Projection for dementia burden in China to 2050: a macro-simulation study by scenarios of dementia incidence trends

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The Lancet Regional Health - Western Pacific 2024;50: 101158

Published Online 30 July 2024

https://doi.org/10.1016/j.lanwpc.2024.101158

Summary

Background It is unclear how temporal trends in dementia incidence, alongside fast-changing demography, will influence China's future dementia burden. We developed a Markov model that combines population trends in dementia, mortality, and dementia-related comorbidities, to forecast and decompose the burden of dementia in China to 2050.

Methods Population-based Chinese ageing cohorts provided input data for a 10-health-state Markov macrosimulation model, IMPACT-China Ageing Model (CAM), to predict sex- and age-specific dementia prevalence among people aged 50+ by year to 2050. We assumed three potential future scenarios representing the range of likely dementia incidence trends: upward (+2.9%), flat (0%) or downward (–1.0%). Sensitivity analyses were conducted to examine uncertainty associated with trends in mortality rates and CVD incidence. The projected dementia burden was decomposed into population growth, population ageing, and changing dementia prevalence corresponding to the three incidence trend scenarios.

Findings Under the upward trend scenario, the estimated number of people living with dementia is projected to rise to 66.3 million (95% uncertainty interval (UI) 64.7–68.0 million), accounting for 10.4% of the Chinese population aged 50+ by 2050. This large burden will be lower, 43.9 (95% UI 42.9–45.0) million and 37.5 (95% UI 36.5–38.4) million, if dementia incidence remains constant or decreases. Robustness of the projection is confirmed by sensitivity analyses. Decomposition of the change in projected dementia cases indicates dominate effects of increasing dementia prevalence and population ageing, and a relatively minor contribution from negative population growth.

Interpretation Our findings highlight an impending surge in dementia cases in China in the forthcoming decades if the upward trend in dementia incidence continues. Public health interventions geared towards dementia prevention could play a pivotal role in alleviating this burgeoning disease issue.

Funding National Science Foundation of China/UK Economic and Social Research Council.

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Keywords: Dementia prevalence projection; Modelling study; Decompose analysis; Dementia incidence trend; China

Research in context

Evidence before this study

We systematically reviewed studies published between 1st January 2020, and 31st October 2023 on projections of future dementia incidence in China, searching PubMed Database using terms "dementia", "projection", "forecasting", "simulation", "model", and "China", with no language restrictions. Additional hand searches of reference lists were conducted. Results were inconsistent: two macro-simulation modelling studies (2021, 2022) suggest a future dementia burden of 45~49 million by 2050. A microsimulation study (2017) predicts half this number. We found that most projections do not consider the influence of epidemiological trends on dementia incidence. Rising incidence is observed in several Chinese population-scale studies. If the increasing trend is not an artefact of diagnostic practices, there are implications for the future health of the older population, and for social care requirements. Estimation of dementia burden should take into account the interplay of changing dementia prevalence, population ageing, and population growth.

Added value of this study

Our study provides three projections and decomposition of China's future dementia burden to 2050, derived from a probabilistic population-based 10-health-state Markov model, IMPACT-China Ageing Model (CAM). We used the best available data from nationwide longitudinal ageing cohorts, accounting for dementia-related morbidities, and key temporal trends in dementia incidence. In a worst-case scenario (2.9% relative annual increase), we project there will be 66.3 (95% Uncertainty Interval (UI) 64.7–68.0) million people living with dementia by 2050. The forecasted dementia cases are 1.5 times greater than those projected under a flat incidence scenario (0% change), which has been the primary assumption for most previous projections. If dementia incidence declines by 1.0% annually, the number of dementia cases would be lower than most previous estimates (37.5, 95% UI 36.5–38.4 million) in 2050. Future growth in dementia burden is mainly driven by the rapidly ageing population and rising dementia prevalence.

Implications of all the available evidence

Our projection provides a broad perspective on the public health and social challenges posed by the future burden of dementia in China. If the observed rise in dementia continues, there would be a greater surge in dementia cases than earlier predictions. Implementing effective interventions to counteract this escalating incidence trend could reduce this burden considerably.

Introduction

Expansion of the global ageing population has increased the number of older people living with dementia, requiring considerable support from family, caregivers and society. Of the estimated 51.6 million individuals living with dementia worldwide in 2019, over a quarter (13.1 million) are in China.[1] Its associated annual socioeconomic cost of dementia is estimated at $47 billion.[2] Well-designed predictions of future dementia trends in China are urgently needed to formulate appropriate policy interventions.

Estimates of China's future dementia burden have mainly been generated via extrapolation methods based on published studies.[3] Few macro-[4,5] and micro-[6] simulation models have attempted to derive more reliable estimates of transition probabilities between health and disease (Appendix p 10). However, findings of these simulations are inconsistent. Two macro-simulation studies suggest a future dementia burden of 45–49 million by 2050,[4,5] while a prior microsimulation study predicted half this number.[6]

Besides the model structure and input data on starting prevalence and transition probabilities, model-based forecasts rely on assumptions of key epidemiological trends. Prior studies have not considered the joint impact of dementia-related diseases such as cardiovascular diseases (CVD) and disability on dementia.[7] CVD is the leading cause of death and disability-adjusted life-years in China,[8] which share common risk factors with dementia[9] and stroke doubles the risk of dementia.[10] Further, most current forecasts do not consider the influence of epidemiological trends on dementia incidence. They primarily assumed a constant incidence trend, with only few considering a declining trend to reflect hypothetical intervention effects.[4,6] Cumulating population-scale evidence indicates that dementia incidence is rising (Appendix p 11). The magnitude of this rise is non-trivial,[11,12] and if this trend continues, the implications for health and social care in China may be considerable. Estimation of dementia burden should take into account the interplay of changing dementia prevalence, population ageing and population growth.

