Chronic Non-communicable Diseases in Low- and Middle-income Countries

Edited by

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4 Ageing and Neurodegenerative Diseases in Low- and Middle-income Countries

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4.1 Introduction

In 2013, the number of older persons (aged 60 years and above) was 841 million, representing an 11.7% share of the global population [1]. By 2050, this number is expected to more than double to 2 billion, representing a 21.1% share of the global population [1]. By this period, older persons will exceed the number of children for the first time. These trends have major implications for low- and middle-income countries (LMICs) in Africa, Asia and Latin America, as population ageing is occurring fastest in these regions due to complex modes of epidemiological transition (see Oni and Unwin, Chapter 3, this volume). Thus, while it took high-income countries like France more than 100 years for the share of the population aged 65 years or older to double from 7 to 14%, it is estimated that it will take LMICs such as Brazil and China less than 25 years to reach the same growth [2]. By 2050, 80% of the world's older population will be concentrated in LMIC regions.

The United Nations (UN) states that while population ageing 'is a triumph of development', it also 'presents social, economic and cultural challenges to individuals, families, societies and the global community'. The 2013 UN report on World Population Ageing [1] highlights a number of multifaceted challenges that face ageing populations globally, and LMICs specifically.

First, poverty rates of older persons tend to be higher than the population average in a number of countries. Poverty rates are likely to increase among the older populations, especially in countries with limited coverage of social security systems. Secondly, the prevalence of non-communicable diseases, neurodegenerative disorders and disability will rise among the older populations with implications for health systems and health and social care at the community and family

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levels. Finally, the older population is predominantly female, as women have a higher life expectancy compared with men (this is true for both the 60+ years and 80+ years categories). However, the labour force participation of older persons is higher among men, with higher levels of participation in LMICs. This raises issues around gendered dimensions of social security, family and social care, both in terms of what older people contribute and what they receive. For example, the existing data suggest that older persons make 'net financial contributions to younger family members until rather advanced ages' [1]. 'Advanced ages' refers to those aged 80 years and above, or 'the oldest old' population.

In this chapter, we address one public health challenge of ageing in LMICs: the rising burden of neurodegenerative diseases among ageing populations and the implications for public health, social care and related policies. Neurodegenerative diseases are hereditary conditions characterized by progressive dysfunction of the nervous system. The dysfunction is caused by atrophy of the central or peripheral structures of the nervous system. Neurodegenerative diseases can also be pathological conditions affecting the brain. There are over 600 disorders that affect the nervous system and the brain. These include Alzheimer's disease (AD) and other dementias (which number over 100), brain cancer, degenerative nerve diseases, stroke, Parkinson's disease (PD), multiple sclerosis, amyotrophic lateral sclerosis (also known as Lou Gehrig's disease) and Huntington's disease [2, 3]. Research has shown that dementia and PD are the two most common types and together contribute significantly to the global burden of disease [2]. Between 1990 and 2010, the number of deaths attributed to PD more than doubled, and estimates of the number caused by AD and other dementias more than tripled. Furthermore, the years lived with disability attributed to these two disorders increased by more than 70% over the same period [4]. In high-income countries, there is more systematic information on neurodegenerative diseases because population ageing has been established for a number of decades and a strong body of research, interventions and policy has developed to address the complex dimensions [3, 5]. In contrast, research, practice and policy on neurodegenerative diseases are not well developed in LMICs because population ageing and its associated health outcomes are not priority issues [2, 5–7]. The 10/66 Dementia Research group, for example, is so named because it seeks to underscore the fact that while two-thirds (66%) of people living with dementia are located in LMICs, only 10% or less of population-based research has been carried out in these regions [6]. Population-based initiatives focusing on LMICs such as the World Health Organization Study on global AGEing and adult health (SAGE) and the International Network for the Demographic Evaluation of Populations and their Health (INDEPTH) have sought to redress the imbalance (see Kengne *et al.*, Chapter 7, this volume).

In this chapter, we limit attention to the two dominant types of neurodegenerative disease in LMICs – dementia and PD – and present current evidence on prevalence, morbidity, mortality and determinants. First, we describe the prevalence, mortality and morbidity of dementia and PD. Next, we discuss the determinants of dementia and PD. In the concluding section, we consider the key challenges for public health, social care and related policies for ageing populations in LMICs.

