal at 80 years old is expected to have 3.71 children in 1990, 3.96 children in 2019, and 1.79 children in 2050. This nonlinear pattern largely results from the rise and fall of fertility and mortality rates since the 1950s: the immediate fertility drop following the Great Leap Forward Famine (1959–1961), the baby boomers born from 1962 to 1964, the subsequent long-running fertility decline following the Later-Longer-Fewer family planning campaign in the 1970s, and the more stringent One-Child Policy between 1980 and 2016 (Cai 2010, 2008; Feeney and Feng 1993; Peng 1987; Whyte, Feng, and Cai 2015). Nevertheless, as Focal at the age of 40 in 2019 reaches 80, they will have fewer accessible kin of various types, such as children or grandchildren, than Focal at age 80 in 2019. This pattern reflects the ongoing decline in fertility rates, with generations born earlier experiencing higher levels of fertility.

These estimates of kinship structure are important as they reveal not only the number of specific kin types that Focal is expected to have across various life stages during different periods but also the maximum number of available kin of specific types that could potentially provide care when Focal develops dementia or other illnesses. We also present a table that shows the number of kin of Focal at different ages in the online appendix Table S2. In the following section, we employ the projected dementia prevalence rates from the Global Burden of Disease (GBD) study to estimate the prevalence of dementia in Focal's kinship network.

Abundance of dementia in the kinship network

Figure 2 depicts age-specific dementia prevalence rates in 1990, 2019, and 2050 estimated by the Dementia Forecasting collaborators in the Global Burden of Disease Study (Nichols et al. 2022). Figures 2B and 2C display the projected number of dementia cases by age of Focal, as well as the total count of dementia cases for the years 1990, 2019, and 2050. The sources of data are described in the Methods section and Table S1 in the online appendix. Per age, dementia prevalence grew considerably between 1990 and 2019. For example, 7 out of 100 people aged 80 had dementia in 1990, and this number increased to 10 out of 100 in 2019. The rise in dementia prevalence in China over the last three decades has been well reported, reflecting increased longevity and improved diagnostic criteria (Chan et al. 2013; Jia et al. 2020). Between 2019 and 2050, the projected age-specific dementia prevalence rate shows only a small increase. However, the proportion of people with dementia in the population is expected to increase dramatically by 2050, because the population as a whole is expected to be much older.

*** Figure 2 About Here ***

Combining the prevalence and kin age distributions we obtain the expected number of kin with dementia. Figure 3A presents the expected number of kin with dementia as a function of Focal's age in 1990, 2019, and 2050. These results suggest that the number of kin with dementia has increased substantially between 1990 and 2019 and is expected to further increase over the next three decades. Over time, individuals would have more grandparents and great-grandparents with dementia at younger ages, parents and aunts/uncles with dementia at middle age, and children, siblings, nieces/nephews, and cousins with dementia at older ages. As individuals live longer and have older kin, they would not only experience dementia themselves but also become subject to the ripple effect of dementia within their kinship networks.

The probability of having at least one relative of each type with dementia, as a function of the age of Focal, is shown in Figure 3B. Nearly half of individuals born in 2050 can expect to have at least one great-grandparent with dementia at birth. Among individuals at age 30 in 2050, 25% are expected to have at least one grandparent with dementia; among those at age 60, 16% will have parents with dementia; and among those aged 75, 15% of them will have siblings with dementia, 23% will have aunts and uncles with dementia, and more than 65% will be expected to have cousins with dementia. Given the elevated prevalence of dementia within kinship networks, it is highly possible that the majority of the population will experience its direct or indirect consequences at some point in their lives.

*** Figure 3 About Here ***

The increase in the number of kin with dementia is a result of both the rising prevalence of dementia and population aging. To clarify the relative importance of these two factors over time, we use the Kitagawa method (1955) to decompose the change in the number of kin with dementia into contributions from changing prevalences (rate effect) and changing age distributions. Figures 4*A* and 4*B* present the decomposition results for different types of kin for two time periods, 1990–2019 and 2019–2050. The overall size of the colored region in each figure represents the change in the number of kin with dementia between two anchoring years. The red region indicates the portion of change due to shifts in the age distribution of a certain type of kin, while the blue region indicates the portion of change attributable to changes in the prevalence of dementia within that specific type of kin. Between 1990 and 2019, the rate and the age effects jointly determine the increase in kin with dementia as each plot appears as a combination of red and blue regions. Between 2019 and 2050, the age effect is expected to dominate the increase in kin with dementia, with the red regions accounting for nearly all of the changes observed. The dominant age effect suggests that, despite a mild projected increase in age-specific dementia rates from now until 2050, the demand for dementia caregiving is expected to increase disproportionately due to the rapidly changing kinship age structure alone.

*** Figure 4 About Here ***

Dementia Burden in China and Globally

The components of the Dementia Dependency Ratio DDR(x), and the DDR itself, are shown in Figure 5 for the years 1990, 2019, and 2050. The age-specific DDR(x) values presented in Figure 5*C* indicate that the DDR among the kin of Focal is higher when Focal is younger than 25 and older than 60. For example, the dementia dependency ratio among the kin of an individual close to retirement age at age 65 is 0.7 in 1990 and 2.4 in 2019, indicating a more than threefold increase. The DDR values are expected to increase dramatically in the next three decades. By 2050, the dementia dependency ratio among the kin of an individual aged 65 will have more than tripled from 2.4 in 2019 to 7.3 in 2050. The dramatic increase in DDR is driven by two factors: the increase in the number of kin who have dementia (Figure 5*A*) and the decline in kinship size over time (Figure 5*B*). For example, the expected number of kin with dementia for an individual at age 65 will increase by 43.6% (= 1.12/0.78 - 1) between 2019 and 2050, whereas the number of kin aged 16 to 64 without dementia will decline by 52.5% (= 1 - 15.5/32.6).

*** Figure 5 About Here ***

The rapid increase in dementia dependency burden seen in China, as illustrated in Figure 5, might not be an isolated case. To gain a broader perspective, we situate China in a global context. Specifically, we conduct similar DDR calculations for 194 countries worldwide. To perform the analyses, we rely on two key data sources: dementia prevalence estimates from the Global Burden of Disease database and demographic rates, such as age-specific fertility and mortality and population age distribution, from the United Nations (Nichols et al. 2022; United Nation 2022). We then develop a population-level dependency burden index called $\mathrm{DDR}_{\mathrm{pop}}$ using age-specific DDR weighted by the population age distribution. Results in Appendix Table S3 show the population-level $\mathrm{DDR}_{\mathrm{pop}}(t)$ for all countries, at five time points: 1990, 2019, 2030, 2040, and 2050.

Figure 6 shows a series of heat maps, one for each year from 1990 to 2050, to visualize population-level $\mathrm{DDR}_{\mathrm{pop}}(t)$ across countries at each of those times. In 1990, $\mathrm{DDR}_{\mathrm{pop}}$ is highest in Europe and North America. Notably, United States and Sweden had the highest value at 1.8. By contrast, China's $\mathrm{DDR}_{\mathrm{pop}}$ was one of the lowest at 0.4, similar to countries such as Morocco and South Africa in the same year. Fast forwarding to 2019, the global landscape of $\mathrm{DDR}_{\mathrm{pop}}$ has shifted. Japan now leads the ranking with a $\mathrm{DDR}_{\mathrm{pop}}$ level of 5.8. China's $\mathrm{DDR}_{\mathrm{pop}}$ increased appreciably to 1.7, similar to Ireland and Chile in that year.

The most dramatic changes in $\mathrm{DDR}_{\mathrm{pop}}(t)$ are projected for 2050. China's $\mathrm{DDR}_{\mathrm{pop}}$ is expected to be among the highest globally, reaching a level of 7.2. This value surpasses those projected in 2050 for many well-known aging societies such as Germany (6.4) and France (5.9).

*** Figure 6 About Here ***

To better understand changes in $\mathrm{DDR}_{\mathrm{pop}}(t)$ during the period of 1990 to 2050, we summarize these changes in Figure 7.[6] The figure highlights the dramatic increase that China is

6. Appendix Table S3 also documents the fold change in the population-level $\mathrm{DDR}_{\mathrm{pop}}(t)$ between 1990 and 2019, and from 2019 to 2050.

expected to experience. By 2050, China's $\mathrm{DDR}_{\mathrm{pop}}(t)$ is projected to be approximately 18 times higher than it was in 1990, indicating one of the fastest growth rates globally. Only Singapore is projected to see a more dramatic rise, with a roughly 24-fold increase. However, the sheer size of China's population adds another layer of complexity to this challenge. While Singapore may experience a similar growth rate in $\mathrm{DDR}_{\mathrm{pop}}(t)$, the number of Chinese people with dementia will be far greater due to its massive population base. Furthermore, China's public health support system is currently underdeveloped, raising further concerns about its ability to cope with this rapidly growing demographic shift.

Although studies suggest that North Africa, Sub-Saharan Africa, and the Middle East may experience the highest increases in dementia cases in the next three decades (Nichols et al. 2022), many low-income countries in these areas maintain low values of $\mathrm{DDR}_{\mathrm{pop}}(t)$ and exhibit minimal changes. For instance, in 1990, Niger had the lowest recorded $\mathrm{DDR}_{\mathrm{pop}}(t)$ at 0.2, and this figure hardly changed by 2019, and it is projected to rise to only 0.3 by 2050. This persistently low $\mathrm{DDR}_{\mathrm{pop}}(t)$ in low-income countries can be attributed to high fertility rates, which contribute to expansive kinship networks for individuals with dementia. However, the low values may also result from potential underestimation of dementia prevalence within these regions because very few studies have examined aging and cognitive function in low-income countries due to data limitations (Kohler et al. 2023).

*** Figure 7 About Here ***

Discussion and Conclusion

China has the highest number of people living with dementia in the world. As China's population continues to age, dementia is expected to remain a significant social and public health concern for the foreseeable future. While the majority of older adults with dementia are cared for by family members, shrinking family size and changing kinship structures are undermining the traditional family care arrangements. Furthermore, some recent evidence shows that the unit cost of dementia care in China has doubled from 2000 to 2019 and is predicted to double again within the next two decades (Pedroza et al. 2022). The compound effects of increasing dementia cases, smaller families, and rising costs may exacerbate the impact on individuals, families, and the wider society. With the rising demand for dementia care in China, the present study illustrates the evolving accessibility of potential care provided by family members, who offer an alternative care source to professional providers and healthcare institutions.

Using demographic models of kinship, we estimate kin availability and prevalence of dementia among individuals' kinship networks. We find the probability that an individual has a close family member with dementia rises significantly. For example, among people aged 30, the likelihood of having at least one living grandparent with dementia grew from 5% in 1990 to nearly 30% in 2050, whereas among those aged 50, the likelihood of having at least one living parent with dementia climbed from 3% to 11%. What has been driving this rise? Our decomposition analysis indicates that both increasing dementia prevalence and changes in kinship age structure contribute to the trend, though their relative impacts vary over time. From 1990 to 2019, rising dementia prevalence and an aging kinship network jointly boosted the probability of having a close relative with dementia. However, from 2019 to 2050, the rapid aging of kinship networks will emerge as the dominant factor.

Furthermore, the number of kin available to older adults for caregiving will plummet over the next three decades. Factoring in changing kinship sizes and structures, our kin-based indices of dementia dependency ratios shed more light on the impact of demographic change on the dementia caregiving demand. Our results suggest that the dementia caregiving burden in China is expected to climb 18-fold, one of the most dramatic projected changes for any country. For example, in 1990, an individual of age 80 would have had 0.4 kin with dementia (considering all types of kin and kin of different ages) and 35.1 working-age, dementia-free kin (defined as kin aged 16 to 64 without dementia). In 2019, an 80-year-old Focal would have had 1.2 kin with dementia and 29.9 kin who were dementia-free and could have been care providers. Looking ahead to 2050, these figures are expected to change to 2.2 kin with dementia but only 11.6 dementia-free kin[7]. Taken together, these trends suggest that even a significant breakthrough in reducing dementia prevalence may not be sufficient to offset the growing dementia caregiving demands. As the number of affected relatives increases and the pool of potential family caregivers shrinks, the traditional reliance on family-based care will face increasing pressure, highlighting the need for stronger institutional support and policy interventions.

By incorporating the kin ties beyond the nuclear family, our study also joins the research agenda on building the *demography of kinship* (Furstenberg 2020; Furstenberg et al. 2020) and rethinking family networks and support structures, especially in an era of extended shared lifetimes among kin and heightened caregiving demands. This is particularly relevant for China, where a third of families are one-child families (Cai and Feng 2021). A promising direction for future research would be to examine the frequency and intensity of exchanges between distant kin, such as cousins, nieces, and nephews, for the one-child generation and their parents, exploring the extent to which kin from alternative family forms may substitute for nuclear family members.

This study has several limitations. First, we treat the population as a homogeneous group with a single set of demographic rates and dementia prevalences, despite variations in fertility, mortality, and dementia rates by socioeconomic factors such as educational attainment, *hukou* status, and place of residence (Crimmins et al. 2018; Jiang 1995; Luo, Zhang, and Pan 2019; Ruiz et al. 2023; Zhang, Song, and Chen 2022; Zhang 2006). Furthermore, families with a his-

7. It is also worth noting that because kinship models are projections of the consequences of the demographic rates conditional on these hypotheses, they are not expected to duplicate the results found from empirical censuses of kin (as noted explicitly by Goodman, Keyfitz, and Pullum (1974)). Rather, they capture the main effects of the demographic structure against which the effects of violations of these assumptions can be evaluated.

tory of dementia may have members with a higher genetic risk and share environmental factors that increase dementia risk, leading to greater caregiving demands within these family networks compared to others (Loy et al. 2014). These factors would lead to variations in the estimates of kinship structure and dementia burden that are overlooked in the current study. In the Chinese context, previous research has found that older adults with lower education and rural *hukou* status have lower cognitive function and experience faster cognitive decline (Ruiz et al. 2023; Zhang, Song, and Chen 2022). Although they may have larger kinship networks compared to the urban educated population (Jiang 1995), they remain vulnerable due to limited access to public support, including pensions, health insurance, and care facilities. Future research may investigate the complex interaction between kinship and other social factors to identify the most vulnerable, hard-to-reach groups with limited access to health care. Multistate matrix kinship models (Caswell 2020) and micro-simulations (Zagheni 2015) could be promising approaches for improving our analysis by capturing population heterogeneity in kinship compositions and dementia rates.

Second, our demographic models of kinship consider only common biological kin ties, excluding spouses, in-laws, and kin from other alternative family forms such as step-kin, adopted family members, and voluntary kin. Models incorporating spouses would be a valuable addition because they are more likely than children and other biological kin to live with the person with dementia (Hu and Ma 2018) and are often better equipped to provide care due to their closer emotional bond with the dementia patient (Evans and Lee 2014; Hayes, Boylstein, and Zimmerman 2009). However, the impact of omitting spouses and in-laws on our estimates remains unclear, as they can be both caregivers and care recipients of dementia, which may balance out their overall effect on the caregiving burden. It is also worth noting that spouses of dementia patients are likely to be “hidden patients” themselves, as they often face their own health issues (Liu et al. 2019). In addition, caregiving is often gendered. In the Chinese context, daughters-in-law are a significant source of care for older adults (Cong and Silverstein 2008), as they are traditionally expected to move into the husband's family household. However, this tradition has weakened under China's rapid demographic and social changes. Recent empirical evidence indicates a growing involvement of daughters in caregiving (Hu 2017; Lei 2013). Some studies even suggest that daughters now provide as much, if not more, support than sons (Silverstein, Gans, and Yang 2006; Xie and Zhu 2009; Zeng et al. 2016). Fictive or voluntary kin from alternative family forms can also play an important role, particularly for older adults who lack children, spouses, or siblings, or during times when nuclear family members are unavailable (Furstenberg et al. 2020; Reed et al. 2023; Sun 2014). Caregiving exchanges within these kin-like relationships are often overlooked or underreported due to limitations in existing data collection practices(Furstenberg 2020). As a result, models that exclude non-biological kin may overstate the caregiving burden placed on biological relatives. Future research using large-scale household-level microdata, in-depth qualitative interviews, or other innovative data collection approaches could provide valuable insights into how family complexity shapes dementia caregiving in China and beyond.