This study aims to forecast the future dementia burden in the Chinese population to 2050 using the best available representative data, considering CVD and disability as influential related morbidities, and capturing key temporal trends in dementia incidence, ranging from continuous upward, flat to downward trends. We explore the main drivers of dementia burden by decomposing dementia increasing cases into population growth, population ageing, and changing dementia prevalence.

Methods

Model design

The methodological framework of IMPACT-BAM (a UK-based model)[7,13] was adapted to develop a counterpart IMPACT-CAM (China Ageing Model). IMPACT-CAM is a population-based discrete-time probabilistic Markov model that follows the progression of the Chinese population aged 35–100 years through eight health states characterized by the presence or absence of cognitive impairment, CVD, disability, and two states for death from CVD and non-CVD causes to 2050. Transitions of the population across these ten states are governed by age-, sex- and calendar year-specific transition probabilities (TPs) per year, with a new disease-free cohort of 35-year-olds entering into the model annually (Appendix p 6–7). Our modelling approach is reported following the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER, Appendix p 12).

Data sources

We derived the required inputs for IMPACT-CAM from the best available data (Appendix p 4), including two population-representative ageing cohorts, the China Health and Retirement Longitudinal Study (CHARLS),[14] approved by the Ethical Review Committee of Peking University (IRB00001052-11015) and the Chinese Longitudinal Healthy Longevity Study (CLHLS), authorized by the research ethics committee of Peking University (IRB00001052-13074).[15] All survey respondents provided their informed consent before participating. CHARLS and CLHLS adhere to rigorous research design, with high response rates, repeat measures on the age-related functional domains, and good national representativeness of the Chinese ageing population. Cohort profiles are documented in high-impact journals.[14,15] Sample selection and sociodemographic characteristics are shown in Appendix p 21, 14 and 15. For each study sample, participants with missing key variables on sociodemographic characteristics (age, sex and education) and health states (CVD, FI and dementia) over repeat measures were less than 5% and assumed missing at random. Survey weights are applied to guarantee the participants form a national representative sample. Individual weights are calculated as the inverse of sampling probabilities (conditional probability of selection of country, village, household and individual), incorporated with non-response in each eave estimated at the household and individual levels by logit regressions. Detailed procedures for sampling weight calculation have been published.[14]

Age- and sex-specific population estimates from the latest United Nations (UN) statistics (2022) were combined with prevalence data from CHARLS (2011–2018, N = 25,041) to populate all states at the model baseline (survey mid-point, 2015) in Appendix p 20. UN population projections to 2050 were used to generate the assumed disease-free input population of 35 years old. TPs between health states (i.e. incidence or recovery rates) were derived from CHARLS; while TPs from each health state to CVD- or non-CVD death were derived from CLHLS (2002–2005 and 2014–2018, N = 39,747, with records on causes of death), which were combined with UN and GBD mortality projections to generate population-level estimates. Detailed methods on data sources and inputs calculations are presented in Appendix pp 3–9.

Multi-health state definition and measure

The 10 states include eight health-related states (i.e. disease-free, cognitive impairment (CI), disability or functional impairment (FI) and CVD, and their combinations), and two cause-specific death states: CVD or non-CVD death. Data sources used in each input parameter of different states were shown in Appendix p 16.

CI is defined as impairment in two or more domains of cognitive function. Common latent cognitive domains (i.e. orientation, memory, executive function and language) were identified via confirmatory factor analysis on cognitive tests of CHARLS and CLHLS (Appendix p 13),[16] tests of which have been modified to reduce literacy-related items.[15] Impairment in each cognitive domain was defined as a factor score of 1.5 standard deviations or lower below the mean of the population aged 50+ years with the same level of education.[17] To avoid the effect of transient cognitive decline, resulting from delirium or other mental disorders, if the participant improved by 1 SD or more in two or more domains at the subsequent wave,[18] they were considered to not have cognitive impairment.

FI is defined as an inability to independently perform one or more basic activities of daily living (BADL) based on the Katz scale.[19] These activities are key tasks related to self-care, which included bathing, getting in or out of bed, changing clothes, using the toilet, cutting food and eating, controlling urination and bowel movements. Our definition of FI thus captures numbers of people with difficulty maintaining basic self-care independence and require supportive care on daily basis. If participants reported FI once (excluding those in the last wave) but fully recovered to perform BADL independently in all subsequent waves, they were considered to be transient and not categorized as having FI.