4.2 Dementia and PD Prevalence, Morbidity and Mortality

4.2.1 Dementia prevalence, morbidity and mortality

We identified dementia prevalence studies from 15 LMIC countries, the majority of which were cross-sectional community-based studies in Asian countries (Table 4.1). The most common type of dementia reported was AD. Focusing on community-based studies alone, the prevalence of dementia based on studies conducted on people aged 65 and older varied from 0.7% (in Taiwan) to 22.9% (in Turkey) [20, 25]. For the overall reviewed studies, the highest prevalence (85.0%) occurred in Cameroon based on a hospital study of human immunodeficiency virus (HIV)-positive patients aged 34–47 years [33].

There were some variations across regions. In Latin America, the prevalence of dementia ranged from 7.1 (in Brazil) [10] to 10.8% (in Cuba) [9]. The most common type of dementia was AD, followed by mixed dementia. The highest prevalence was recorded in Cuba from a prospective longitudinal study of 3015 adults aged 65 years and above in municipalities of Havana city and Matanzas provinces [9]. Research has shown that Cuba exhibits health indictors that are similar to those of the high-income countries. The population is ageing rapidly, and by 2020, about 21.6% of the population will be 60 years and above, making it the country with the highest proportion of elderly people in Latin America.

In Africa, the prevalence of dementia varied from 2.01% (in Egypt [30]) to 85.0% (in Cameroon [33]). AD was more common than vascular dementia. The highest overall prevalence (85%) occurred among HIV patients in Cameroon, and the highest prevalence from community studies was 21.6% and this occurred in Tanzania [28].

Dementia was associated with behavioural and psychiatric complications (Table 4.2). A community study of 1271 people living with dementia in China showed that sleep disturbance was the most common symptom associated with dementia and this was present in more than one-fifth (21.9%) of this population [34]. The other forms of complications associated with dementia included irritability, apathy, depression and aberrant motor behaviour. In Taiwan, a hospital study of 142 people showed that more than half had at least one form of delusion, as well as hallucinations, aggressiveness, affective disturbances, anxiety and phobia [35].

Dementia mortality ranged from 0.9% (in a cross-sectional study in China [37]) to 66.4% (in a prospective study in China [38]). The predictors of dementia mortality included: advancement in age [37, 38, 40], severe dementia [38], substantial disability [38], co-morbidity [38], living in urban areas [37], physical illness at the time of diagnosis [41], living with cardiovascular disease [42] and depression [40]. There were mixed results regarding low levels of education [40] or high levels of education [37] as a predictor of dementia mortality. There were also mixed results on gender and dementia mortality. A cross-sectional community study in China showed that females had higher odds of dementia mortality, and dementia mortality was higher for AD than for vascular dementia [37]. Another 5-year longitudinal study of 91 people living with dementia in China showed that 51 people (37.2%) died during this period and the death rates were higher among males [38].

Table 4.1. Prevalence, risk-factors and types of dementia in LMICs.

Country	Reference	Study design	Setting	Sample size	Prevalence	Determinants	Types
Cuba	Llibre *et al.*, 2009 [8]	Cross-sectional	Community based	18,351	The prevalence of dementia was 8.2% and was similar among males and females (8.3 and 8.1%, respectively)	Advancement in age, history of stroke, hypertension, depression, skull-brain trauma, family history, low education	AD was the most common
Cuba	Llibre *et al.*, 2011 [9]	Prospective	Community based	3,015	The prevalence of dementia was 10.8%		
Brazil	Herrera *et al.*, 2002 [10]	Cross-sectional	Census	1,656	The prevalence of dementia was 7.1%	Illiteracy	
Brazil	Lopes *et al.*, 2012 [11]	Cross-sectional	Community based	1,145	The prevalence of dementia was 12.5%	Advancement in age, low education, stroke, absence of arthritis and not reading books	AD accounted for 60.3%
China	Guo *et al.*, 2012 [12]	Cross-sectional	Hospital based	264	The prevalence of dementia was 36.7%	Advancement in age, being female, low education and living in a nursing home	
China	Chen *et al.*, 2012 [13]		Community based	6,244	The prevalence of dementia was 9.2% for women and 7.3% for men	Being female, living in rural areas, advancement in age, lower education, larger waist circumference and lower income	
China	Zhou *et al.*, 2006 [14]	Cross-sectional	Community based	16,095	The prevalence of dementia was 5.3%	Advancement in age and lower level of education	AD accounted for 80.5%