Third, we did not account for factors such as the social expectations, cultural significance, and geographical proximity of kin ties (Lin and Tang 2023; Murphy 2008; Shanas 1973), which may moderate kin relationships and caregiving dynamics. Among these factors, gender is one important dimension warranting further consideration. Previous studies indicate that caregiving for older adults within families is gendered, shaped not only by the caregiver's gender but also by the gender of the care recipient and other available family members (Grigoryeva 2017), with women disproportionately bearing more care responsibilities than men (Carr and Utz 2020; Silverstein and Giarrusso 2010). The type of support provided to older parents can vary significantly by gender, with daughters often offering more emotional and instrumental support, while sons typically focus on financial assistance (Lei 2013; Zeng et al. 2016). Furthermore, we did not account for the institutional contexts in which kin ties are embedded. Studies in Europe have shown that caregiving for older parents by children is more common in Southern and Central Europe than in Northern Europe, where public support systems are stronger (Attias-Donfut, Ogg, and Wolff 2005; Haberkern and Szydlik 2010). This limitation affects our cross-national comparison, as we infer the care gap based on kin availability and dementia prevalence among kinship networks, without considering social norms, health policies, and accessibility of formal care services.

Future research should examine whether the increasing prevalence of dementia within kinship networks will reinforce existing social inequalities or create new ones, affecting both those providing care and those at risk of having kin with dementia, and how these dynamics vary across institutional contexts. From a life course perspective, having grandparents or parents with dementia at younger ages may temporarily disrupt an individual's work as he or she takes time off or adjusts work schedules to provide care for family members. Such disruptions may even lead to long-term consequences for reduced work performance, diminished career prospects, and financial strain. The repercussions on labor market outcomes for individuals caring for relatives with dementia is another critical, yet largely unexplored, area for future research.

Our findings based on demographic estimates have policy implications for national healthcare systems and the well-being of families. Our findings based on demographic estimates have policy implications for national healthcare systems and the well-being of families. Compared to other aging societies, the projected increase in dementia care demands in China is both rapid and large in scale. This challenge is further compounded by the country's aging kinship structure, which undermines traditional family-based care. China's basic medical insurance covers some dementia-related medical expenses, such as diagnostic tests, hospitalizations, and medications. However, long-term care and non-hospital services are often not covered (Feng et al. 2020; Jia et al. 2020; Wu et al. 2016). Furthermore, the existing programs primarily support older adults with severe dementia. There are no specific subsidies or support programs for individuals experiencing mild cognitive decline or early-stage dementia (Wu et al. 2020; Ye et al. 2024). In many aging societies, such as Japan, Korea, and Germany, long-term care insurance is a mandatory component of the social security system (Kang et al. 2023; Spasova et al. 2018; Sun et al. 2020). While China began piloting long-term care insurance in a limited number of cities in 2016, it still lacks a comprehensive nationwide system (Feng et al. 2020). To close this gap, policymakers should consider making equitable access possible across the country to ensure that individuals, regardless of where they live or their social background, have a fair chance to benefit from the program. In addition to strengthening formal care policies, it is also urgent for China to promote and expand informal caregiving networks. While the size of close kinship networks has declined in recent decades, our findings suggest that a substantial number of extended family members remain potential caregivers. Expanding caregiver subsidies to include extended relatives, such as nieces and nephews, could provide much-needed support and alleviate the burden on primary caregivers. This approach would also encourage a more flexible, community-based caregiving model—an essential adaptation for a society where single-child households become increasingly common. Although we highlight the rapid increase in China's dementia caregiving burden from 1990 to 2050, the absolute scale of the dementia caregiving challenge remains high in rapidly aging societies across East Asia and Europe. For example, kin-based indices of dementia dependency ratios are consistently higher in Japan and Italy than in China throughout the estimated years (Figure 6 and Table S3). In our analysis, we focus on comparing the aggregate dementia caregiving burden across countries. Future research could apply our analytical framework to other aging contexts to examine the evolving kinship structure in detail and identify the specific ages at which caregiving demands peak across different historical periods and into the future [8].

8. A replication package with the code for all analyses is available at XXX (Link containing author information).

References

Alburez-Gutierrez, Diego, Nicola Barban, Hal Caswell, Martin Kolk, Rachel Margolis, Emily Smith-Greenaway, Xi Song, Ashton M. Verdery, and Emilio Zagheni. 2022. *Kinship, Demography, and Inequality: Review and Key Areas for Future Development,* June. https://doi.org/10.31235/osf.io/fk7x9.

Alburez-Gutierrez, Diego, Iván Williams, and Hal Caswell. 2023. "Projections of human kinship for all countries." *Proceedings of the National Academy of Sciences* 120, no. 52 (December): e2315722120. https://doi.org/10.1073/pnas.2315722120.

Attias-Donfut, Claudine, Jim Ogg, and François-Charles Wolff. 2005. "European patterns of intergenerational financial and time transfers." *European Journal of Ageing* 2, no. 3 (September): 161–173. https://doi.org/10.1007/s10433-005-0008-7.

Baumgart, Matthew, Heather M. Snyder, Maria C. Carrillo, Sam Fazio, Hye Kim, and Harry Johns. 2015. "Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A population-based perspective." *Alzheimer's & Dementia: The Journal of the Alzheimer's Association* 11, no. 6 (June): 718–726. https://doi.org/10.1016/j.jalz.2015.05.016.

Bongaarts, John, and Susan Greenhalgh. 1985. "An Alternative to the One-Child Policy in China." *Population and Development Review* 11 (4): 585–617. https://doi.org/10.2307/1973456.

Brodaty, Henry, and Marika Donkin. 2009. "Family caregivers of people with dementia." *Dialogues in Clinical Neuroscience* 11, no. 2 (June): 217–228. https://doi.org/10.31887/DCNS.2009.11.2/hbrodaty.

Cai, Yong. 2008. "An assessment of China's fertility level using the variable-r method." *Demography* 45, no. 2 (May): 271–281. https://doi.org/10.1353/dem.0.0003.

———. 2010. "China's Below-Replacement Fertility: Government Policy or Socioeconomic Development?" *Population and Development Review* 36 (3): 419–440. https://doi.org/10.1111/j.1728-4457.2010.00341.x.

Cai, Yong, and Wang Feng. 2021. "The Social and Sociological Consequences of China's One-Child Policy." *Annual Review of Sociology* 47, no. Volume 47, 2021 (July): 587–606. https://doi.org/10.1146/annurev-soc-090220-032839.

Cai, Yong, Wang Feng, and Ke Shen. 2018. "Fiscal Implications of Population Aging and Social Sector Expenditure in China." *Population and Development Review* 44 (4): 811–831. https://doi.org/10.1111/padr.12206.

Carr, Deborah, and Rebecca L. Utz. 2020. "Families in Later Life: A Decade in Review." *Journal of Marriage and Family* 82 (1): 346–363. https://doi.org/10.1111/jomf.12609.

Caswell, Hal. 2019. "The formal demography of kinship: A matrix formulation." *Demographic Research* 41:679–712.

———. 2020. "The formal demography of kinship II: Multistate models, parity, and sibship." *Demographic Research* 42 (June): 1097–1146.

———. 2022. "The formal demography of kinship IV: Two-sex models and their approximations." *Demographic Research* 47 (September): 359–396.

Caswell, Hal, Rachel Margolis, and Ashton Verdery. 2023. "The formal demography of kinship V: Kin loss, bereavement, and causes of death." *Demographic Research* 49 (December): 1163–1200.

Caswell, Hal, and Xi Song. 2021. "The formal demography of kinship III: Kinship dynamics with time-varying demographic rates." *Demographic Research* 45 (August): 517–546.

Chan, Kit Yee, Wei Wang, Jing Jing Wu, Li Liu, Evropi Theodoratou, Josip Car, Lefkos Middleton, et al. 2013. "Epidemiology of Alzheimer's disease and other forms of dementia in China, 1990–2010: a systematic review and analysis." *The Lancet* 381, no. 9882 (June): 2016–2023. https://doi.org/10.1016/S0140-6736(13)60221-4.

Chan, Sally Wai-Chi. 2011. "Family Caregiving in Dementia: The Asian Perspective of a Global Problem." *Dementia and Geriatric Cognitive Disorders* 30, no. 6 (January): 469–478. https://doi.org/10.1159/000322086.

Chang, Yu-Ping, Joanne Kraenzle Schneider, and Loralee Sessanna. 2011. "Decisional conflict among Chinese family caregivers regarding nursing home placement of older adults with dementia." *Journal of Aging Studies* 25, no. 4 (December): 436–444. https://doi.org/10.1016/j.jaging.2011.05.001.

Chen, Feinian, and Guangya Liu. 2009. "Population Aging in China." In *International Handbook of Population Aging,* edited by Peter Uhlenberg, 157–172. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-1-4020-8356-3_8.

Cheng, Cheng. 2017. "Anticipated support from children and later-life health in the United States and China." *Social Science & Medicine* 179 (April): 201–209. https://doi.org/10.1016/j.socscimed.2017.03.007.

Cheng, Sheung-Tak, Linda C. W. Lam, Timothy Kwok, Natalie S. S. Ng, and Ada W. T. Fung. 2013. "The Social Networks of Hong Kong Chinese Family Caregivers of Alzheimer's Disease: Correlates With Positive Gains and Burden." *The Gerontologist* 53, no. 6 (December): 998–1008. https://doi.org/10.1093/geront/gns195.

China National Bureau of Statistics. 2021. "China Statistical yearbook 2021." *China Statistics Press,* Table 2–7.

Chung, Pil H, and Monica Alexander. 2019. “Kin Dependency Ratios: An Extension and Application of the Goodman Method for Estimating the Availability of Kin.” *Presented at the Population Association of America’s 2019 Annual Meeting.*

Chung, Pil H., and Peter Hepburn. 2018. “Mass Imprisonment and the Extended Family.” *Sociological Science* 5 (June): 335–360. https://doi.org/10.15195/v5.a15.

Cleary, Jennifer L., Jasmine A. Manalel, Sato Ashida, Christopher Steven Marcum, Jeffrey Rewley, and Laura Koehly. 2022. “Interpersonal Correlates of Dementia Caregivers’ Emotional Support Networks: Considering Family History.” *Research on Aging* 44, nos. 5-6 (May): 405–413. https://doi.org/10.1177/01640275211026919.

Cong, Zhen, and Merril Silverstein. 2008. “Intergenerational Support and Depression Among Elders in Rural China: Do Daughters-In-Law Matter?” *Journal of Marriage and Family* 70 (3): 599–612. https://doi.org/10.1111/j.1741-3737.2008.00508.x.

Crimmins, Eileen M, Yasuhiko Saito, Jung Ki Kim, Yuan S Zhang, Isaac Sasson, and Mark D Hayward. 2018. “Educational Differences in the Prevalence of Dementia and Life Expectancy with Dementia: Changes from 2000 to 2010.” *The Journals of Gerontology: Series B* 73, no. suppl_1 (April): S20–S28. https://doi.org/10.1093/geronb/gbx135.

Evans, David, and Emmanuel Lee. 2014. “Impact of dementia on marriage: A qualitative systematic review.” *Dementia* 13, no. 3 (May): 330–349. https://doi.org/10.1177/1471301212473882.

Feeney, Griffith, and Wang Feng. 1993. “Parity Progression and Birth Intervals in China: The Influence of Policy in Hastening Fertility Decline.” *Population and Development Review* 19 (1): 61–101. https://doi.org/10.2307/2938385.

Feng, Kai, Xi Song, and Hal Caswell. 2024. “Kinship And Care: Racial Disparities In Potential Dementia Caregiving In The U.S. From 2000 To 2060.” *The Journals of Gerontology: Series A* (April): glae106. https://doi.org/10.1093/gerona/glae106.

Feng, Zhanlian, Elena Glinskaya, Hongtu Chen, Sen Gong, Yue Qiu, Jianming Xu, and Winnie Yip. 2020. “Long-term care system for older adults in China: policy landscape, challenges, and future prospects.” *The Lancet* 396, no. 10259 (October): 1362–1372. https://doi.org/10.1016/S0140-6736(20)32136-X.

Freedman, Vicki A., Emily M Agree, Judith A Seltzer, Kira S Birditt, Karen L Fingerman, Esther M Friedman, I-Fen Lin, et al. 2024. “The Changing Demography of Late-Life Family Caregiving: A Research Agenda to Understand Future Care Networks for an Aging U.S. Population.” *The Gerontologist* 64, no. 2 (February): gnad036. https://doi.org/10.1093/geront/gnad036.

Freedman, Vicki A., Sarah E. Patterson, Jennifer C. Cornman, and Jennifer L. Wolff. 2022. "A day in the life of caregivers to older adults with and without dementia: Comparisons of care time and emotional health." *Alzheimer's & Dementia* 18 (9): 1650–1661. https://doi.org/10.1002/alz.12550.

Friedman, Esther, Vicki Freedman, and Sarah Patterson. 2023. "Families and Dementia: Estimates and Exposures." *Innovation in Aging* 7, no. Supplement_1 (December): 106–107. https://doi.org/10.1093/geroni/igad104.0346.

Furstenberg, Frank F. 2020. "Kinship Reconsidered: Research on a Neglected Topic." *Journal of Marriage and Family* 82 (1): 364–382. https://doi.org/10.1111/jomf.12628.

Furstenberg, Frank F., Lauren E. Harris, Luca Maria Pesando, and Megan N. Reed. 2020. "Kinship Practices Among Alternative Family Forms in Western Industrialized Societies." *Journal of Marriage and Family* 82 (5): 1403–1430. https://doi.org/10.1111/jomf.12712.

Goodman, Leo A., Nathan Keyfitz, and Thomas W. Pullum. 1974. "Family formation and the frequency of various kinship relationships." *Theoretical Population Biology* 5, no. 1 (February): 1–27. https://doi.org/10.1016/0040-5809(74)90049-5.

Goody, Jack. 1996. "Comparing Family Systems in Europe and Asia: Are There Different Sets of Rules?" *Population and Development Review* 22 (1): 1–20. https://doi.org/10.2307/2137684.

Grigoryeva, Angelina. 2017. "Own Gender, Sibling's Gender, Parent's Gender: The Division of Elderly Parent Care among Adult Children." *American Sociological Review* 82, no. 1 (February): 116–146. https://doi.org/10.1177/0003122416686521.

Haberkern, Klaus, and Marc Szydlik. 2010. "State care provision, societal opinion and children's care of older parents in 11 European countries." *Ageing & Society* 30, no. 2 (February): 299–323. https://doi.org/10.1017/S0144686X09990316.

Hammel, E. A., C. Mason, K. Wachter, F. Wang, and H. Yang. 1991. "Rapid population change and kinship: the effects of unstable demographic changes on Chinese kinship networks, 1750–2250." In *Consequences Of Rapid Population Growth In Developing Countries.* Taylor & Francis.