Dementia is defined by an algorithmic case definition based on the coexistence of cognitive impairment and functional impairment, or a report of a doctor's diagnosis of dementia or memory-related disease by the participant or caregiver, in line with prior IMPACT-BAM studies.[7,13] Informant reports of doctor diagnosis of dementia help identify cases when participants were unable to participate in the study (i.e. 32% without cognitive scores). We took account of the non-specific CHARLS item on doctor-diagnosed dementia ("Have you been diagnosed with memory-related diseases?")

using the ratio of Parkinson's disease to dementia for China based on the Global Burden of Disease 2019 study.[20] This algorithmic case definition conforms to DSM-5 and ICD-10 criteria in that it hinges on non-transient impairment in two or more cognitive domains, and difficulties with basic daily living activities. Our case definition has been validated against clinical diagnosis in COAST, a multisite cross-sectional survey.[16]

CVD is defined as doctor-diagnosed heart disease, myocardial infarction, stroke and/or angina. CVD death and non-CVD death are defined by the cause of death of the decedent participants. Cause of death was obtained from interviews with the decedents' relatives. We include CVD death and non-CVD death states in the model, as CVD is the leading cause of mortality in China,[8] and fundamentally influences dementia prevalence. Competing risks due to death from non-CVD causes such as cancer and COPD are accounted for through an aggregated non-CVD death state.

Model assumptions and sensitivity analyses

Table 1 presents the main assumptions and justification for IMPACT-CAM. Our literature review (Appendix p 11), indicates that three potential future scenarios would represent the range of likely dementia incidence trends: continuous upward, flat or downward trends. Under the upward trend scenario, we assumed that the dementia incidence would follow a relative annual increase of 2.9%, as an upper limit. The assumption is based on evidence from Shanghai Ageing Studies[11] with a clinical diagnosis of dementia two decades apart (1987/92–2010/16), and a similar education structure of its baseline sample as CHARLS (≤6 years 63.8% vs 69.6%). A similar growth rate was obtained in an independent study based on the CLHLS cohort (2002–2014) of +2.5%.[12] Two alternative scenarios were evaluated against this upward trend scenario, a flat trend scenario with constant age-specific incidence (i.e. 0% annual change) to align with prior projections; and a downward trend with a relative annual decline of 1.0% to reflect potential impact of rising education levels and public health interventions.

A declining trend in CVD and non-CVD mortality in China to 2050 was assumed as evidence by the Global Burden of Disease (GBD) Study 1990–2019 and the United Nation's mortality projection (1990–2050) (Appendix p 22). Further, we assumed that future trends in CVD incidence would parallel the rate of decline in CVD mortality, and FI incidence would remain stable as suggested by prior evidence.[22] Sensitivity analyses were conducted to address future uncertainties in these assumptions, we tested 1) mortality rates remaining constant from 2022 to 2050, contrary to the projected declining trend; 2) CVD incidence maintaining stability after 2015 (without a calendar effect), compared to the modelled declining trend parallel to mortality, and 3) FI incidence decline trend by showed in a recent study.[23]

Model outputs and validation

IMPACT-CAM provides age- and sex-specific cases and prevalence of dementia by year to 2050. Age-standardized dementia prevalence was obtained in reference to China's 2020 Population Census. Monte Carlo simulation was conducted to quantify the effect of parameter uncertainty on IMPACT-CAM outputs. The procedure entailed iterative sampling 1000 times from specified distributions for model input parameters, and a recalculation of outputs to estimate 95% uncertainty intervals (UIs).

To validate model estimates, estimated dementia prevalence was compared with a nationwide survey of dementia in 2018.[24] Estimates of population size and structure were compared with the UN and China's 2020 Population Census, and the projected number of deaths was compared with the National Bureau Statistics from 2016 to 2021. CVD estimates were compared with corresponding GBD data in 2019,[25] and disability prevalence with the newly released CHARLS 2020 report.[23]

Decomposition

The Das Gupta decomposition method[26] was applied to quantify the relative contribution of three factors: population growth, population ageing and dementia prevalence. Decomposition was based on the equation below, used to calculate the standardized impact of each multiplicative factor and their additive contributions (100%) to explain yearly changes in dementia cases from 2020 (reference) to 2050.

$$Dementia\ cases = Pop_y \times \frac{pop_{a,s,y}}{Pop_y} \times \frac{cases_{a,s,y}}{pop_{a,s,y}}$$

a is age, s is sex and y is year; and Pop_y refers to the population growth for age range 0–100. $pop_{a,s,y}$ indicates the population in each age and sex in each year from 50 to 100. $cases_{a,s,y}$ are the dementia cases in each age and sex in each year from 50 to 100. Population ageing is represented by $\frac{pop_{a,s,y}}{Pop_y}$, and dementia prevalence by $\frac{cases_{a,s,y}}{pop_{a,s,y}}$. Dementia prevalence in the formula corresponds to the three scenarios of dementia incidence. Given that the mortality rate was set to be the same in each scenario, differences in dementia cases contributed by dementia prevalence indicate the effect of changing dementia incidence trends.