continued

Table 4.1. *continued.*

Country	Reference	Study design	Setting	Sample size	Prevalence	Determinants	Types
China	Zhang *et al.*, 2005 [15]	Cross-sectional	Community based	34,807	The prevalence of dementia was 3.0%	AD was higher for women, while VaD was higher for men	AD accounted for 71.3% and VaD 38.7%
China	Li *et al.*, 2007 [16]	Cross-sectional	Community based	1,593	The prevalence of dementia was 2.5%	Advancement in age, illiteracy and low income	The prevalence was higher for AD
China	Wu *et al.*, 2011 [17]	Cross-sectional	Community based	2,788	The prevalence of dementia was 6.1%		
Turkey	Arslantas *et al.*, 2009 [18]		Community based	3,100	The prevalence of dementia was 8.4%	Being female, low level of education, living in rural areas, family history of dementia and advancement in age	VaD accounted for 51.1% and AD for 48.8%
Turkey	Gurvit *et al.*, 2008 [19]	Prospective	Community based	1,019	The prevalence rate was 20%	Advancement in age and being female	The prevalence of AD was 11.0%
Turkey	Keskinoglu *et al.*, 2006 [20]	Cross-sectional	Community based	204	The prevalence of dementia was 22.9%	Advancement in age, being female, having bad health status, no occupation and high level of depressive symptoms	
Sri Lanka	de Silva *et al.*, 2003 [21]		Community based	703	The crude prevalence rate of dementia was 3.98%	Advancement in age	AD, 71.4%; VaD, 14.3%; mix of AD and VaD, 7.1%

Country	Reference	Study design	Setting	Sample size	Prevalence	Determinants	Types
Lebanon	Chahine *et al.*, 2006 [22]	Cross-sectional	Hospital based	117	The prevalence of dementia was 59.8%	Being female	Mild dementia, 27.9%; moderate dementia, 22.9%; severe dementia, 49.2%
India	Shaji *et al.*, 2005 [23]	Cross-sectional	Community based	1,934	The prevalence of dementia was 33.6 per 1000 of the population	Family history and history of hypertension and being male	AD, 54%; VaD, 39%; infection, tumour and trauma, 7%
Taiwan	Chien *et al.*, 2008 [24]	Prospective	Community based	22,118	The annual prevalence rate of dementia increased from 0.71 to 1.92% from 1996 to 2003		
Taiwan	Su *et al.*, 2012 [25]	Longitudinal quasi-experimental	Sanatorium	129	The prevalence of dementia among the leprosy patients was 45.7–50.4%		
Central Africa	Guerchet *et al.*, 2013 [26]		Community based	244	The prevalence of dementia was 8.0%	Peripheral arterial disease	AD, 75.7%; VaD, 24.3%
South Africa	Ramlall *et al.*, 2013 [27]	Cross-sectional	Elderly home	140	The prevalence of dementia was 7.9%	Advancement in age, high blood pressure, age, years of education, blackouts, not engaging in physical activities	
Tanzania	Paddick *et al.*, 2013 [28]	Cross-sectional	Community based	296	The age-standardized prevalent rate of dementia was 21.6%		

continued

Table 4.1. *continued.*

Country	Reference	Study design	Setting	Sample size	Prevalence	Determinants	Types
Nigeria	Yusuf *et al.*, 2013 [29]	Cross-sectional	Hospital based	121	The prevalence of dementia was 9.1%	Advancement in age and enuresis	
Egypt	El Tallawy *et al.*, 2014 [30]	Cross-sectional	Community based	4,329	The prevalence among those who were 50+ years was 2.01%	Illiteracy and advancement in age	AD, 48.3%
Senegal	Toure *et al.*, 2012 [31]	Cross-sectional	Hospital based	507	The prevalence of dementia was 8.87%	Advancement in age, illiteracy, epilepsy and family history	
Tanzania	Longdon *et al.*, 2012 [32]	Cross-sectional	Community based	1,198	The age-adjusted prevalence rate was 6.4%	Advancement in age	
Cameroon	Atashili *et al.*, 2013 [33]	Cross-sectional	Hospital	400	The prevalence among HIV patients was 85.0%	Low education, being formerly married and having HIV symptoms	

AD, Alzheimer's disease; VaD, vascular dementia.