Hayes, Jeanne, Craig Boylstein, and Mary K. Zimmerman. 2009. "Living and loving with dementia: Negotiating spousal and caregiver identity through narrative." *Journal of Aging Studies* 23, no. 1 (January): 48–59. https://doi.org/10.1016/j.jaging.2007.09.002.

Hu, Anning. 2017. "Providing More but Receiving Less: Daughters in Intergenerational Exchange in Mainland China." *Journal of Marriage and Family* 79 (3): 739–757.

Hu, Bo, and Sai Ma. 2018. "Receipt of informal care in the Chinese older population." *Ageing & Society* 38, no. 4 (April): 766–793. https://doi.org/10.1017/S0144686X16001318.

Jia, Jianping, Cuibai Wei, Shuoqi Chen, Fangyu Li, Yi Tang, Wei Qin, Lina Zhao, et al. 2018. “The cost of Alzheimer’s disease in China and re-estimation of costs worldwide.” *Alzheimer’s & Dementia* 14, no. 4 (April): 483–491. https://doi.org/10.1016/j.jalz.2017.12.006.

Jia, Jianping, Xiumei Zuo, Xiang-Fei Jia, Changbiao Chu, Liyong Wu, Aihong Zhou, Cuibai Wei, et al. 2016. “Diagnosis and treatment of dementia in neurology outpatient departments of general hospitals in China.” *Alzheimer’s & Dementia* 12, no. 4 (April): 446–453. https://doi.org/10.1016/j.jalz.2015.06.1892.

Jia, Longfei, Meina Quan, Yue Fu, Tan Zhao, Yan Li, Cuibai Wei, Yi Tang, et al. 2020. “Dementia in China: epidemiology, clinical management, and research advances.” *The Lancet Neurology* 19, no. 1 (January): 81–92. https://doi.org/10.1016/S1474-4422(19)30290-X.

Jiang, Lin. 1995. “Changing Kinship Structure and its Implications for Old-Age Support in Urban and Rural China.” *Population Studies* 49 (1): 127–145.

Kang, Younhee, Dukyoo Jung, Jung Jae Lee, Sumalee Lirtmunlikaporn, Huei-Chuan Sung, Miyae Yamakawa, Yujin Hur, and Leeho Yoo. 2023. “A comparison of dementia care and policy in five Asian regions: A literature review.” *Journal of Korean Gerontological Nursing* 25, no. 2 (May): 174–184. https://doi.org/10.17079/jkgn.2303.16001.

Kitagawa, Evelyn M. 1955. “Components of a Difference Between Two Rates*.” *Journal of the American Statistical Association* 50, no. 272 (December): 1168–1194. https://doi.org/10.1080/01621459.1955.10501299.

Kohler, Iliana V., Fabrice Kämpfen, Chiwoza Bandawe, and Hans-Peter Kohler. 2023. “Cognition and Cognitive Changes in a Low-Income Sub-Saharan African Aging Population.” *Journal of Alzheimer’s disease : JAD* 95 (1): 195–212. https://doi.org/10.3233/JAD-230271.

Lang, Linda, Angela Clifford, Li Wei, Dongmei Zhang, Daryl Leung, Glenda Augustine, Isaac M. Danat, et al. 2017. “Prevalence and determinants of undetected dementia in the community: a systematic literature review and a meta-analysis.” *BMJ Open* 7, no. 2 (February): e011146. https://doi.org/10.1136/bmjopen-2016-011146.

Lei, Lei. 2013. “Sons, Daughters, and Intergenerational Support in China.” *Chinese Sociological Review* 45, no. 3 (April): 26–52. https://doi.org/10.2753/CSA2162-0555450302.

Liang, Zai. 2016. “China’s Great Migration and the Prospects of a More Integrated Society.” *Annual Review of Sociology* 42, no. Volume 42, 2016 (July): 451–471. https://doi.org/10.1146/annurev-soc-081715-074435.

Lin, Zhiyong, and Dan Tang. 2023. “Separated kin: location of multiple children and mental health trajectories of older parents in rural China.” *Aging & Mental Health* 27, no. 2 (February): 425–433. https://doi.org/10.1080/13607863.2021.2019191.

Liu, Huiying, Boye Fang, Jieling Chan, and Gengzhen Chen. 2019. "The relationship between comorbidities in dementia patients and burden on adult–child primary caregivers: Does having a secondary caregiver matter?" *International Journal of Mental Health Nursing* 28 (6): 1306–1317. https://doi.org/10.1111/inm.12640.

Livingston, Gill, Andrew Sommerlad, Vasiliki Orgeta, Sergi G. Costafreda, Jonathan Huntley, David Ames, Clive Ballard, et al. 2017. "Dementia prevention, intervention, and care." *The Lancet* 390, no. 10113 (December): 2673–2734. https://doi.org/10.1016/S0140-6736(17)31363-6.

Loy, Clement T., Peter R. Schofield, Anne M. Turner, and John BJ Kwok. 2014. "Genetics of dementia." *The Lancet* 383, no. 9919 (March): 828–840. https://doi.org/10.1016/S0140-6736(13)60630-3.

Luo, Ye, Lingling Zhang, and Xi Pan. 2019. "Neighborhood Environments and Cognitive Decline Among Middle-Aged and Older People in China." *The Journals of Gerontology: Series B* 74, no. 7 (September): e60–e71. https://doi.org/10.1093/geronb/gbz016.

Murphy, Michael. 2008. "Variations in Kinship Networks Across Geographic and Social Space." *Population and Development Review* 34 (1): 19–49. https://doi.org/10.1111/j.1728-4457.2008.00204.x.

———. 2010. "Family and Kinship Networks in the Context of Ageing Societies." In *Ageing in Advanced Industrial States: Riding the Age Waves - Volume 3,* edited by Shripad Tuljapurkar, Naohiro Ogawa, and Anne H. Gauthier, 263–285. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-90-481-3553-0_11.

Nichols, Emma, Jaimie D Steinmetz, Stein Emil Vollset, Kai Fukutaki, Julian Chalek, Foad Abd-Allah, Amir Abdoli, et al. 2022. "Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019." *The Lancet Public Health* 7, no. 2 (February): e105–e125. https://doi.org/10.1016/S2468-2667(21)00249-8.

Nichols, Emma, Cassandra E I Szoeke, Stein Emil Vollset, Nooshin Abbasi, Foad Abd-Allah, Jemal Abdela, Miloud Taki Eddine Aichour, et al. 2019. "Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016." *The Lancet Neurology* 18, no. 1 (January): 88–106. https://doi.org/10.1016/S1474-4422(18)30403-4.

Ory, M. G., R. R. Hoffman, J. L. Yee, S. Tennstedt, and R. Schulz. 1999. "Prevalence and impact of caregiving: a detailed comparison between dementia and nondementia caregivers." *The Gerontologist* 39, no. 2 (April): 177–185. https://doi.org/10.1093/geront/39.2.177.

Patterson, Sarah E, Ashley M Tate, Yi-Ling Hu, Jue (Jessie) Wang, Robert F Schoeni, and Hwa-Jung Choi. 2023. “The Social Cost of Providing Care to Older Adults With and Without Dementia.” *The Journals of Gerontology: Series B* 78, no. Supplement_1 (February): S71–S80. https://doi.org/10.1093/geronb/gbac146.

Pedroza, Paola, Molly K Miller-Petrie, Carina Chen, Suman Chakrabarti, Abigail Chapin, Simon Hay, Golsum Tsakalos, Anders Wimo, and Joseph L Dieleman. 2022. “Global and regional spending on dementia care from 2000–2019 and expected future health spending scenarios from 2020–2050: An economic modelling exercise.” *eClinicalMedicine* 45 (March): 101337. https://doi.org/10.1016/j.eclinm.2022.101337.

Peng, Xizhe. 1987. “Demographic Consequences of the Great Leap Forward in China’s Provinces.” *Population and Development Review* 13 (4): 639–670. https://doi.org/10.2307/1973026.

———. 2011. “China’s Demographic History and Future Challenges.” *Science* 333, no. 6042 (July): 581–587. https://doi.org/10.1126/science.1209396.

Quail, Zara, Angelina Wei, Vicky Fan Zhang, and Mark McLean Carter. 2020. “Barriers to dementia diagnosis and care in China.” *BMJ Case Reports CP* 13, no. 3 (March): e232115. https://doi.org/10.1136/bcr-2019-232115.

Reed, Megan N., Linda Li, Luca Maria Pesando, Lauren E. Harris, Frank F. Furstenberg, and Julien O. Teitler. 2023. “Communication with Kin in the Wake of the COVID-19 Pandemic.” *Socius* 9 (January): 23780231231199388. https://doi.org/10.1177/23780231231199388.

Reyes, Adriana M., Robert F. Schoeni, and Vicki A. Freedman. 2021. “National estimates of kinship size and composition among adults with activity limitations in the United States.” *Demographic research* 45 (November): 1097. https://doi.org/10.4054/demres.2021.45.36.

Ruiz, Milagros, Yaoyue Hu, Pekka Martikainen, and Martin Bobak. 2023. “Life Course Socioeconomic Position and Cognitive Aging Trajectories: A Cross-National Cohort Study in China and England.” *Innovation in Aging* 7, no. 6 (July): igad064. https://doi.org/10.1093/geroni/igad064.

Schulz, Richard, Jill Eden, Committee on Family Caregiving for Older Adults, Board on Health Care Services, Health and Medicine Division, and Engineering National Academies of Sciences. 2016. “Family Caregiving Roles and Impacts.” In *Families Caring for an Aging America.* National Academies Press (US), November.

Schulz, Richard, and Lynn M. Martire. 2004. “Family caregiving of persons with dementia: prevalence, health effects, and support strategies.” *The American Journal of Geriatric Psychiatry: Official Journal of the American Association for Geriatric Psychiatry* 12 (3): 240–249.

Shanas, Ethel. 1973. “Family-Kin Networks and Aging in Cross-Cultural Perspective.” *Journal of Marriage and Family* 35 (3): 505–511. https://doi.org/10.2307/350586.

Silverstein, Merril, Daphna Gans, and Frances M. Yang. 2006. “Intergenerational Support to Aging Parents: The Role of Norms and Needs.” *Journal of Family Issues* 27, no. 8 (August): 1068–1084. https://doi.org/10.1177/0192513X06288120.

Silverstein, Merril, and Roseann Giarrusso. 2010. “Aging and Family Life: A Decade Review.” *Journal of marriage and the family* 72, no. 5 (October): 1039. https://doi.org/10.1111/j.1741-3737.2010.00749.x.

Sohn, Heeju. 2023. “Structural Inequities in the Kin Safety Net: Mapping the Three-Generational Network throughout Early Adulthood.” *American Journal of Sociology* 128, no. 6 (May): 1650–1677. https://doi.org/10.1086/724817.

Song, Xi, Cameron D. Campbell, and James Z. Lee. 2015. “Ancestry Matters: Patrilineage Growth and Extinction.” *American Sociological Review* 80, no. 3 (June): 574–602. https://doi.org/10.1177/0003122415576516.

Song, Xi, and Hal Caswell. 2022. “The Role of Kinship in Racial Differences in Exposure to Unemployment.” *Demography* 59, no. 4 (August): 1325–1352. https://doi.org/10.1215/00703370-10057831.

Song, Xi, and Robert D. Mare. 2019. “Shared Lifetimes, Multigenerational Exposure, and Educational Mobility.” *Demography* 56, no. 3 (May): 891–916. https://doi.org/10.1007/s13524-019-00772-8.

Spasova, Slavina, Rita Baeten, Stéphanie Coster, Dalila Ghailani, Ramón Peña-Casas, Bart Vanhercke, et al. 2018. “Challenges in long-term care in Europe.” *Eurohealth* 24 (4): 7–12.

Sun, Fei, Emmanuel Chima, Tracy Wharton, and Vijeth Iyengar. 2020. “National policy actions on dementia in the Americas and Asia-Pacific: Consensus and challenges.” *Revista Panamericana de Salud Pública* 44:e2.

Sun, Ken Chih-Yan. 2014. “Transnational Kinscription: A Case of Parachute Kids in the USA and Their Parents in Taiwan.” *Journal of Ethnic and Migration Studies* 40, no. 9 (September): 1431–1449. https://doi.org/10.1080/1369183X.2013.847359.

United Nation. 2022. *World Population Prospects: The 2022 Revision.* United Nations, New York.

Verdery, Ashton M. 2019. *Modeling the Future of Chinas Changing Family Structure to 2100.* Technical report. American Enterprise Institute.

Verdery, Ashton M., and Rachel Margolis. 2017. "Projections of white and black older adults without living kin in the United States, 2015 to 2060." *Proceedings of the National Academy of Sciences* 114, no. 42 (October): 11109–11114. https://doi.org/10.1073/pnas.1710341114.

Wachter, K. W. 1997. "Kinship resources for the elderly." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 352, no. 1363 (December): 1811–1817. https://doi.org/10.1098/rstb.1997.0166.

Wang, Feng. 2011. "The Future of a Demographic Overachiever: Long-Term Implications of the Demographic Transition in China." *Population and Development Review* 37:173–190.

Wang, Feng, Yong Cai, and Baochang Gu. 2013. "Population, Policy, and Politics: How Will History Judge China's One-Child Policy?" *Population and Development Review* 38:115–129.

Wang, Feng, Baochang Gu, and Yong Cai. 2016. "The End of China's One-Child Policy." *Studies in Family Planning* 47 (1): 83–86. https://doi.org/10.1111/j.1728-4465.2016.00052.x.

Wang, Feng, and Andrew Mason. 2007. "Population Ageing: Challenges, Opportunities, and Institutions." In *Transition and Challenge: China's Population at the Beginning of the 21st Century,* edited by Zhongwei Zhao and Fei Guo, 0. Oxford University Press, February. https://doi.org/10.1093/acprof:oso/9780199299294.003.0011.

Wang, Huali, Hengge Xie, Qiumin Qu, Wei Chen, Yongan Sun, Nan Zhang, Yu Liu, et al. 2019. "The continuum of care for dementia: needs, resources and practice in China." *Journal of Global Health* 9 (2): 020321. https://doi.org/10.7189/jogh.09.020321.

Wang, Shanshan, Daphne Sze Ki Cheung, and Angela Y. M. Leung. 2019. "Overview of dementia care under the three-tier long-term care system of China." *Public Health Nursing* 36 (2): 199–206. https://doi.org/10.1111/phn.12573.

Whyte, Martin King, Wang Feng, and Yong Cai. 2015. "Challenging Myths About China's One-Child Policy." *The China Journal* 74 (July): 144–159. https://doi.org/10.1086/681664.

Williams, Iván, Diego Alburez-Gutierrez, Xi Song, and Hal Caswell. 2022. *DemoKin: An R Package to Implement Demographic Matrix Kinship Models (https://github.com/IvanWilli/DemoKin).*

Wolf, A. Douglas. 1994. "The Elderly and Their Kin: Patterns of Availability and Access." In *Demography of Aging.* National Academies Press (US).

Wu, Christina, Lin Gao, Shulin Chen, and Hengjin Dong. 2016. "Care services for elderly people with dementia in rural China: a case study." *Bulletin of the World Health Organization* 94, no. 3 (March): 167–173. https://doi.org/10.2471/BLT.15.160929.

Wu, Jialan, Siman Chen, Huangliang Wen, Yayan Yi, and Xiaoyan Liao. 2020. "Health status, care needs, and assessment for beneficiaries with or without dementia in a public long-term care insurance pilot in Guangzhou, China." *BMC Health Services Research* 20, no. 1 (December): 1127. https://doi.org/10.1186/s12913-020-05965-1.

Xie, Yu, and Haiyan Zhu. 2009. "Do Sons or Daughters Give More Money to Parents in Urban China?" *Journal of Marriage and Family* 71 (1): 174–186. https://doi.org/10.1111/j.1741-3737.2008.00588.x.