The model was implemented in R 4.2.2. Detailed modelling methods were provided in Appendix pp 4–9.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

Results

As shown in Fig. 1, under the upward dementia incidence trend scenario (2.9% relative annual increase), the

Assumption	Justification
IMPACT-CAM model is a probabilistic Markov model simulating the health transitions to death in the Chinese population of age 35+. The input data are age- and sex-specific prevalence, and the transition probabilities (TPs) by age, sex and calendar year.	
Population numbers by age and sex	
Baseline population aged 35–100, and future population aged 35 were obtained from the UN (2022). **Assumption 1:** The UN's population projection for China is realistic.	UN (2022) is the latest population projection of China based on the 2020 China Census, reports and surveys by China's national statistical authorities up to 2021.[21]
Projection baseline prevalence	
Age- and sex-specific prevalence of health states at the model baseline were obtained from the China Health Aging and Retirement Longitudinal Study (CHARLS). **Assumption 2:** CHARLS is a representative nationwide ageing survey of China.	In 2011, CHARLS enlisted participants aged 45 years and above via multi-tiered random sampling across China, with the response rate exceeding 85% in biennial follow-up waves (2013, 2015 and 2018). Refreshment cohorts for those aged less than 50 years are periodically introduced to the study. The representativeness of CHARLS was maintained by low attrition rates and weighting.
Four waves of CHARLS data were pooled to estimate the prevalence of health status of the mid-point of the cohort, which is 2015 (projection baseline). This pooling of data was undertaken to enhance statistical power. **Assumption 3:** The pooled data from all waves of CHARLS yields adequate estimates of health state prevalence at the survey's midpoint.	The prevalence of each health status (i.e. cardiovascular diseases (CVD), functional impairment (FI), and dementia) exhibits a linear trend throughout the follow-up waves. The estimated prevalence derived from the pooled CHARLS data aligned with the prevalence values procured at the mid-point of CHARLS (2015) as well as external data, demonstrating a good representation of the Chinese older population.
Assumption 4: The number of individuals in each state is calculated by adding the number of individuals in that state from the previous year and the number of new cases that occurred, and subtracting those who transitioned to another health state or death state according to the transition probabilities (TPs).	Epidemiological concept of Markov models.
Transition probability (TP)	
TPs were obtained as a function of age and sex from incident cases between wave n and n + 1 of CHARLS, based on pooled data attributing to the survey midpoint. **Assumption 5:** The age- and sex-specific TPs (equivalent to incidence) of CVD, FI, and cognitive impairment (CI) of CHARLS are similar to those of the whole Chinese population.	TPs are based on representative populations with sampling weights, providing universal estimates for age and sex combinations, encompassing the combined effects of various variables, including education, marital status and region. TPs or incidence of CVD, FI and CI by age and sex were comparable with age- and sex-specific incidence values obtained from external evidence in the mid-point time.
Assumption 6: CVD and non-CVD mortality of the Chinese Longitudinal Healthy Longevity Study (CLHLS) were similar to those of the entire Chinese population from the National Statistical Bureau.	Cause-specific deaths were provided by CLHLS 2002–2005 and 2014–2018. CLHLS is a nationwide ageing cohort with an adequate response rate. Survey weight was applied to ensure population representativeness. Deaths predicted by IMPACT-CAM matched with Global Burden of Diseases (GBD) estimates (Appendix p 26).
Assumption 7: TPs are considered as a weighted average of the different levels of severity of each disease. Similarly, the survival of people in each health state is assumed to be equivalent to the weighted average survival of people with different severities.	Under the assumption that CHARLS and CLHLS are both population-representative, the observed severity spectrum of conditions (like CVD, or CI) should be proportionate to that of the population. TPs extracted from two cohorts thus represent a weighted average of the severity spectrum of health conditions. Multiplying the weighted average TP by the total number of individuals in a given health state is mathematically equal to the sum of the individual products of severity-specific TPs and the respective population sizes in that health state.
Assumption 8: The model considered the effect of comorbidities such as hypertension, diabetes and BMI et al.	Estimates for risks of dementia, CVD, FI and death of CHARLS and CLHLS represent a weighted average of risk levels across the spectrum of severity of these conditions and their comorbidities.
Calendar trend	
TPs (mortality rates and incidence of CVD and dementia) change over time	
Assumption 9: The downward trends in mortality observed over the past will continue, and life expectancy is expected to increase.	GBD estimates show that CVD and non-CVD mortality rates followed a decline consistently from 1990 to 2019. We assumed this trend would be most likely to continue and applied the cause-specific ratio of CVD/Non-CVD estimated from GBD (1990–2019) to the UN's mortality projection from 2020 to 2050 (Appendix p 22). Along with the reduction in mortality rates, we projected a subsequent increase in life expectancy. To examine the uncertainty of this assumption, we conducted a sensitivity analysis assuming a constant mortality rate from 2022 (Fig. 2).
Assumption 10: The trends in CVD incidence over time align with the cardiovascular mortality trend.	In line with IMPACT-BAM,[7] we assumed the calendar effect of CVD incidence would decline in parallel with the future calendar effect of mortality. Sensitivity analysis was conducted assuming CVD incidence would remain stable after 2015.
Assumption 11: Trends in incidence of CI and dementia would follow three possible future scenarios: upward, flat or downward.	Under the upward trend scenario, we assumed that the dementia incidence would follow a relative annual increase of 2.9%, as an upper limit.[12] A flat trend scenario with constant age-specific incidence (i.e. 0% annual change) to align with prior projections; and a downward trend with a relative annual decline of 1.0% to reflect the potential impact of public health interventions.
Assumption 12: The incidence of functional impairment remains constant over the projection	Given prior studies have shown a stable trend in the incidence of FI in China,[22] no calendar effect of FI was assumed.