Table 4.2. Mortality and morbidity of dementia.

Country	Reference	Study design	Setting	Sample size	Key findings
China	Haibo *et al.*, 2013 [34]	Cross-sectional	Community based	1271	50.1% of the patients experienced at least one form of behavioural and psychiatric symptoms of dementia. The most common symptoms were sleep disturbance, irritability, apathy, depression and aberrant motor behaviour
Malaysia	Eshkoor *et al.*, 2013 [35]	Cross-sectional	Community based	1210	41% of the patients had sleep disturbance and this was higher among those who were single, female, those with no education, those who were isolated and those in the Malay ethnic group.
Taiwan	Liu *et al.*, 2007 [36]	Prospective	Hospital based	142	50.7% experienced delusion with the most common type being delusion of theft, 24.6% experienced hallucinations and 40.1% experienced activity disturbances; aggressiveness was found in 27.5%, diurnal rhythm disturbance in 29.5%, affective disturbances in 30.3% and anxiety and phobia in 50%. Men had higher scores on aggression, while women had higher affective scores
China	Wen *et al.*, 2011 [37]	Cross-sectional	Community based	3885	The mortality rate of dementia was 0.9% and this increased with age and was higher among females. Other predictors of low mortality were higher levels of education, living in urban areas and being married. The age-standardized mortality rate for AD among 65+ was 0.42% and that of VaD was 0.36%. The mortality in both AD and VaD patients increased with age and was higher among females
China	Wang *et al.*, 2010 [38]	Prospective	Community based	137	The mortality rate of dementia was 66.4% during the 5-year period. The median time of survival was 4.2 years. Those with severe dementia, substantial disability, co-morbid conditions and a higher age had a shortened survival time. There was no sex difference
Tanzania	Mushi *et al.*, 2014 [39]	Cross-sectional	Community based	41 PWD and caregivers	Knowledge about dementia and its causes was low. Both PWD and their caregivers had pluralistic health-seeking behaviour. Dementia was accepted as a problem of old age. It had a huge impact on the social and economic life of families. The majority of PWD were poor and economically inactive

AD, Alzheimer's disease; VaD, vascular dementia; PWD, people with dementia.

4.2.2 PD prevalence, morbidity and mortality

The lowest and highest prevalence of PD occurred in Latin America and ranged from 50.2 per 100,000 of the population (in Bolivia) [43] to 3300 per 100,000 of the population (in Brazil) [44] (Table 4.3). The mean age of PD onset was between 54 years in Pakistan [58] and 61.5 in Nigeria [61]. In terms of morbidity, Asian studies reported associations between PD and physical problems (higher rate of hip fracture) and mental health disorders (dyskinesias, and depression) [13, 59, 63] (Table 4.4). In Africa, hypertension and diabetes were co-morbid conditions for PD [61]. Tanzanians living with PD also experienced other neurological symptoms such as dyskinesias [60].

4.3 Determinants of Dementia and PD

4.3.1 Determinants of dementia

Determinants of dementia in LMICs included socio-economic factors, socio-demographic characteristics, a history of cardiovascular diseases, depression, poor health condition, lifestyles and a family history of dementia. The key dimensions of socio-economic status, highlighted in studies from Latin America, Asia and Africa, included low levels of education, illiteracy, a low income, unemployment and living in rural areas.

For instance, a cross-sectional study of 1656 people aged 65 years and above in an urban area in Brazil showed that the prevalence of dementia ranged from 3.5% in people with eight or more years of schooling to 12% among those who were illiterate [10]. A hospital study of 264 elderly people in China showed that a low level of education was associated with a higher dementia risk [12]. Other community-based studies in China and Turkey showed that those who live in rural areas had higher risks of dementia compared with those who live in urban areas [12, 18]. A hospital study of 400 patients attending the Bamenda Regional Hospital AIDS-treatment Centre in Cameroon showed that, after adjusting for other confounding factors, those with a higher level of education had a lower risk of dementia compared with those with only primary education or less [33].

Advancement in age was a major risk factor of dementia. However, the associations between other socio-demographic characteristics and dementia were not so clear cut. There were contradictory findings with respect to sex. Asian studies reported contradictory findings relating to sex, while studies in Latin America and Africa showed that the risk of dementia was the same for men and women (Table 4.2).