Yang, Haiou. 1992. "Population dynamics and kinship of the Chinese rural elderly: A microsimulation study." *Journal of Cross-Cultural Gerontology* 7, no. 2 (April): 135–150. https://doi.org/10.1007/BF00115941.

Ye, Bei, Yingxin Xu, Wing Kit Chan, Zhongyan Zhang, Sophia Lobanov-Rostovsky, Natasha Curry, Eric John Brunner, and Jing Liao. 2024. "Why are people with dementia overlooked in long-term care insurance policy in Guangzhou, China?" *BMC Health Services Research* 24, no. 1 (December): 1646. https://doi.org/10.1186/s12913-024-12126-1.

Zagheni, Emilio. 2015. "Microsimulation in Demographic Research." *International Encyclopedia of Social and Behavioral Sciences* 15:343–346.

Zeng, Yi, Linda Gerorge, Melanie Brasher, Danan Gu, and James Vaupel. 2016. "Older Parents Receive Greater Filial Piety and Care from Daughters than Sons in China." *American Journal of Medical Research* 3 (1): 244–272.

Zeng, Yi, Zhenglian Wang, Leiwen Jiang, and Danan Gu. 2008. "Future trend of family households and elderly living arrangement in China." *Genus* 64 (1/2): 9–36.

Zhang, Yuan, Qian Song, and Jen-Hao Chen. 2022. "Cumulative (Dis)Advantage in Cognitive Health: Rural/Urban Residency, Hukou, and Cognitive Aging in Older Chinese." *Innovation in Aging* 6, no. Supplement_1 (November): 170–171. https://doi.org/10.1093/geroni/igac059.678.

Zhang, Zhenmei. 2006. "Gender Differentials in Cognitive Impairment and Decline of the Oldest Old in China." *The Journals of Gerontology: Series B* 61, no. 2 (March): S107–S115. https://doi.org/10.1093/geronb/61.2.S107.

Zhou, Maigeng, Haidong Wang, Xinying Zeng, Peng Yin, Jun Zhu, Wanqing Chen, Xiaohong Li, et al. 2019. "Mortality, morbidity, and risk factors in China and its provinces, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017." *Lancet (London, England)* 394, no. 10204 (September): 1145–1158. https://doi.org/10.1016/S0140-6736(19)30427-1.

Zhou, Zhangjun, Ashton M Verdery, and Rachel Margolis. 2019. "No Spouse, No Son, No Daughter, No Kin in Contemporary China: Prevalence, Correlates, and Differences in Economic Support." *The Journals of Gerontology: Series B* 74, no. 8 (October): 1453–1462. https://doi.org/10.1093/geronb/gby051.

Figures

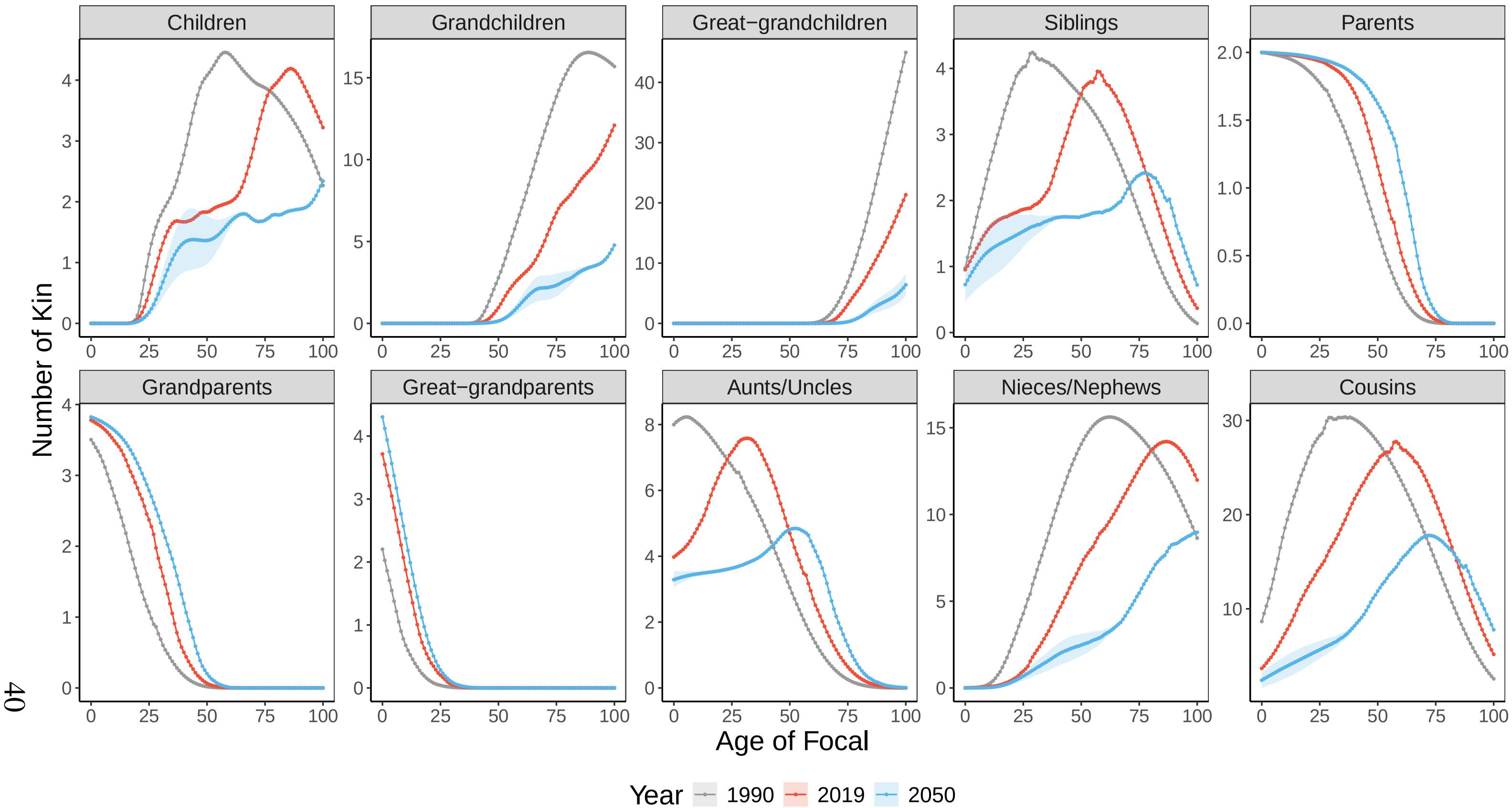

Figure 1. Expected Numbers of Kin of Various Kinds as a Function of the Age of Focal in 1990, 2019, and 2050

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition; GBD 2019 Dementia Forecasting Collaborators (Nichols et al. 2022).

Notes: The figure presents the expected numbers of living kin of various types as a function of the age of Focal in 1990, 2019, and 2050, respectively. The living kin are estimated from the time-varying kinship model using period age-specific fertility and mortality rates from 1950 to 2050 from the UN's 2022 Revision of World Population Prospects (United Nation 2022). The results in a particular year reflect the changing mortality and fertility schedules in China from 1950 up to that year. The methodology is described in the Materials and Methods section. To estimate the number of all kinds of kin from both paternal and maternal ancestry, we assume that the demographic rates of female and male kin are equal. The shaded areas on the 2050 projection indicate the range of uncertainty in the estimates resulting from different WPP fertility scenarios.

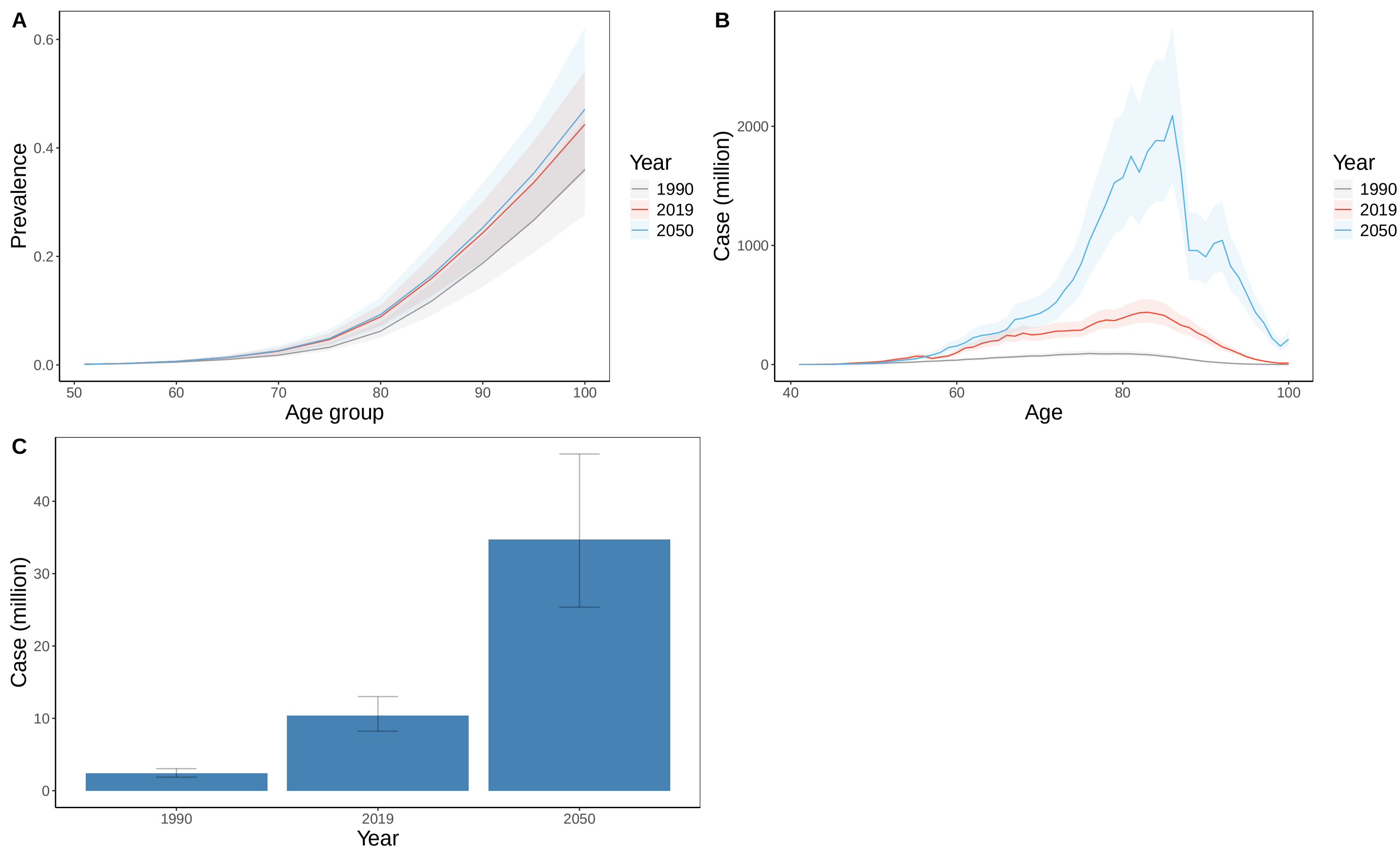

Figure 2. (A) Projected Age-Specific Dementia Prevalence Rate and the Number of Dementia Cases in 1990 and 2019, and 2050 (B) Projected Number of Dementia Cases by Age in 1990, 2019, and 2050. (C) Projected Total Number of Dementia Cases (in millions) in 1990, 2019, and 2050.

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA: IHME, 2021. GBD 2019 Dementia Forecasting (Nichols et al. 2022).

Notes: Panel A shows the age-specific prevalence rate of dementia in 1990, 2019, and 2050; Panel B shows the number of dementia cases (in million) in 1990, 2019, and 2050; and Panel C shows the total number of dementia cases (in million) in 1990, 2019, and 2050. These numbers are calculated using dementia prevalence estimates from the GBD 2019 Dementia Forecasting Collaborators (Nichols et al. 2022). The shaded areas and error bars indicate the range of uncertainty in the dementia prevalence estimates resulting from different GBD scenarios.

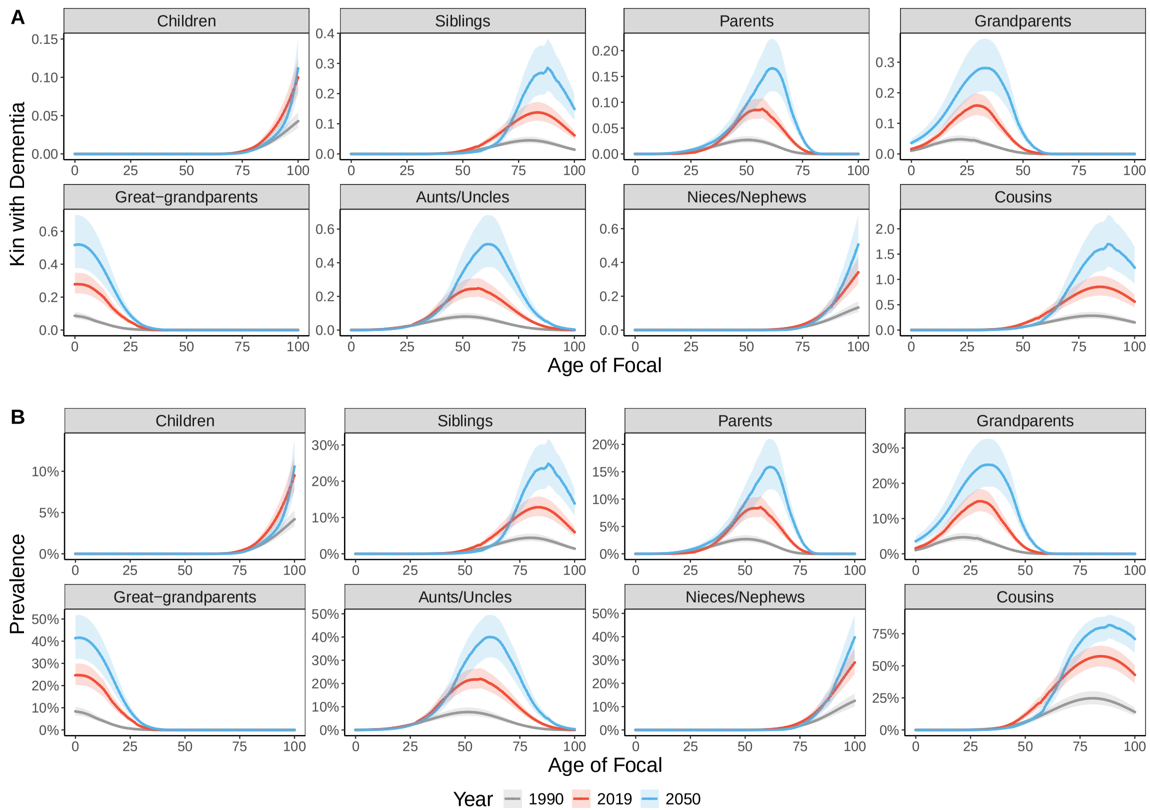

Figure 3. (A) Estimated Number of Kin with Dementia as a Function of the Age of Focal in 1990, 2019, and 2050. (B) Estimated Probabilities of Having at Least One Kin with Dementia as a Function of the Age of Focal in 1990, 2019, and 2050.