(Table 1 continues on next page)

Assumption	Justification
(Continued from previous page)	
Assumption 13: Survival with CVD, dementia, or FI changes in proportion to changes in overall life expectancy.	IMPACT-CAM considers that survival from each health state is indirectly influenced by changes in mortality rates. It is assumed that the ratio of mortality rates for each health state of the model, compared to the general population, is similar to that observed in CHARLS and CLHLS. Therefore, the model's measures of mortality for each health state change are similar with that observed in the overall population.
Competing risk	
Assumption 14: Deaths due to CVD and non-CVD (cancer etc.) and changes in cause-specific mortality are competing risks for the development of dementia cases.	In the context of the model, CVD and non-CVD constitute the terminal states. If an individual die from any cause, they are no longer at risk of developing dementia.

Table 1: **Summary of assumptions of IMPACT-China Ageing Model (CAM).**

number of dementia cases among the Chinese population aged 50+ years is projected to rise from 12.1 (95% UI, 11.9–12.3) million in 2020 to 66.3 (95% UI 64.7–68.0) million accounting for 10.4% of the Chinese population aged 50+ by 2050, an increase of 449.0%. This staggering increase will be reduced to 43.9 (95% UI 42.9–45.0) million and 37.5 (95% UI 36.5–38.4) million, if dementia incidence remains constant or decreases by 1.0% annually, The corresponding dementia prevalence is estimated at 11.0% (95% UI 10.8%–11.3%), 7.2% (95% UI 7.0%–7.4%) and 6.1% (95% UI 6.0%–6.3%), respectively in 2050. After standardizing the population structure to China 2020 Census, the projected prevalence reduces to 6.9% (95% UI 6.8%–7.1%), 4.3% (95% UI 4.2%–4.4%) and 3.6% (95% UI 3.5%–3.6%). Sex- and age-group-specific prevalence of dementia is presented in Appendix p 23.

A constant mortality trend since 2022 would lead to approximately a 15.7% decrease in dementia cases by 2050 due to elevated mortality risks, contrasting with the main analysis. Consistently, the scenario of an upward trend in dementia incidence projects around 78% more cases compared to the scenario with a declining trend. The projected dementia burden is similar in the sensitivity analysis where CVD incidence remains unchanged after 2015. The reduction in the number of dementia cases by 2050 is approximately 5.4% across three scenarios of dementia incidence, compared to the main analysis (Fig. 2). Instead of the assumed a constant FI, a declining trend of FI by 0.36% annually[23] would result in 2.8 million (4% reduction) fewer dementia cases by 2050 (Appendix p 24).

Decomposition of the change in projected dementia cases indicates an overwhelming effect of increasing