A history of cardiovascular diseases like stroke, hypertension and peripheral artery disease was also shown to be associated with dementia. For instance, a community-based study in Cuba showed that a history of stroke and hypertension was associated with dementia. Those who had a history of stroke were about six times more likely to develop dementia than those without a history of stroke [8].

Other determinants of dementia included depression and a family history of dementia. A community study of elderly residents in Havana Municipality, Cuba,

Table 4.3. Prevalence of Parkinson's disease in LMICs.

Country	Reference	Study design	Setting	Sample size	Key findings
Brazil	Barbosa *et al.*, 2006 [44]	Cross-sectional	Community based	1,186	The prevalence rate of PD was 3.3 per 1000 of the population and the rates for men and women were not statistically different
Bolivia	Nicoletti *et al.*, 2003 [43]	Cross-sectional	Community based	9,955	The crude prevalence rate of PD was 50.2 per 100,000 and 286 per 100,000 of the population among those aged 40+. The prevalence increased with age and was higher among women for those aged 40+
Argentina	Bauso *et al.*, 2012 [45]	Cross-sectional	Hospital based	140,000	The prevalence of PD was 394 per 100,000 of the population aged 40+
Argentina	Melcon *et al.*, 1997 [46]	Cross-sectional	Community based	7,765	The prevalence of PD was 656.8 per 100,000 of the population and was higher in men
Cuba	Giroud Benitez *et al.*, 2000 [47]	Cross-sectional	Community based	17,784	The prevalence of PD was 135 per 100,000 of the population. About 12.5% of patients with PD showed a family history of the disease
Colombia	Sánchez *et al.*, 2004 [48]	Case–control	Hospital based		The prevalence of PD was 176.4 per 100,000 of the population of people aged 50+
Ecuador	Del Brutto *et al.*, 2013 [49]	Cross-sectional	Community based	642	The prevalence of PD among those who were 40+ was 312 per 100,000 and 671 per 100,000 of the population among those who were 60+
Thailand	Bhidayasiri *et al.*, 2011 [50]	Cross-sectional	Hospital based	60,565	The age-adjusted prevalence of PD was 424.57 per 100,000 of the population. It was higher in urban areas compared with rural areas (126.83 per 100,000 vs 90.82 per 100,000). The rate was highest in areas with a high level of pesticide use
Jordan	Alrefai *et al.*, 2009 [51]	Cross-sectional	Hospital based	102	The crude prevalence rate of PD was 59 per 100,000 person-years. About 10.9% of those with PD had a family history of the disease
Thailand	Lolekha *et al.*, 2010 [52]	Cross-sectional	Hospital based	704	The crude prevalence rate of PD among boxers was 710 per 100,000 and 980 per 100,000 of the population for those aged 50+. This increased with age, and the number of boxing fights (>100) was also associated with PD
China	Zhang *et al.*, 2005 [53]	Cross-sectional	Community based	16,488	The age-sex adjusted prevalence rate of PD was 522 per 100,000 of the population
China	Woo *et al.*, 2004 [54]	Cross-sectional	Community based	415	The prevalence of PD among those 55+ was 480 per 100,000 of the population

continued

Table 4.3. *continued.*

Country	Reference	Study design	Setting	Sample size	Key findings
China	Zhang *et al.*, 2005 [55]	Cross-sectional	Community based	29,454	The prevalence rate of PD for those 65+ was 1700 per 100,000 of the population and was higher for men
China	Zhang *et al.*, 2003 [56]		Community based	5,952	The prevalence of PD was 1% (100 per 100,000 of the population) and increased with age. There was no gender difference. However, in urban areas, the rate was higher for men at older ages and higher for women in rural areas at older ages
Taiwan	Chen *et al.*, 2012 [57]	Case–control	Hospital based	3,940	Those with PD had a significantly higher rate of hip fracture than those without PD (10.4 vs 4.1%). Those with PD had a significantly higher rate of hypertension, hyperlipidaemia and osteoporosis
Pakistan	Khealani and Baig, 2006 [58]		Hospital based	80	The prevalence of PD was higher among men. The mean age of onset was 54 years. PD was associated with rigidity, bradykinesia (slow movement), tremors, hypomimia, primitive reflexes, difficulty in performing fine work and difficulty in walking
China	Wen *et al.*, 2012 [59]	Cross-sectional	Hospital based	901	Dyskinesias and depression were associated with PD pain
Tanzania	Dotchin *et al.*, 2008 [60]	Cross-sectional	Community based	308	The age-standardized prevalence of PD to the UK population was 40 per 100,000 of the population (64 per 100,000 for males and 20 per 100,000 for females)
Nigeria	Okubadejo *et al.*, 2010 [61]	Cross-sectional	Hospital based	1,360	Out of 124 people with parkinsonism, 79% had PD while 21% had secondary parkinsonism. Males had a higher risk of PD and the incidence of PD was higher among the older age group. Hypertension and diabetes were co-morbid conditions for PD. The mean age at onset was 61.5 (standard deviation 10). Males were more than females
Egypt	Khedr *et al.*, 2012 [62]	Cross-sectional	Community based	5,920	The crude prevalence rate of PD was 57 per 100,000 of the population. It accounted for more than 80% of parkinsonism (84.6%). There was no significant difference between males and females. It was highest among those aged 70–79 years, rural residents and those who were illiterate