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: Section A presents the count of kin, categorized by kin type, with dementia for an individual by the age of that individual in the years 1990, 2019, and 2050. Section B shows the probability that an individual has a certain type of kin with dementia by the age of the individual in 1990, 2019, and 2050. These numbers are estimated from time-varying age-specific fertility, mortality, and prevalence of dementia in the population. The estimation details are described in the Methods section. The shaded areas for the blue lines indicate the range of uncertainty in the estimates resulting from different GBD dementia prevalence and WPP projected fertility scenarios. The shaded areas for the red and gray lines indicate the range of uncertainty in the estimates resulting from different GBD dementia prevalence scenarios.

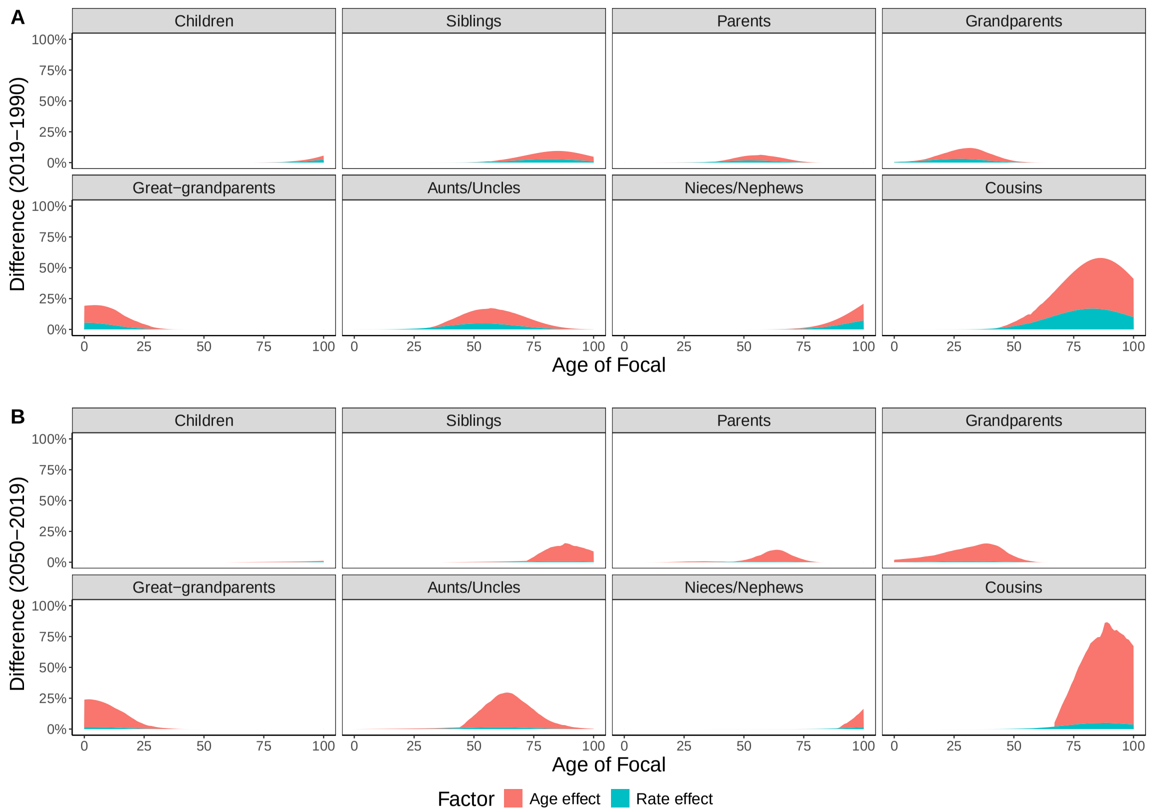

Figure 4. (A) Decomposition of the Difference in the Number of Kin with Dementia between 1990 and 2019. (B) Decomposition of the Difference in the Number of Kin with Dementia between 2019 and 2050.

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: Sections A and B present the Kitagawa's decomposition results. The total area of each graph gives the difference in the number of kin with dementia between 1990 and 2019 (A), 2019 and 2050 (B), partitioned into contributions from the difference in age structure of kin and the difference in age-specific dementia rate.

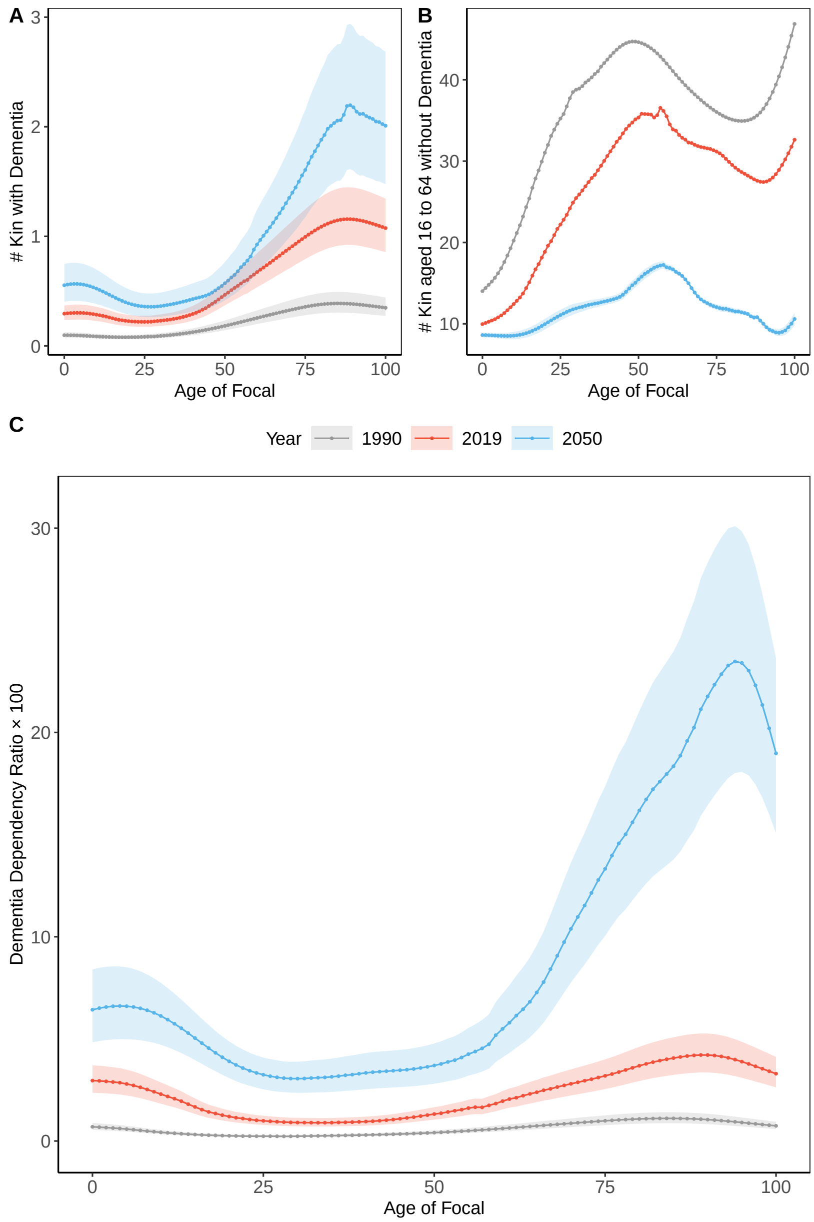

Figure 5. (A) The Number of Kin with Dementia. (B) The Number of Kin Aged 16–64 without Dementia. (C) The Dementia Dependency Ratio (DDR(x)) as a Function of the Age of Focal in 1990, 2019, and 2050.

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: These figures show the estimated number of kin with dementia, the number of kin aged 16-64 without dementia, and the estimated dementia dependency ratio (DDR) by age of individuals in 1990, 2019, and 2050. DDR refers to the proportion of family members with dementia to family members without dementia who are at risk for providing family care. The mathematical definition of DDR is discussed in the Methods section. The shaded areas for the blue lines indicate the range of uncertainty in the estimates resulting from different GBD dementia prevalence and WPP projected fertility scenarios. The shaded areas for the red and gray lines indicate the range of uncertainty in the estimates resulting from different GBD dementia prevalence scenarios.

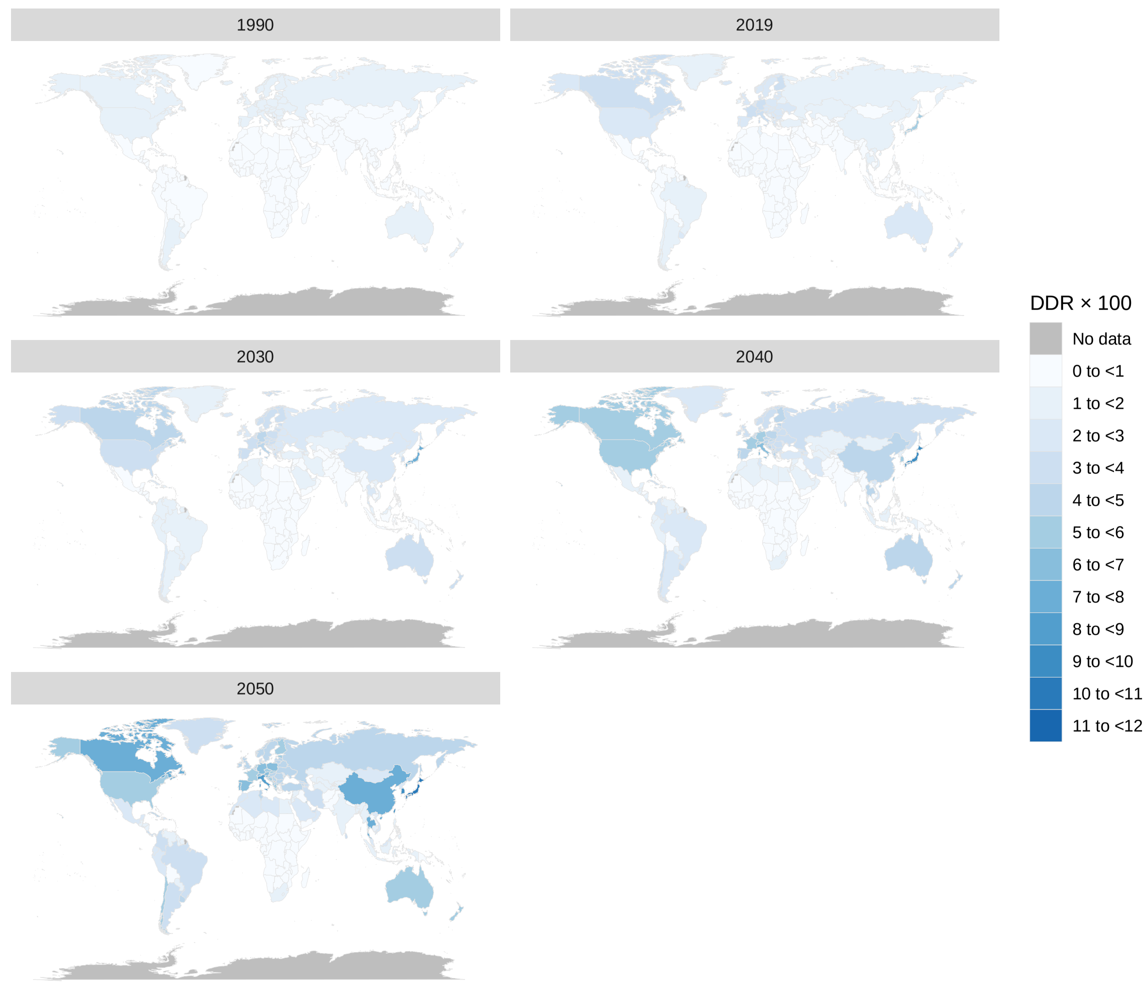

Figure 6. Population-Level Dementia Dependency Ratio DDR$_{\text{pop}}(t)$ Across Countries and Regions in 1990, 2019, 2030, 2040, and 2050

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA:

IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition; GBD 2019 Dementia Forecasting Collaborators (Nichols et al. 2022).

Notes: This figure presents five heat maps of $\mathrm{DDR}_{\mathrm{pop}}(t)$ for countries of the world in 1990, 2019, and 2050. We apply the method used for estimating the DDR index for China to other countries. The indexes draw on dementia data from GBD 2019 Dementia Forecasting Collaborators and data of fertility and mortality rates in the UN's 2022 Revision of World Population Prospects (United Nation 2022). A darker blue color indicates a higher caregiving burden caused by dementia on kinship groups, whereas a lighter blue color indicates a lower caregiving burden caused by dementia on kinship groups. The detailed DDR estimates are presented in Appendix Table S3.

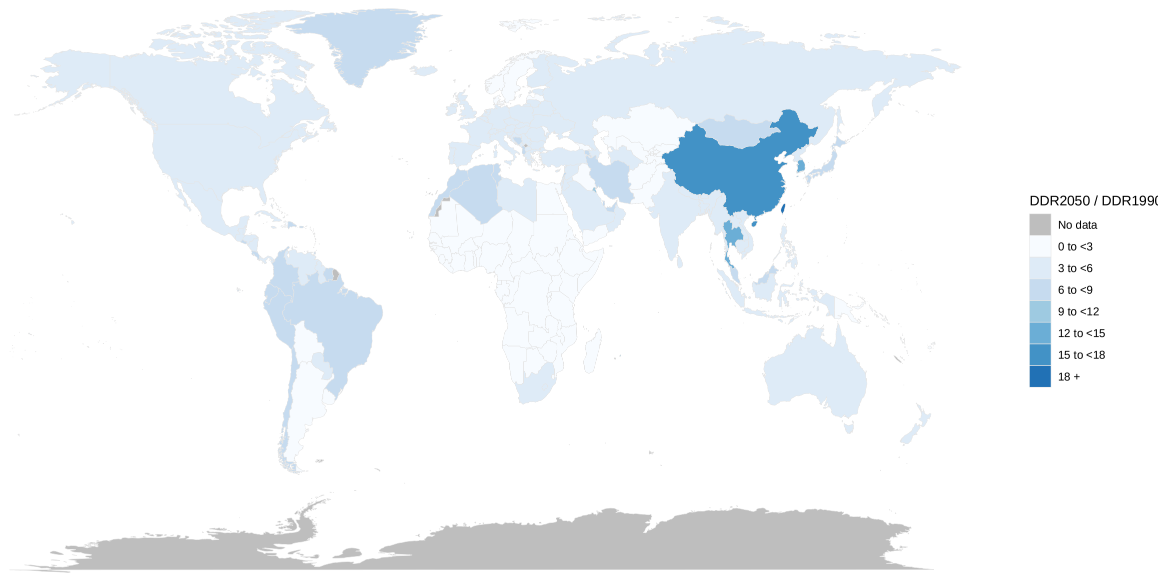

Figure 7. Change in the Population-Level Dementia Dependency Ratio Across Countries and Regions from 1990 to 2050

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: This figure presents a heat map of changes in the population-level Dementia Dependency Ratio (DDR) from 1990 to 2050 across 194 countries. We apply the method used for estimating DDR in China to other countries and calculate the ratio of DDR in 2050 relative to that in 1990. A dark blue color indicates a rapidly increasing dementia burden on kin, whereas a light blue color indicates a slowly increasing burden caused by dementia on kin over time.

Supplementary appendix for

The Present and Future Dementia Burden in China: Kinship-Based Projections and Global Comparisons

This PDF file includes:

Data Description

Figs. S1 to S3

Tables S1 to S3

References and Notes

Contents

1 Input Data Used for Kinship Estimates

1.1 Demographic Inputs for Analysis

The World Population Prospects (WPP) 2022 serves as the primary data source for the analysis. The kinship models utilize annual single-year age-specific fertility and mortality rates spanning the years from 1950 to 2100 for 195 countries and territories. As we discussed in the Materials and Methods section, the time-varying kinship model also relies on a time-zero boundary condition $\mathbf{k}(x, 0)$, which was obtained by the distribution of mother's ages at childbirth at time 0 implied by the stable population assumption (see equation (3) in Caswell (2019)). Specifically, we derived this distribution by dividing age-specific birth counts by the total number of births in a specific year.