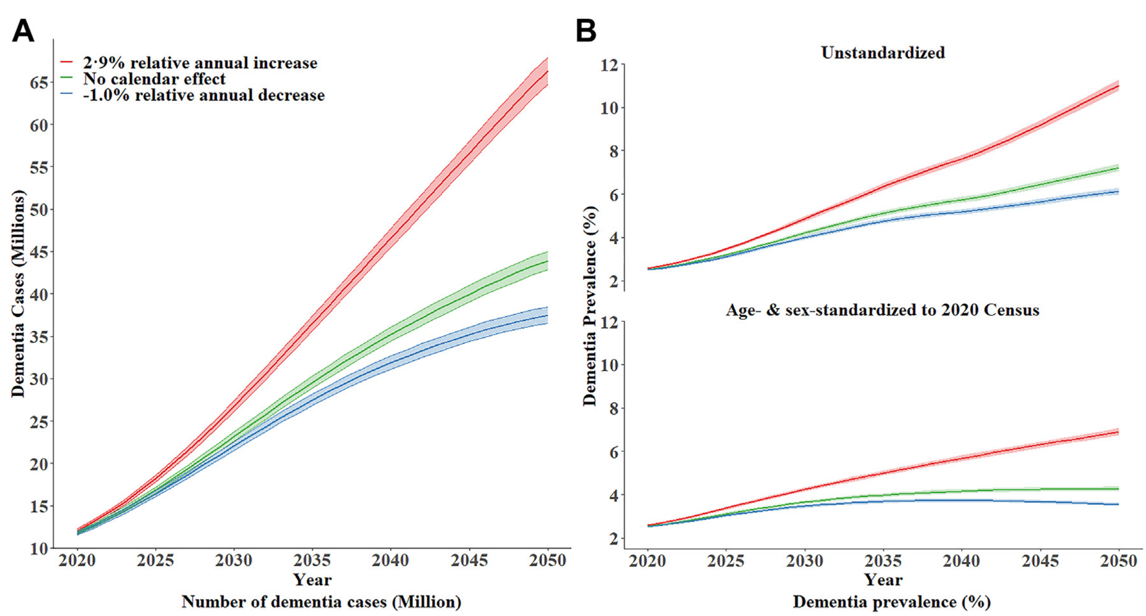
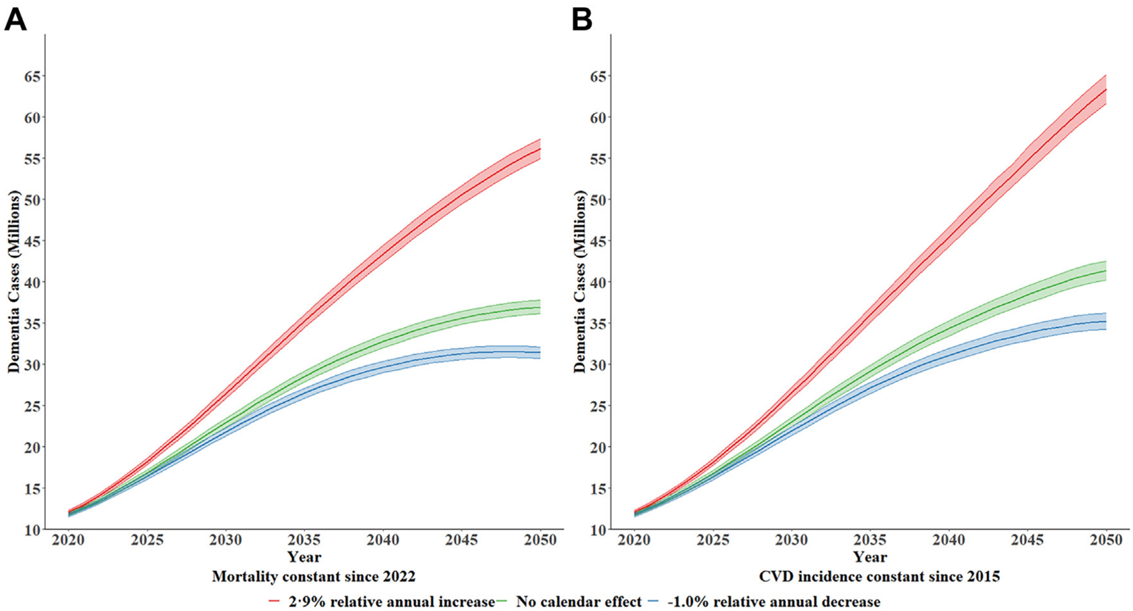


Fig. 1: **Projected number (A) and prevalence of dementia cases (unstandardized and age- & sex-standardized) (B) for the Chinese population aged 50+ years, 2020–2050, forecast under three scenarios of temporal trend in dementia incidence: 2.9% relative annual increase (red line), no calendar effect (green line) and 1.0% relative annual reduction (blue line). Shade indicates 95% uncertainty intervals.**



Model Comparison	Dementia Incidence Scenario	Change% in number of dementia cases 2025	2030	2035	2040	2045	2050
Mortality Constant vs Declining	2·9% relative annual increase	0·1	-1·2	-3·5	-6·7	-10·7	-15·3
	No calendar effect	0·1	-1·1	-3·5	-6·8	-10·9	-15·8
	-1·0% relative annual decrease	0·1	-1·1	-3·5	-6·9	-11·1	-16·1
CVD Constant vs Declining	2·9% relative annual increase	-0·3	-0·8	-1·5	-2·3	-3·3	-4·4
	No calendar effect	-0·2	-0·5	-1·3	-2·3	-3·8	-5·7
	-1·0% relative annual decrease	-0·2	-0·5	-1·2	-2·3	-3·9	-6·0

Fig. 2: **Sensitivity analysis with alternative assumption on constant mortality rate since 2022 (A) or constant CVD incidence since 2015 (B). The table below indicates the number of dementia cases changed (%) between sensitivity and main analyses for three dementia incidence trend scenarios**.

dementia prevalence and population ageing, and a fairly small effect of negative population growth. Fig. 3 illustrates these relative contributions against three dementia incidence scenarios. In reference to 2020, if dementia incidence continues to increase by 2.9% annually, the dementia prevalence will contribute to 31.4 million dementia cases by 2050, 5.8 million more than that of population ageing. Turning this upward trend of dementia incidence to a flat or downward would lessen by a third to a half, respectively.

Key model outputs were validated against empirical data. The estimated age-sex-specific dementia prevalence for 2018 was compatible with findings from the nationwide cross-sectional COAST study (Appendix p 25).[24] Our model outputs on population size from 2016 to 2019 match well with the UN's estimates, with a similar population age structure as the 2020 Census (Appendix p 26). Our sex-specific annual estimates of CVD and non-CVD death cases from 2015 to 2019 are also in line with GBD (Appendix p 27). Model estimates on CVD and disability were also close to the current best evidence (Appendix p 19).

Discussion

Our macro-simulation modelling study, based on population-representative cohorts, provides three projections and a decomposition of China's future dementia burden to 2050. Our findings highlight an impending surge in dementia cases in China in the forthcoming decades if the upward trend in dementia incidence continues. Future growth in dementia burden is mainly driven by the rapidly ageing population and rising dementia prevalence.

