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Research Paper

The Impact of Alzheimer's Disease on the Chinese Economy

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ABSTRACT

Background: Recent increases in life expectancy may greatly expand future Alzheimer's Disease (AD) burdens. China's demographic profile, aging workforce and predicted increasing burden of AD-related care make its economy vulnerable to AD impacts. Previous economic estimates of AD predominantly focus on health system burdens and omit wider whole-economy effects, potentially underestimating the full economic benefit of effective treatment.

Methods: AD-related prevalence, morbidity and mortality for 2011–2050 were simulated and were, together with associated caregiver time and costs, imposed on a dynamic Computable General Equilibrium model of the Chinese economy. Both economic and non-economic outcomes were analyzed.

Findings: Simulated Chinese AD prevalence quadrupled during 2011–50 from 6–28 million. The cumulative discounted value of eliminating AD equates to China's 2012 GDP (US$8 trillion), and the annual predicted real value approaches US AD cost-of-illness (COI) estimates, exceeding US$1 trillion by 2050 (2011-prices). Lost labor contributes 62% of macroeconomic impacts. Only 10% derives from informal care, challenging previous COI-estimates of 56%.

Interpretation: Health and macroeconomic models predict an unfolding 2011–2050 Chinese AD epidemic with serious macroeconomic consequences. Significant investment in research and development (medical and non-medical) is warranted and international researchers and national authorities should therefore target development of effective AD treatment and prevention strategies.

1. Introduction

The last century witnessed dramatic global improvements in life expectancy and quality of life. However, since dementia primarily affects those aged over 60, increased longevity has led to increased rates of dementia and, more specifically, its most common form, Alzheimer's Disease (AD) (Prince et al., 2009). AD represents 42–81% of dementia cases (Nussbaum and Ellis, 2003), and is characterized by progressive, global deterioration of intellect, including memory, learning, orientation, language, comprehension and judgment. It affects the ability to perform everyday activities (ADI, 2014), causes distress to patients and their close contacts, creates extra demands on health systems, and imposes a substantial burden of long-term care (Wimo et al., 1999). There are currently no effective treatments or interventions to mitigate AD progression, and the incidence rates for AD double every 5 years from age 65 (Brookmeyer et al., 1998). The global burden of AD is therefore expected to accelerate in the face of reductions in mortality from other conditions: from 26.6 million cases in 2006 to 106.8 million by 2050 (Brookmeyer et al., 2007). Some evidence suggests that incidence rates for AD in the US and Europe may have declined in recent years (Matthews et al., 2013; Qiu et al., 2013; Langa, 2015), possibly due to reduced exposure to minor life-style related AD risk factors such as obesity, diabetes and smoking (Langa, 2015; Satizabal et al., 2014). However, dementia and, by implication, AD, has been highlighted as a particular concern for China (Sousa et al., 2009), since life-style risk factors are currently increasing with growing income-levels and since the on-going demographic transition combined with the demographic profile means that the primary risk factor for AD, aging, will drive future increases in Chinese prevalence. Chinese life expectancy increased from 70.0 to 75.2 during 1993–2012 and population estimates (USCB, 2014) suggest that the proportion of the Chinese population aged 60

Abbreviations: AD, Alzheimer's Disease; NPV, Net Present Value; GDP, Gross Domestic Product; COI, Cost Of Illness; RMB, Renminbi; DALYs, Disability Adjusted Life Years; YLL, Years of Life Lost; YLD, Years Lived with a Disability; CGE, Computable General Equilibrium; GTAP, Global Trade Analysis Project; SAM, Social Accounting Matrix; CDR, Clinical Dementia Rating; PADL, Personal Activities of Daily Living; IADL, Instrumental Activities of Daily Living; p.a., per annum.

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and over, the ages at which onset of Alzheimer's Disease is most likely, will increase from 12% in 2010 to 33% by 2050.

In addition to the burden on the population, it is hypothesized that the considerable health and care burden of AD will impose a large economic burden throughout affected economies. Previous economic studies estimate the 2009 worldwide cost of dementia to be US$421 billion and attribute 10% of the global burden (US$41 billion) to China (ADI, 2009). Shanghai-specific per patient costs of AD were estimated to be 19,001RMB (US$2,384; 2006 prices) (Wang et al., 2008). However, indirect (unpaid) caregiver costs (56%) drive the cost estimates and all previous estimates are formed by using a Cost-of-Illness (COI)-based method to scale direct patient-specific and indirect caregiver and medical costs by the number of cases. Existing estimates of AD therefore ignore the wider spillover and interaction effects for the economy, in general, and the extent to which these compound over time, and they also commonly monetize caregiving time by non-workers. Over and above the economic effects across sectors, the predicted scale of the future Chinese AD health and economic burdens suggests that Chinese labor markets may be affected. The combined interactions of China's predicted economic development, increased proportion of elderly workers, excess labor availability (Das and N'Diaye, 2013), and health and caregiver burdens over time, will affect labor supply and wage levels in a way which previously employed methodologies cannot accurately predict. These dynamic impacts, which are the fundamental units by which health and care effects should be valued, can only be estimated using a macroeconomic multi-sector approach and yet no studies of this nature have yet been conducted for AD or, more broadly, for dementia.