1.2 Data Sources and Estimation Methods

The age-specific demographic estimates for the years 1950 to 2022 are derived from a comprehensive range of data sources, including 2,890 nationally representative sample surveys, 1,758 censuses, vital registration systems, and surveys conducted between 1950 and 2022. The WPP 2022 applies additional techniques such as smoothing and adjustment methods to address missing values and generate single-year estimates. These methods aim to enhance the accuracy and reliability of the demographic data used in the analysis.

1.3 Population Projection Method

The WPP 2022 employs probabilistic projection methods to project population changes from 2022 to 2100. This projection method takes into consideration historical patterns in migration, death, and fertility rates. Various estimates are produced by the WPP 2022 based on different assumptions, allowing for a range of possible population scenarios. For our calculations, we rely on the medium-variant projection, as it represents the most likely future trend among the different projections presented by the WPP 2022.

1.4 Medium-Variant Projection

The medium scenario, based on the WPP medium-variant projection, takes into account specific trends for fertility and life expectancy. It predicts a continued decline in fertility rates in countries where women have, on average, two or more children during their lifetime. Conversely, it assumes a slight increase in fertility rates in countries where women are currently having fewer than two children. Additionally, the medium scenario assumes a general improvement in life expectancy across all countries. Demographic rates based on these assumptions jointly determine the projected population changes in the medium-variant projection.

1.5 Methodological Details

For a more detailed explanation of the methodologies utilized in the World Population Prospects 2022, we recommend referring to the WPP 2022 Methodology Report (United Nation 2022a). This report provides comprehensive descriptions and insights into the specific methodologies employed in estimating historical and projected fertility and mortality rates. The Materials and Methods section in our main text provides an overview of the demographic models of kinship utilized in our analysis. However, for a more comprehensive introduction to the models and additional model extensions, we recommend referring to the series of publications on the formal demography of kinship (Caswell 2019, 2020, 2022; Caswell and Song 2021). These publications delve into detailed explanations and advancements related to the demographic models employed in our study.

2 Dementia Prevalence

2.1 Dementia Prevalence Inputs, Definition, and Interpolation

Our analyses draw on datasets of female age-specific prevalence rates of Alzheimer's and other dementia (hereafter referred to as dementia) for 195 countries and territories. These prevalence rates, covering the years 1990, 2019, 2030, 2040, and 2050, were estimated by the Global Burden of Disease (GBD) 2019 Dementia Forecasting Collaborators and published in Nichols et al. (2022) (see also GBD 2019 Collaborators (2021) and Nichols et al. (2019)).

It is important to note that the dementia prevalence rates used for 1990 and 2019 exhibit a slight deviation from the estimates provided in the online GBD Results Tool. The online GBD Results Tool employs a narrower definition, excluding dementia caused by some clinical diseases. Nichols et al. (2022) adopted a broader definition of dementia, encompassing not only Alzheimer's disease and other dementia but also dementia caused by Down syndrome, Parkinson's disease, clinical stroke, and traumatic brain injury. We followed the inclusive definition of dementia in this study as it enables a more comprehensive assessment of the overall burden of dementia (GBD 2019 Dementia Collaborators and others 2021).

The original dementia prevalence provided by the GBD Dementia Collaborators is grouped into five-year age intervals. We applied linear interpolation to estimate the prevalence rates for single-year age groups up to the age of 100.

2.2 Data Sources and Estimation Methods

The GBD (2019) systematically collected all available data on dementia prevalence from cross-sectional studies, cohort studies, and administrative claims databases. The GBD 2019 identified 522 sources that reported on dementia prevalence, covering 18 out of 21 world regions. In the case of China, the prevalence estimate was derived from 43 empirical studies. All the data sources used in the GBD 2019 are accessible at: http://ghdx.healthdata.org/gbd-2019/

data-input-sources.

To estimate dementia prevalence by age, sex, and year for 195 countries and territories, the GBD study utilized the Disease Modelling Meta-Regression (DisMod-MR) 2.1, a Bayesian meta-regression tool commonly used for nonfatal modelling (Flaxman, Vos, and Murray 2015). In addition to the prevalence input, two country-level covariates were incorporated into the analysis. Age-standardized education was considered as a proxy for general brain health, which could potentially have a protective effect against dementia. Age-standardized smoking prevalence was also included as a covariate, as existing literature has shown a positive relationship between smoking and dementia.

The data sources for Western Europe, East Asia, high-income Asia-Pacific, and high-income North America were more abundant compared to other regions. However, there was a lack of available input data for Oceania, central Asia, or southern sub-Saharan Africa. To address this limitation, the GBD 2019 used predictions based on surveys that collected data on cognitive tests and functional limitations. This approach aimed to expand data coverage and provide additional information in regions where data on dementia prevalence were scarce.

The DisMod-MR 2.1 model incorporated these covariates and leveraged information from locations within the same region that had available data to generate estimates for locations with little or no input data. This methodology allowed for more comprehensive estimation of dementia prevalence across various regions.

2.3 Dementia Prevalence Projection

To project dementia prevalence rates beyond 2019, our analysis relied on forecasted rates for 2030, 2040, and 2050 from data provided in Nichols et al. 2022 (Nichols et al. 2022) by the GBD 2019 Dementia Forecasting Collaborators. The forecasting method involves two key components: (1) forecasting dementia prevalence attributable to risk factors and (2) forecasting risk-deleted dementia prevalence. The final total forecasted dementia prevalence was obtained by combining these two components.

The GBD first forecasted changes in the prevalence of dementia from 2019 to 2050 attributable to three well-known risk factors: high body-mass index, high fasting plasma glucose, and smoking. Additional risk factors, such as low physical activity, high blood pressure, low education, alcohol use, and exposure to air pollution, were evaluated for their association with dementia prevalence. If these risk factors demonstrated significance and their effect direction aligned with previous evidence, they were included in the forecasting model. The GBD first forecasted the prevalence of these risk factors from 2019 to 2050 and then predicted risk-attributable dementia prevalence globally, by world region, and by country.

To quantify risk factors other than education, the GBD developed a summary exposure value (SEV), which is a risk-weighted prevalence of a particular risk factor exposure. SEV values range from 0 to 1, with a value of 0 indicating no risk in a population and a value of 1 indicating a maximum risk. The GBD first computed the yearly rate of change in SEV on a logit scale for different locations, age groups, sexes, and previous years. Future rates of change were estimated using a weighted average of previous rates observed throughout the time series. Years closer to the projected year were given higher weights, indicating their greater influence on the estimation. Conversely, more distant years were assigned lower weights, implying their relatively lesser impact on the projected rates of change.

For predicting risk-deleted dementia prevalence, the GBD used linear regression models for males and females separately. The model included 5-year age groups, world region, and years of education as predictors. Years of education are assumed to be unchanged after the age of 25 and are held constant within a specific birth cohort based on location and sex.

In order to account for uncertainty, the GBD 2019 employed an additional method of conducting 1,000 draws at each calculation step. This approach enabled the propagation of uncertainty arising from different sources, including input data, correction for measurement errors, and estimates of nonsampling error. The resulting 95% uncertainty intervals were defined as the range between the 2.5th and 97.5th ordered values of the draws. For our analysis, we utilized the mean prevalence estimate derived from these 1,000 draws as the point estimate.

3 Uncertainty Interval

In our analysis, estimate uncertainty can arise from two sources: the projections of age-specific dementia prevalence and the projections of vital statistics. For our dementia prevalence projections, we use Nichols et al. (2022), which provide mean estimates as well as lower and upper bounds of the estimates. These bounds are not confidence intervals but uncertainty intervals that represent the 2.5th and 97.5th values of the ordered draws from Bayesian models. This uncertainty is reflected in our projections of total dementia cases, as shown in Figure 2.

For our vital statistics projections, we rely on the medium scenario projections from the UN's World Population Prospects (WPP) 2022. According to the WPP, the medium scenario "corresponds to the most likely population projection based on several thousand simulated future trends, each one based on distinct trajectories of fertility and mortality for individual countries and areas."

The WPP provides multiple fertility projection scenarios. We incorporate both low and high fertility scenario projections alongside the medium scenario estimates. The high fertility scenario projects a TFR that is 0.5 births above the medium scenario, while the low fertility scenario projects a TFR that is 0.5 births below the medium. This uncertainty is reflected in our 2050 kinship network projections, as shown in Figure 1.

The WPP only provides a single scenario for future mortality changes, which assumes a continued decline in death rates and an increase in life expectancy. We use this scenario in kinship projections.

Since our estimate of dementia caregiving burden involves both dementia prevalence and the size of the kinship network, extra consideration is required when calculating the lower and upper bounds. We combine low fertility estimates with high dementia prevalence to represent the lower bound, as this scenario reflects fewer younger generation kin members who could potentially serve as caregivers, alongside a high demand for caregiving from the older generation. In contrast, the upper bound combines high fertility with low dementia prevalence, representing a scenario with a larger younger generation of kin members and lower caregiving demands for the older generation. These uncertainties are now reflected in Figure 3 and Figure 5.

For the decomposition analysis and calculation of $\mathrm{DDR}_{\mathrm{pop}}(t)$, we use medium scenario projections for vital statistics and mean estimates for dementia prevalence throughout the analysis.

4 Replication Package

Link:

5 Figures and Tables

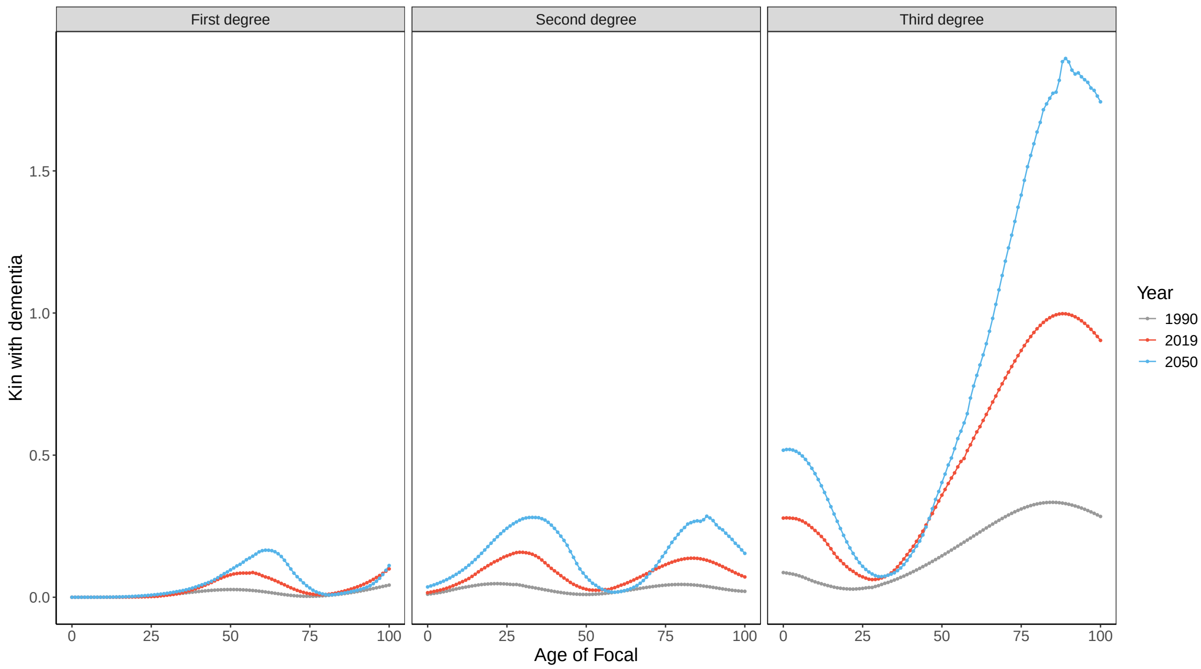

Fig. S1. Estimated Number of Kin with Dementia, by Degrees of Relatedness, as a Function of the Age of Focal in 1990, 2019, and 2050

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition; GDB 2019 Dementia Forecasting Collaborators (Nichols et al. 2022).

Notes: The figure shows an individual's numbers of first-degree kin, second-degree kin, and third-degree kin with dementia by age of the individual in 1990, 2019, and 2050, respectively. First-degree kin include children and parents; second-degree kin include grandchildren, grandparents, and siblings; and third-degree kin include great-grandchildren, great-grandparents, aunts, uncles, nieces, and nephews.

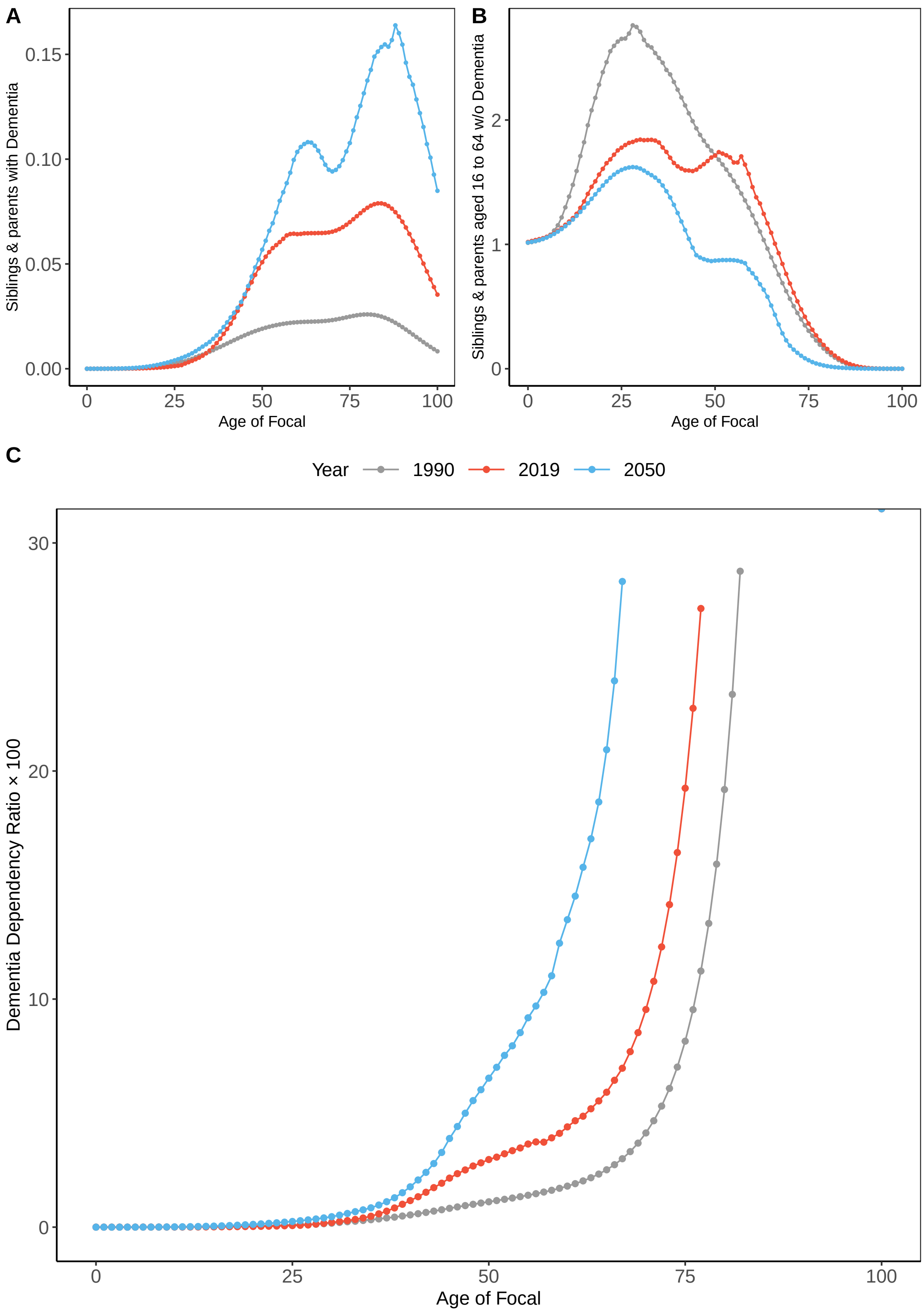

Fig. S2. (A) The Number of Parents with Dementia. (B) The Number of Siblings Aged 16–64 Without Dementia. (C) The Dementia Dependency Ratio (DDR(x)), restricted to

parents and siblings, as a Function of the Age of Focal in China in 1990, 2019, and 2050.