Deriving model parameters from the best available nationwide ageing cohorts, our prevalence and TP estimates offer a more accurate representation of the Chinese population compared to prior studies reliant on provincial surveys[4] or adjustments based on global estimations.[5] We used a consistent algorithmic dementia case definition across survey waves, which overcomes biases due to heterogeneity between studies and changes in diagnostic practices over time.[27]

We refined China's dementia projections by modelling a continuous rise in dementia incidence rate, alongside scenarios of constant and decreasing

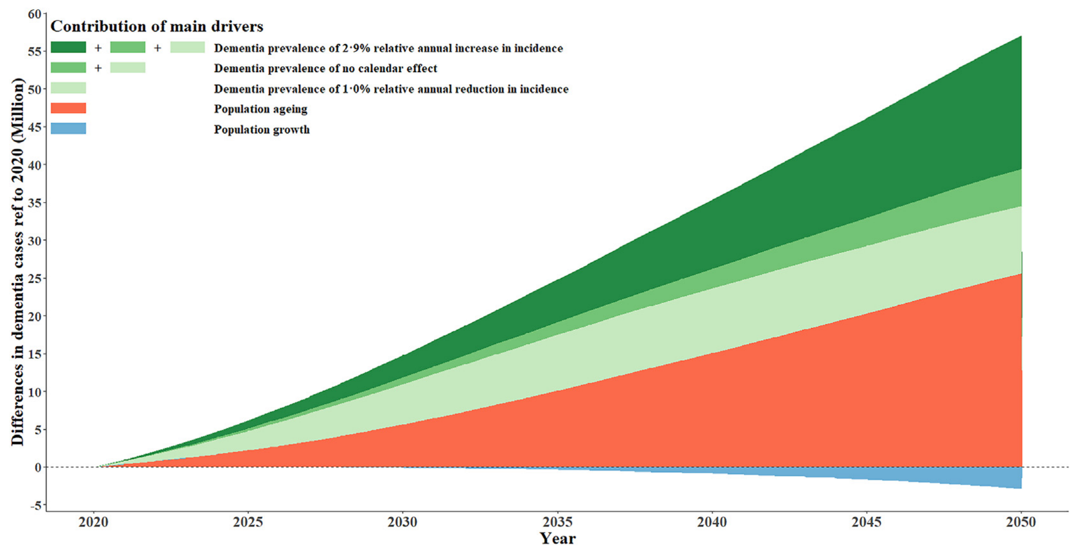


Fig. 3: **Composition of annual changes in dementia cases of the Chinese population aged 50 + years between 2020 (ref) and 2050 by dementia prevalence of three incidence scenarios, population ageing and population growth**.

incidence trends, to capture eventual disease occurrence. Under the upward incidence scenario, the forecasted dementia cases are estimated to be up to 1.5 times greater than those projected under the assumption of a constant incidence rate, which has been the primary basis for most previous projections (Appendix p10). Few studies have examined the temporal trend in dementia incidence in China.[28] The population-scale evidence supports an upward trend over recent decades. Regional studies conducted in Shanghai[11] and Beijing,[29] involving clinical diagnoses, suggest an upward trajectory in dementia incidence spanning from 1987 to 2016. Similar findings were observed in the nationwide CLHLS study between 2002 and 2014.[12] A recent cross-country analysis utilizing GBD data identified China, Singapore, Japan and several other East Asian countries among those experiencing statistically significant rises in dementia incidence between 1990 and 2019, with China showing an acceleration in annual incidence change rate from 2010 to 2019.[30] This finding is in agreement with a prior meta-analysis that a stabilizing or decreasing dementia incidence was found in Western high-income countries, while reverse trends occurred in high-income countries of other regions like Japan.[31] Given China and Japan have similar cultural and demographic profiles, it is possible that with the economic growth, China follows a similar dementia incidence trend as Japan. Utilizing multi-state models to address missing data due to death bias, the corresponding growth rate in the UK is estimated at 2.8% for 2008–2016.[32]

Potential explanations for this rising trend, other than heightened awareness and diagnosis, include unhealthy urban lifestyles, increased metabolic risk, particularly diabetes and obesity, reduced competing risks of premature death, and improved survival rates following stroke.[33,34] We utilized the trend estimation from the Shanghai Aging Studies,[11] whereby the putative rise in dementia incidence occurred despite improvement in the educational attainment of study participants (from 31% to 88% with >6 years of education). Considering lower education levels and a higher incidence of dementia in rural compared to urban areas,[35] along with the escalating prevalence of adult obesity, diabetes, and unhealthy lifestyles,[36] the upward trend in dementia incidence may persist. Consequently, we projected the associated dementia burden to reflect a worst-case scenario.

Our study is one of the few to forecast the future burden of dementia in China by synthesizing the combined effects of dementia, CVD and disability, while considering competing mortality risks over time. Although previous projections[4,5] have considered the relative risk of death, the complex interplay between dementia and its associated comorbidities, prevalent among older adults, is largely overlooked. Our modelling approach enhances earlier projections by simultaneously addressing the dynamics arising from extended life expectancy and a population susceptible to dementia and CVD, which share determinants[9] and are interrelated with functional impairmentAmong the total projected dementia cases, around 42% combine with CVD across three scenarios, and these proportions would increase 1.4 times if the future trend in CVD incidence stabilizes rather than declines. Additionally, changing FI incidence trend or survival rates of CVD would impact the number of people with dementia. According to our sensitivity analysis, declining

FI or elevated CVD mortality risks would result in 4% or 15% less dementia cases. Nonetheless, the projected disparity between scenarios based on upward versus downward dementia incidence trends remains notably huge, signifying that the trajectory of future dementia incidence holds greater influence over the projected dementia burden than the trend in mortality rates and FI incidence trend.