A multi-sector macroeconomic simulation model is employed in this study together with an epidemiological model of AD. The dual macroeconomic and disease simulations are employed to consistently estimate the twin macroeconomic and health burdens of AD in China from 2011 to 2050. The macroeconomic simulations focus on the accurate estimation of dynamic labor supply and wage effects of AD health and care burdens on working individuals whilst population-wide AD health and care burdens are assessed in parallel with the macroeconomic effects and include the health and care impacts that fall outside the labor force. The methodology employed to produce this holistic assessment is outlined in the next section.

2. Methods

2.1. Study Design

The analysis presented in this paper employs a double-simulation model framework consisting of an epidemiological model of AD progression and a macroeconomic Computable General Equilibrium (CGE) model of the Chinese economy for 2011–2050. China is a complicated country to undertake AD assessment given its rapid development, aging population and changing labor market structures, but the CGE model captures all relevant labor market structures as well as public and private health budget shocks, including the burgeoning cohort of 60–70 year old workers, creating potential for dramatic increases in the proportion of retired dependents with AD.

2.2. Alzheimer's Disease Model

A multistate probabilistic simulation model of AD progression (Brookmeyer et al., 2007, 1998; Johnson et al., 2007; Colantuoni et al., 2010) was used, based on Chinese population projections (USCB, 2014), age and gender-specific projections of Chinese mortality rates (Banister and Hill, 2004) and age-specific exponentially growing projections of AD incidence rates from age 60 (Brookmeyer et al., 2007) to forecast the number of Chinese individuals who contract AD. Whilst incidence grows exponentially with age, age-specific incidence rates are conservatively assumed to remain fixed over time. Co-morbidities of AD patients were not explicitly accounted for, but are implicitly captured in the mortality rates.

Two stages of AD were simulated. Stage 1 corresponds to mild or moderate disease, and stage 2 corresponds to severe disease, as defined by the Clinical Dementia Rating (CDR) scale (Morris, 1993). Full discussion of the AD progression model is included in Appendix 1. The 11% annual transition probability from stage 1 to stage 2 (Brookmeyer et al., 2007) mirrors the observed transition from moderate AD to nursing care (Neumann et al., 2001) and is consistent with the six year average transition from detection to nursing care requirement (Stern et al., 1997). Similar to previous AD model applications (Brookmeyer et al., 2007), baseline simulations assumed no excess mortality for stage 1 patients but an annual 11% excess mortality rate for stage 2 patients. Previously established AD disability weights (Colantuoni et al., 2010; Stouthard et al., 1997) were used to estimate Years Lived with Disability (YLD) effects.

2.3. Economic Model

The economic model used in this study was a macroeconomic Computable General Equilibrium (CGE) model (Löfgren et al., 2002). CGE models have been used successfully in health-related assessments of pandemic influenza outbreaks (Smith et al., 2009), dietary change (Lock et al., 2010), and environmental change (Jensen et al., 2013) and a similar approach is applied here to assess the AD economic burden. In particular, attention is given to both improved simulation of future labor market wages at which economic burdens are assessed utilizing literature-based predictions that excess unskilled labor supplies may continue until 2025 (Das and N'Diaye, 2013) and separation of economic and non-economic impacts (monetizing only informal caregiver time by employed caregivers). The analysis of economic impacts is enhanced by using Net Present Value of GDP (NPV GDP) impact as the main macroeconomic indicator of AD disease burden. This accounts for the time value of money and so is the most relevant measure if the impacts are to be used for long-term investment planning.

The CGE model was calibrated using a 2011 Social Accounting Matrix (SAM) dataset for China which was extracted from the GTAP 9 database (GTAP, 2014). The static model was converted to a recursive-dynamic model by introducing factor updating equations, expanded to account for excess unskilled labor (until 2025) and fitted to a counterfactual growth path where growth rates decline linearly over time such that Chinese GDP per capita converges to predicted UK-levels in 2050, in accordance with the recent 2011–2014 decline in Chinese growth rates. The counterfactual solution for the model represents an annual series of business-as-usual snapshots of the Chinese economy for 2011–2050. AD burden scenarios were modelled as 'health shocks' to the economy (described below), i.e. they were removed from the counterfactual to result in an alternative set of snapshots, which was compared with the counterfactual to estimate the relative economic disease burden. More details on the CGE model and the SAM data set can be found in Appendix 2.

2.4. Modelling AD Economic Burden from AD Health Forecasts

In order to measure the macroeconomic burden of AD, it is important to accurately capture the main drivers. This analysis considered impacts on the labor force and public health system costs to be the main such drivers. Quantification of 'health shocks' were based on the AD model forecasts of prevalence and Disability-adjusted Life Years (DALYs) as measured by the sum of Years Lived with Disability (YLD) and Years of Life Lost (YLL) (see results below). The health forecasts were used to derive labor market and health budget shocks based on parameter values which are shown in Table 1. These parameter values highlight the focus of our model shocks on the loss of productive labor supply. Estimates suggest that 25.5% of informal caregivers lose time from work and that their work-time loss averages 0.246 work-years