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: These figures show the estimated number of siblings and parents with dementia, the number of siblings and parents aged 16-64 without dementia, and the estimated dementia dependency ratio (DDR) by the age of Focal in 1990, 2019, and 2050. The DDR refers to the proportion of siblings and parents with dementia to siblings and parents without dementia who are at risk for provide family care, conditioning on the survival of Focal. To calculate the DDR, the denominator is the number of siblings aged 16 to 64 without dementia, while the numerator is the number of parents with dementia, irrespective of their age. The mathematical definition of DDR is discussed in the Materials and Methods section.

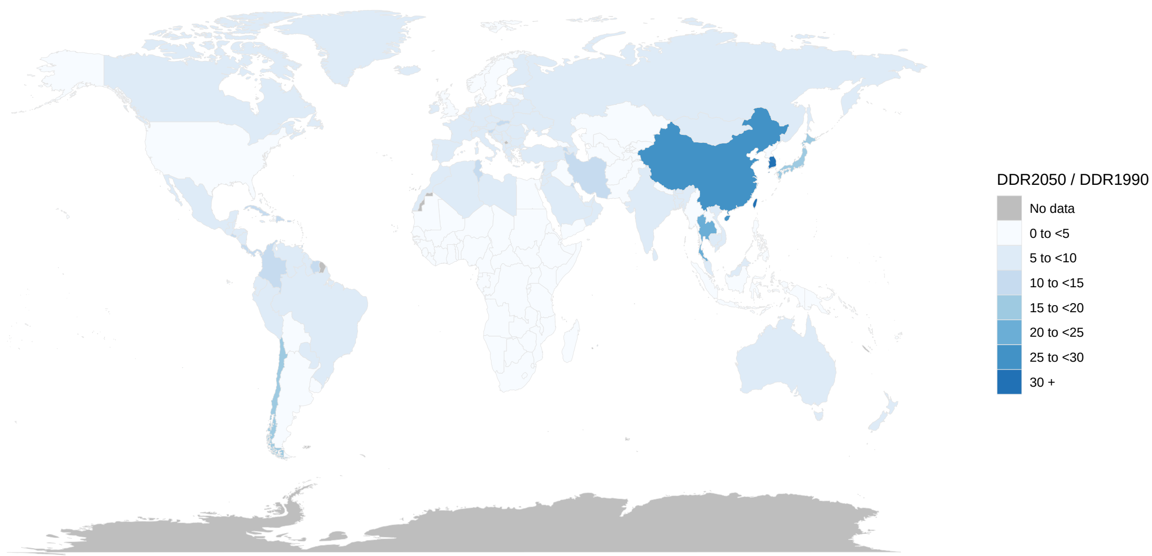

Fig. S3. Change in the Population-Averaged Dementia Dependency Ratio DDR(pop) by Country and Region from 1990 to 2050, Limiting Kin Types to Parents and Siblings

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition; GDB 2019 Dementia Forecasting Collaborators (Nichols et al. 2022).

Notes: This figure presents a heat map of change in DDR(pop) by country from 1990 to 2050. As a robustness check, in this graph we limit the kin types to parents and siblings, conditioning on the survival of Focal. To calculate the DDR(x), the denominator is the number of siblings aged 16 to 64 without dementia, while the numerator is the number of parents and siblings with dementia, irrespective of their age. We apply the method used for estimating the DDR(x) index for China to other countries. The indexes draw on dementia data from GDB 2019 Dementia Forecasting Collaborators and data of fertility and mortality rates in the UN's 2022 Revision of World Population Prospects (United Nation 2022b). A darker blue color indicates a rapidly increasing dementia burden on kin, whereas a lighter blue color indicates a slowly increasing burden caused by dementia on kin over time.

Table S1. Data Sources for Kinship and Dementia Estimates

Data Source	Data Type	Sex	Year	Age Range
(1) Mortality, q_x				
UN's 2022 World Population Prospects	Survey record/Estimate	Female	1950–2021	0–100
UN's 2022 World Population Prospects	Medium variant	Female	2022–2050	0–100
(2) Fertility, f_x				
UN's 2022 World Population Prospects	Survey record/Estimate	Female	1950–2021	15–49
UN's 2022 World Population Prospects	Medium variant	Female	2022–2050	15–49
(3) Alzheimer's disease and other dementias				
GDB 2019 Dementia Forecasting Collaborators	Meta analysis/Estimate	Female	1990, 2019, 2050	0–100

Notes: The medium-variant projection refers to the median of several thousand distinct trajectories of each demographic component derived using the probabilistic model of the variability in changes over time based on the Population Division of the UN; The Global Burden of Disease (GBD) uses the Bayesian meta-regression tool to estimate prevalence rate, and provide the mean value out of 1,000 draws from their model. We used a revised dementia prevalence estimates and the 2050 projection directly from the GDB 2019 Dementia Forecasting Collaborators. Compared to the estimates from the GBD 2019 public database, the estimates we used also include dementia that is caused by other clinical diseases such as clinical stroke, Parkinson's disease, Down syndrome, and traumatic brain injury. See details in (Nichols et al. 2022). We use the mean-value estimation of dementia prevalence throughout our analysis. The input data sources for estimating dementia prevalence in China was derived from a meta-analysis of 43 peer-reviewed journal articles.

Table S2. Expected Number of Kin in Named Type for a Randomly Selected Individual by Age and Year

Focal's Age at 0										
Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
1990	0	0	0	0.98	2	3.50	2.20	8.00	0	8.66
2019	0	0	0	0.95	2	3.78	3.72	3.98	0	3.68
2050	0	0	0	0.73	2	3.82	4.30	3.29	0	2.42
Focal's Age at 10										
Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
1990	0	0	0	2.47	1.96	2.71	0.68	8.05	0.21	18.59
2019	0	0	0	1.57	1.99	3.49	1.88	4.83	0.08	7.38
2050	0	0	0	1.23	1.99	3.64	2.38	3.46	0.02	3.80
Focal's Age at 20										
Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
1990	0.13	0	0	3.69	1.87	1.57	0.13	7.23	2.45	26.10
2019	0.07	0	0	1.79	1.96	2.82	0.47	6.53	0.45	12.35
2050	0.03	0	0	1.44	1.97	3.17	0.71	3.56	0.33	5.04
Focal's Age at 30										
Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
1990	1.78	0	0	4.21	1.65	0.69	0.01	6.25	6.37	30.3
2019	1.20	0	0	1.94	1.89	1.70	0.06	7.57	1.99	16.60
2050	0.58	0	0	1.61	1.93	2.33	0.09	3.75	1.09	6.25
Focal's Age at 40										
Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
1990	2.77	0.07	0	3.97	1.23	0.18	0	4.76	10.64	30.12
2019	1.67	0.01	0	2.60	1.70	0.50	0	6.78	4.40	21.70
2050	1.33	0	0	1.74	1.84	1.19	0	4.15	1.93	8.19

Year	Children	Grandchildren	Great-grandchildren	Siblings	Parents	Grandparents	Great-grandparents	Aunts/Uncles	Nieces/Nephews	Cousins
Focal's Age at 50										
1990	4.08	2.79	0	3.58	0.68	0.02	0	3.05	14.06	27.72
2019	1.83	0.96	0	3.61	1.16	0.06	0	4.70	7.11	25.70
2050	1.36	0.14	0	1.76	1.62	0.20	0	4.81	2.47	11.89
Focal's Age at 60										
1990	4.42	7.08	0.07	3.06	0.22	0	0	1.50	15.57	23.63
2019	2.00	2.91	0	3.81	0.52	0	0	2.71	9.18	27.11
2050	1.67	1.26	0	1.83	1.12	0.01	0	4.31	3.08	15.19
Focal's Age at 70										
1990	3.99	11.75	2.92	2.28	0.03	0	0	0.52	15.17	18.14
2019	2.87	5.04	0.84	3.20	0.11	0	0	1.15	11.45	24.14
2050	1.70	2.17	0.05	2.17	0.27	0	0	2.17	4.37	17.66
Focal's Age at 80										
1990	3.71	15.49	12.64	1.34	0	0	0	0.11	13.76	11.91
2019	3.96	7.69	5.84	2.20	0	0	0	0.31	13.64	17.98
2050	1.79	2.69	1.02	2.38	0.01	0	0	0.61	6.67	16.61
Focal's Age at 90										
1990	3.15	16.53	28.16	0.55	0	0	0	0.01	11.6	6.33
2019	4.04	9.47	12.68	1.13	0	0	0	0.05	14.05	10.92
2050	1.88	3.45	3.42	1.77	0	0	0	0.11	8.30	13.38

Data sources: United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition.

Notes: The table presents the expected number of kin of various kinds for a Focal individual at ages 0, 10, 20, 30, 40, 50, 60, 70, 80, and 90 living in 1990, 2019, and 2050. The estimation details are described in the Methods section. This table corresponds to Figure 1 in the main text.

Table S3. Dementia Dependency Ratios and Change in Dementia Dependency Ratios by Country and Year

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
Afghanistan	0.28	0.36	0.41	0.49	0.64	1.28	1.80	2.31
Albania	0.80	1.66	2.39	3.80	5.97	2.08	3.61	7.49
Algeria	0.38	0.74	1.15	1.74	2.81	1.94	3.78	7.33
American Samoa	0.44	0.55	0.73	1.02	1.38	1.24	2.52	3.13
Andorra	1.64	2.88	3.60	5.20	7.56	1.76	2.62	4.61
Angola	0.36	0.36	0.38	0.43	0.51	1.02	1.39	1.42
Antigua and Barbuda	0.70	1.42	2.13	3.11	4.24	2.04	2.99	6.09
Argentina	1.11	1.74	1.93	2.33	3.01	1.57	1.73	2.72
Armenia	0.78	1.67	2.38	3.39	4.89	2.15	2.93	6.28
Australia	1.31	2.70	3.56	4.70	5.71	2.06	2.12	4.36
Austria	1.35	2.59	3.54	4.77	6.22	1.91	2.40	4.60
Azerbaijan	0.58	0.97	1.30	2.07	3.11	1.67	3.22	5.37
Bahamas	0.58	1.10	1.55	2.19	2.98	1.89	2.70	5.11
Bahrain	0.54	0.95	1.40	2.20	3.53	1.76	3.73	6.56
Bangladesh	0.28	0.46	0.70	1.07	1.66	1.68	3.57	5.99
Barbados	0.67	1.45	2.13	3.00	3.59	2.17	2.48	5.39
Belarus	1.40	1.99	2.43	3.21	4.46	1.42	2.24	3.19
Belgium	1.46	2.75	3.29	4.06	4.88	1.87	1.78	3.33
Belize	0.46	0.61	0.81	1.13	1.70	1.34	2.80	3.74
Benin	0.32	0.30	0.31	0.35	0.40	0.93	1.33	1.23
Bermuda	0.84	2.41	3.49	4.86	5.86	2.86	2.43	6.94
Bhutan	0.22	0.33	0.47	0.74	1.27	1.48	3.79	5.63
Bolivia (Plurinational State of)	0.33	0.45	0.52	0.67	0.89	1.34	2.00	2.68
Bosnia and Herzegovina	0.91	1.91	2.70	4.13	5.81	2.10	3.05	6.40
Botswana	0.35	0.40	0.48	0.64	0.90	1.14	2.24	2.55
Brazil	0.60	1.25	1.79	2.62	3.80	2.08	3.04	6.31
Brunei Darussalam	0.42	0.80	1.09	1.69	2.57	1.91	3.20	6.12
Bulgaria	1.37	2.15	2.54	3.29	4.25	1.57	1.97	3.11
Burkina Faso	0.28	0.26	0.27	0.31	0.37	0.91	1.42	1.30
Burundi	0.29	0.29	0.30	0.34	0.39	1.01	1.34	1.35
Côte d'Ivoire	0.24	0.26	0.28	0.33	0.41	1.06	1.57	1.67
Cabo Verde	0.27	0.58	0.83	1.30	2.13	2.12	3.68	7.79
Cambodia	0.30	0.51	0.68	0.94	1.30	1.74	2.53	4.41
Cameroon	0.34	0.29	0.29	0.32	0.39	0.86	1.36	1.16
Canada	1.58	3.05	4.45	5.97	7.22	1.93	2.36	4.57
Central African Republic	0.39	0.40	0.40	0.40	0.42	1.03	1.04	1.07
Chad	0.30	0.25	0.24	0.25	0.28	0.81	1.14	0.93

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
Chile	0.59	1.89	2.61	3.72	5.24	3.18	2.77	8.82
China	**0.41**	**1.69**	**2.70**	**4.67**	**7.21**	**4.17**	**4.27**	**17.81**
China, Taiwan Province of China	0.48	1.89	3.43	5.85	9.11	3.94	4.83	19.06
Colombia	0.43	0.97	1.44	2.17	3.15	2.23	3.26	7.29
Comoros	0.30	0.29	0.32	0.39	0.48	0.97	1.63	1.58
Congo	0.42	0.40	0.42	0.49	0.60	0.96	1.49	1.43
Costa Rica	0.57	1.26	1.76	2.61	3.88	2.20	3.09	6.79
Croatia	1.41	2.74	3.51	4.38	5.47	1.95	2.00	3.89
Cuba	0.74	1.51	2.10	3.18	4.20	2.04	2.78	5.66
Cyprus	0.81	1.77	2.55	3.44	4.59	2.18	2.59	5.64
Czechia	1.28	2.78	3.64	4.61	5.60	2.18	2.01	4.39
Dem. People's Republic of Korea	0.54	1.00	1.35	1.72	2.26	1.83	2.27	4.16
Democratic Republic of the Congo	0.37	0.41	0.40	0.41	0.44	1.09	1.08	1.18
Denmark	1.54	2.27	2.98	3.69	3.96	1.47	1.75	2.56
Djibouti	0.32	0.36	0.44	0.57	0.78	1.11	2.19	2.42
Dominica	0.54	0.73	1.11	1.67	2.35	1.35	3.24	4.38
Dominican Republic	0.34	0.87	1.22	1.66	2.30	2.54	2.65	6.73
Ecuador	0.39	0.96	1.29	1.84	2.64	2.44	2.75	6.72
Egypt	0.64	0.72	0.82	1.10	1.51	1.14	2.08	2.37
El Salvador	0.35	0.81	1.10	1.55	2.25	2.32	2.78	6.45
Equatorial Guinea	0.38	0.39	0.41	0.48	0.57	1.04	1.44	1.51
Eritrea	0.28	0.36	0.43	0.52	0.65	1.31	1.79	2.35
Estonia	1.57	2.84	3.58	4.33	5.56	1.82	1.96	3.55
Eswatini	0.31	0.35	0.36	0.46	0.60	1.11	1.74	1.94
Ethiopia	0.28	0.33	0.39	0.47	0.61	1.17	1.85	2.16
Fiji	0.31	0.50	0.63	0.76	0.94	1.60	1.87	2.99
Finland	1.20	3.03	3.99	4.89	5.42	2.52	1.79	4.51
France	1.32	3.27	3.98	5.02	5.92	2.48	1.81	4.49
Gabon	0.63	0.50	0.53	0.63	0.80	0.80	1.58	1.26
Gambia	0.32	0.33	0.32	0.35	0.42	1.02	1.27	1.30
Georgia	1.15	1.70	1.99	2.49	3.26	1.48	1.92	2.84
Germany	1.42	3.03	4.16	5.19	6.44	2.13	2.13	4.54
Ghana	0.29	0.33	0.39	0.49	0.64	1.15	1.91	2.20
Greece	1.50	2.71	3.26	4.16	5.67	1.80	2.10	3.78
Greenland	0.45	1.22	1.83	2.65	3.23	2.68	2.65	7.10
Grenada	0.48	0.94	1.27	1.68	2.34	1.95	2.50	4.88
Guam	0.45	1.47	2.12	2.79	3.44	3.23	2.34	7.57