Furthermore, we assessed the significance of dementia incidence concerning population growth and ageing. Our decomposition analysis indicates that the anticipated overall burden of dementia will predominantly escalate due to dementia prevalence and population ageing. In contrast, the impact of negative population growth plays a relatively smaller role. This finding expands upon the GBD's assessment for East Asia[5] by emphasizing that the escalating prevalence of dementia will have an impact on future dementia burden in China that is comparable to the influence of population ageing. While dementia remains incurable, interventions in public health targeting metabolic, cerebrovascular, and lifestyle-related risk factors could potentially delay or prevent the onset of up to 40% of dementia cases.[9] Our projections under the downward trend scenario reinforce this notion, indicating that a 1.0% annual decline in dementia incidence would halve the forecasted burden compared to the worst-case scenario. This reduction could be achieved by modifying cardiovascular and metabolic risk factors, which are estimated to have greater population impacts in China than in high-income countries.[37]

Several limitations should be noted. First, CHARLS and CLHLS participants were not clinically screened for dementia, and we define dementia as an umbrella state for different stages and types of this syndromic disease. This approach does not account for the severity and specific cause of dementia, and allows only for estimation across all conditions. However, our algorithmic case definition, following DSM-5 and ICD-10 criteria, leverages objective cognitive data, information on self-reported difficulties with daily living activities, and informant reports of cognition for non-participating individuals. This method minimizes biases concerning changes in diagnostic and screening practices over time,[27] and is relevant to health and social care policy as it forecasts overall numbers of older adults who would require supportive care. Cognitive assessment used, while grounded in standardized and validated tests, may lack comprehensiveness. This could potentially lead to the oversight of cognitive impairments in untested domains, thereby underestimating cases of dementia. Similarity between our estimation with COAST suggests the potential bias is small.[16]

Second, we assumed an overall time trend for dementia incidence and did not consider potential varying trends across age groups or education levels. Evidence regarding age- or education-specific temporal trends for dementia incidence in China remains limited (Appendix p 11). The dementia incidence trend is driven mainly by trends in older age groups[38] and those with low education attainment[11] where a majority of incident cases would occur. Although care should be exercised to interpret the projected dementia cases in younger age groups, total projected dementia cases would not be greatly affected. The IMPACT-CAM model has the capacity to accommodate updates to input parameters, thereby allowing for revisions in predicting the burden of dementia as new information becomes available.

Third, the present study did not consider potential future changes in dementia risk factors. Our modelling strategy is to incorporate scenario and sensitivity analyses examining different trends of mortality and disease incidence reflecting the composite trend of these risk factors. The Markov model used in this study serves as a platform to assess the impact of changes in risk factors on the future burden of dementia through scenario modelling.[39,40] Last, our projection estimates an overall dementia prevalence for China by sex and age only, the geographic variation of this general estimation deserves further examination.

Conclusion

Our projection provides a broad perspective on the public health and social challenges posed by the future burden of dementia in China. If the observed rise in dementia incidence continues, there would be a greater surge in dementia cases than earlier predictions. This considerable growth is driven by the rapidly ageing population and rising dementia prevalence. Effective and timely interventions addressing the escalating trend of dementia incidence could alleviate this burgeoning disease issue. Our model has important policy implications for assessing the future scale of dementia prevalence, and could be used as a benchmark for measuring the impact of possible dementia prevention strategies.

Contributors

EJB and JL contributed to the conception of the study and the study design, and obtained the research funding to support this study and provided continual supervision. YYL and YJW contributed to the data curation and the statistical analyses. YXL and MRZ contributed to the data and code check. PB, YTC and SLR contributed to the interpretation of the data. YYL and JL accessed and verified the data, wrote the initial version of the manuscript. DRX, XQW, YTH and EF revised the manuscript. All authors had full access to all the data in the study and EJB and JL had final responsibility for the decision to submit for publication.

Data sharing statement

Citations for the data used in the study can be accessed (Appendix p 3). The raw data and code for IMPACT-CAM will be available from the lead and corresponding authors.

Declaration of interests

The authors have no conflicts of interest to disclose.

Acknowledgements
This study was supported by the National Science Foundation of China/the Economic and Social Research Council, UK Research and Innovation joint call: Understanding and Addressing Health and Social Challenges for Ageing in the UK and China. UK–China Health and Social Challenges Ageing Project (UKCHASCAP): present and future burden of dementia, and policy responses. (Grant number 72061137003, ES/T014377/1). We would like to acknowledge the China Health and Retirement Longitudinal Study (CHARLS) team and the Chinese Longitudinal Healthy Longevity Study (CLHLS) team for providing high-quality, nationally representative data.

Appendix A. Supplementary data
Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101158.

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