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
Guatemala	0.34	0.64	0.76	1.04	1.50	1.89	2.33	4.40
Guinea	0.34	0.33	0.34	0.37	0.44	1.00	1.31	1.30
Guinea-Bissau	0.34	0.30	0.29	0.34	0.40	0.86	1.33	1.15
Guyana	0.31	0.65	0.89	1.20	1.55	2.08	2.39	4.97
Haiti	0.34	0.36	0.41	0.49	0.62	1.07	1.74	1.85
Honduras	0.30	0.47	0.62	0.89	1.29	1.54	2.76	4.25
Hungary	1.38	2.49	3.04	3.77	4.62	1.80	1.85	3.34
Iceland	1.22	2.09	2.65	3.52	4.39	1.72	2.09	3.60
India	0.28	0.46	0.60	0.84	1.20	1.64	2.59	4.25
Indonesia	0.40	0.59	0.76	1.05	1.49	1.50	2.51	3.76
Iran (Islamic Republic of)	0.45	0.85	1.34	2.20	3.93	1.88	4.61	8.65
Iraq	0.56	0.52	0.60	0.75	0.98	0.94	1.87	1.76
Ireland	0.81	1.63	2.18	3.16	4.38	2.01	2.69	5.40
Israel	0.85	1.73	2.09	2.51	2.94	2.05	1.70	3.48
Italy	1.71	3.66	4.70	6.35	8.22	2.15	2.24	4.82
Jamaica	0.54	0.61	0.78	1.18	1.82	1.13	2.98	3.37
Japan	1.31	5.77	7.41	9.07	10.21	4.42	1.77	7.82
Jordan	0.40	0.63	0.87	1.29	1.95	1.59	3.10	4.93
Kazakhstan	0.70	1.01	1.25	1.57	1.94	1.45	1.91	2.77
Kenya	0.34	0.37	0.41	0.49	0.65	1.08	1.75	1.90
Kiribati	0.32	0.43	0.51	0.61	0.74	1.33	1.71	2.28
Kuwait	0.54	1.00	1.56	2.86	5.07	1.83	5.09	9.33
Kyrgyzstan	0.59	0.74	0.89	1.15	1.53	1.26	2.06	2.60
Lao People’s Democratic Republic	0.32	0.39	0.51	0.69	1.00	1.24	2.56	3.16
Latvia	1.68	2.50	2.98	3.44	4.33	1.49	1.73	2.58
Lebanon	0.53	1.42	2.12	3.26	4.70	2.67	3.30	8.81
Lesotho	0.44	0.41	0.41	0.46	0.58	0.93	1.42	1.33
Liberia	0.25	0.28	0.29	0.34	0.40	1.11	1.44	1.60
Libya	0.44	0.63	0.85	1.27	2.07	1.44	3.29	4.74
Lithuania	1.50	2.60	3.28	3.99	4.98	1.73	1.91	3.32
Luxembourg	1.36	2.35	3.01	3.80	4.63	1.72	1.97	3.40
Madagascar	0.26	0.37	0.42	0.53	0.65	1.43	1.76	2.52
Malawi	0.38	0.39	0.40	0.46	0.57	1.02	1.47	1.50
Malaysia	0.38	0.79	1.16	1.67	2.42	2.08	3.07	6.40
Maldives	0.37	0.55	0.85	1.37	2.52	1.49	4.57	6.82
Mali	0.23	0.26	0.26	0.28	0.31	1.09	1.23	1.34
Malta	0.71	2.71	4.24	5.55	7.02	3.83	2.59	9.92

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
Marshall Islands	0.28	0.33	0.42	0.57	0.77	1.19	2.36	2.80
Mauritania	0.26	0.29	0.32	0.38	0.48	1.11	1.63	1.82
Mauritius	0.42	1.23	1.93	2.89	3.87	2.91	3.14	9.13
Mexico	0.48	0.76	0.96	1.40	2.08	1.58	2.73	4.31
Micronesia (Fed. States of)	0.33	0.50	0.65	0.88	1.21	1.50	2.43	3.64
Mongolia	0.34	0.58	0.93	1.44	2.40	1.70	4.15	7.06
Montenegro	1.39	2.13	2.93	3.88	4.90	1.54	2.30	3.54
Morocco	0.41	0.70	1.08	1.71	2.72	1.71	3.91	6.69
Mozambique	0.30	0.29	0.30	0.36	0.42	0.98	1.46	1.42
Myanmar	0.34	0.49	0.64	0.88	1.19	1.43	2.43	3.46
Namibia	0.40	0.49	0.49	0.58	0.71	1.22	1.46	1.79
Nepal	0.27	0.37	0.46	0.62	0.91	1.36	2.44	3.33
Netherlands	1.39	2.75	3.66	4.81	5.33	1.98	1.94	3.84
New Zealand	1.12	2.40	3.44	4.72	5.87	2.14	2.45	5.23
Nicaragua	0.33	0.58	0.84	1.22	1.80	1.80	3.07	5.52
Niger	0.21	0.28	0.28	0.29	0.31	1.31	1.14	1.49
Nigeria	0.27	0.23	0.23	0.25	0.29	0.86	1.25	1.07
North Macedonia	0.89	1.71	2.33	3.46	4.78	1.91	2.79	5.34
Northern Mariana Islands	0.40	0.92	1.41	2.30	3.31	2.32	3.60	8.35
Norway	1.60	2.44	3.04	3.99	4.69	1.52	1.92	2.93
Oman	0.58	0.67	0.86	1.24	2.08	1.17	3.09	3.62
Pakistan	0.27	0.31	0.35	0.42	0.53	1.14	1.70	1.94
Panama	0.56	1.24	1.75	2.40	3.26	2.20	2.63	5.78
Papua New Guinea	0.33	0.37	0.43	0.53	0.69	1.11	1.88	2.08
Paraguay	0.48	0.94	1.16	1.51	1.99	1.95	2.13	4.15
Peru	0.33	0.75	1.04	1.50	2.19	2.26	2.94	6.64
Philippines	0.31	0.53	0.68	0.89	1.15	1.69	2.16	3.65
Poland	1.22	2.68	3.61	4.74	6.22	2.19	2.32	5.08
Portugal	1.10	2.39	3.26	4.54	6.28	2.16	2.63	5.69
Puerto Rico	0.89	2.06	3.13	4.48	6.10	2.32	2.96	6.88
Qatar	0.49	0.79	1.22	1.99	3.40	1.61	4.32	6.95
Republic of Korea	0.66	1.82	3.27	5.67	9.55	2.73	5.26	14.37
Republic of Moldova	1.01	1.25	1.55	2.04	2.67	1.24	2.13	2.64
Romania	1.10	2.08	2.63	3.54	4.73	1.89	2.27	4.29
Russian Federation	1.37	2.00	2.53	3.23	4.26	1.45	2.13	3.10
Rwanda	0.25	0.25	0.31	0.42	0.57	0.99	2.32	2.29
Saint Lucia	0.42	0.62	0.90	1.44	2.38	1.46	3.84	5.60

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
Saint Vincent and the Grenadines	0.54	0.99	1.24	1.87	2.75	1.85	2.77	5.12
Samoa	0.29	0.52	0.64	0.83	1.05	1.82	2.02	3.67
Sao Tome and Principe	0.29	0.36	0.42	0.52	0.64	1.22	1.79	2.18
Saudi Arabia	0.46	0.69	1.05	1.64	2.68	1.49	3.89	5.78
Senegal	0.25	0.30	0.34	0.44	0.58	1.20	1.94	2.34
Serbia	1.28	2.45	2.99	3.82	4.72	1.92	1.93	3.70
Seychelles	0.49	0.98	1.32	1.91	2.75	2.00	2.80	5.58
Sierra Leone	0.34	0.27	0.29	0.33	0.41	0.82	1.50	1.22
Singapore	0.49	2.11	4.35	8.02	11.57	4.30	5.49	23.60
Slovakia	1.14	2.17	3.07	4.27	5.77	1.91	2.66	5.08
Slovenia	1.36	3.39	4.50	5.81	7.58	2.49	2.23	5.56
Solomon Islands	0.31	0.38	0.44	0.54	0.70	1.21	1.85	2.25
Somalia	0.28	0.30	0.30	0.32	0.34	1.07	1.12	1.19
South Africa	0.40	0.74	0.87	1.07	1.36	1.85	1.83	3.40
South Sudan	0.25	0.27	0.29	0.33	0.39	1.09	1.44	1.57
Spain	1.62	2.65	3.38	4.76	6.96	1.64	2.63	4.30
Sri Lanka	0.67	1.15	1.67	2.40	3.29	1.71	2.86	4.91
State of Palestine	0.38	0.59	0.76	1.03	1.44	1.53	2.46	3.77
Sudan	0.40	0.53	0.63	0.77	0.92	1.32	1.74	2.29
Suriname	0.30	0.70	1.04	1.44	1.89	2.36	2.70	6.38
Sweden	1.76	2.58	3.08	3.70	4.08	1.47	1.58	2.32
Switzerland	1.64	3.10	4.04	5.17	6.14	1.89	1.98	3.75
Syrian Arab Republic	0.45	0.64	0.78	1.09	1.49	1.40	2.34	3.28
Türkiye	0.92	1.34	1.91	2.80	4.16	1.46	3.10	4.54
Tajikistan	0.51	0.55	0.62	0.85	1.21	1.08	2.19	2.37
Thailand	0.49	1.52	2.63	4.40	7.02	3.08	4.60	14.18
Timor-Leste	0.25	0.39	0.45	0.53	0.67	1.57	1.71	2.67
Togo	0.24	0.24	0.27	0.32	0.37	1.00	1.56	1.56
Tonga	0.38	0.59	0.70	0.87	1.09	1.56	1.86	2.90
Trinidad and Tobago	0.46	1.11	1.75	2.51	3.57	2.44	3.21	7.82
Tunisia	0.49	1.17	1.70	2.54	4.03	2.39	3.43	8.21
Turkmenistan	0.48	0.63	0.78	1.07	1.49	1.30	2.36	3.08
Uganda	0.29	0.23	0.23	0.27	0.34	0.77	1.52	1.17
Ukraine	1.51	2.09	2.59	3.36	4.57	1.38	2.19	3.02
United Arab Emirates	0.49	0.77	1.16	1.88	3.32	1.58	4.29	6.76
United Kingdom	1.30	2.10	2.64	3.35	4.04	1.62	1.93	3.12
United Republic of Tanzania	0.34	0.39	0.42	0.50	0.61	1.15	1.58	1.82

	Dementia Dependency Ratio × 100					Fold Change in DDRs		
	1990	2019	2030	2040	2050	1990 to 2019	2019 to 2050	1990 to 2050
United States of America	1.81	2.99	3.96	5.06	5.87	1.65	1.96	3.25
Uruguay	1.51	2.33	2.62	3.15	4.09	1.55	1.76	2.72
Uzbekistan	0.56	0.65	0.82	1.14	1.66	1.16	2.54	2.95
Vanuatu	0.30	0.47	0.55	0.67	0.87	1.56	1.85	2.88
Venezuela (Bolivarian Republic of)	0.42	0.84	1.06	1.42	1.84	2.01	2.19	4.40
Vietnam	0.54	1.01	1.38	2.00	2.99	1.88	2.97	5.58
Yemen	0.50	0.43	0.45	0.54	0.74	0.87	1.71	1.48
Zambia	0.34	0.27	0.28	0.34	0.44	0.80	1.62	1.30
Zimbabwe	0.35	0.38	0.39	0.47	0.57	1.10	1.48	1.62

Data sources: Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease (GBD) Study 2019. Seattle, WA: IHME, 2021; United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022 Revision, Online Edition; GDB 2019 Dementia Forecasting Collaborators (Nichols et al. 2022) .

Notes: The table presents dementia dependency ratios (DDRs) for 195 countries and territories in 1990, 2019, 2030, 2040, and 2050 and changes in DDRs between years. We measure the DDR by the ratio of kin with dementia to kin without dementia in working ages (16–64). The DDR can be interpreted as a measure of the possible caregiving burden that kin with dementia place on kin without dementia in working ages. We estimate the DDR for each age group and then weight it by the age distribution of the total population in the observed year to derive the overall burden at the population level.

References

Caswell, Hal. 2019. "The Formal Demography of Kinship: A Matrix Formulation." *Demographic Research* 41:679–712.

———. 2020. "The Formal Demography of Kinship II: Multistate Models, Parity, and Sibship." *Demographic Research* 42:1097–1144.

———. 2022. "The Formal Demography of Kinship IV: Two-sex Models and Their Approximations." *Demographic Research* 47:359–396.

Caswell, Hal, and Xi Song. 2021. "The Formal Demography of Kinship III: Kinship dynamics with time-varying demographic rates." *Demographic Research* 45:517–546.

Flaxman, Abraham D, Theo Vos, and Christopher JL Murray. 2015. "An integrative metaregression framework for descriptive epidemiology."

GBD 2019 Collaborators. 2021. "Global mortality from dementia: Application of a new method and results from the Global Burden of Disease Study 2019." *Alzheimer's & Dementia: Translational Research & Clinical Interventions* 7 (1): e12200.

GBD 2019 Dementia Collaborators and others. 2021. "The burden of dementia due to Down syndrome, Parkinson's disease, stroke, and traumatic brain injury: a systematic analysis for the Global Burden of Disease Study 2019." *Neuroepidemiology* 55 (4): 286–296.

Nichols, Emma, Jaimie D Steinmetz, Stein Emil Vollset, Kai Fukutaki, Julian Chalek, Foad Abd-Allah, Amir Abdoli, Ahmed Abualhasan, Eman Abu-Gharbieh, Tayyaba Tayyaba Akram, et al. 2022. "Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019." *The Lancet Public Health* 7 (2): e105–e125.

Nichols, Emma, Cassandra EI Szoeke, Stein Emil Vollset, Nooshin Abbasi, Foad Abd-Allah, Jemal Abdela, Miloud Taki Eddine Aichour, Rufus O Akinyemi, Fares Alahdab, Solomon W Asgedom, et al. 2019. "Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016." *The Lancet Neurology* 18 (1): 88–106.

United Nation. 2022a. *World Population Prospects 2022: Methodology of the United Nations population estimates and projections.* United Nations, Department of Economic / Social Affairs, Population Division.

———. 2022b. *World Population Prospects: The 2022 Revision.* United Nations, New York.