Table 4.4. Morbidity and mortality of PD.

Country	Reference	Study design	Setting	Sample size	Key findings
Taiwan	Chen *et al.*, 2012 [57]	Case–control	Hospital based	3940	Those with PD had a significantly higher rate of hip fracture than those without PD (10.4 vs 4.1%). Those with PD had a significantly higher rate of hypertension, hyperlipidaemia and osteoporosis
China	Wen *et al.*, 2012 [59]	Cross-sectional	Hospital based	901	Dyskinesias and depression were associated with PD pain

showed that the risk of dementia was two times higher for those who had a history of depression [8]. The study also showed that the risk of dementia was higher for those who had a family history of dementia. Another study of 204 elderly people aged 64 years and above in Turkey showed that those who had higher depressive symptoms had higher odds of developing dementia [20].

4.3.2 Determinants of PD

The determinants of PD include socio-economic and demographic factors, hereditary factors, environmental factors and health status including having high haemoglobin levels and living with diabetes (Table 4.3). With the exception of the strong association between advancement in age and PD, the findings on socio-economic and demographic determinants of PD were contradictory. For example, while a study in Thailand showed that the rate of PD was higher among people living in urban areas [64], a community-based study in Egypt showed that PD was higher in rural areas [62]. Also, while some studies showed that the PD risk was higher among males, others showed a higher risk among females and some showed no sex difference in PD prevalence. This inconclusiveness of the effect of sex on risk of PD was shown in all three regions (Latin America, Asia and Africa). One study in Thailand linked PD risk to environmental factors and showed that PD was higher in urban areas with a high level of pesticide use [64]. Other determinants of PD included hypertension, hyperlipidaemia, osteoporosis (in Taiwan) [13] and a family history of PD (in Jordan) [51].

4.4 Ageing and Neurodegenerative Diseases: Future Challenges for Public Health, Social Care and Related Policies

People living with dementia and PD require long-term sustained care because of the progressive debilitating nature of these conditions. In LMICs, these care needs are complex because of the characteristics of the elderly populations at risk and

the characteristics of the systems of formal healthcare and informal health and social care. We discuss these complex care needs and highlight three major challenges for public health and social care.

The first challenge is the quality of and access to healthcare. Healthcare for neurological conditions should ideally be provided through an optimal mix of primary, secondary and tertiary care [2]. Primary care focuses on health promotion, prevention and treatment offered at the level of the community and by primary care professionals. For neurological disorders, this represents the first point of entry for diagnosis and treatment and the opportunity for delivering better clinical outcomes, and should ideally be managed by trained primary care professionals. Secondary care focuses on more sophisticated management and treatment of severe cases, often provided at the level of district or regional health facilities, and requires advanced human and technical resources. Individuals with severe or advanced cases of neurological disorders need access to specialist professionals who can offer expert care, well-equipped health facilities with diagnostic equipment such as electroencephalography and computerized tomography, and other resources such as specialist beds to provide intensive care and respite care. The tertiary care level offers the most specialized package of diagnostic, treatment and rehabilitation interventions, usually at the level of the teaching hospital. Tertiary care facilities ideally constitute a repository of evidence-based care, drawing on epidemiological and clinical research, providing training and educational support, and providing referral services including liaising with community-based support services. The majority of LMIC health systems are not structured to provide the kind of long-term treatment, management and rehabilitative care required for neurodegenerative diseases because they face multiple health crises and lack the optimal mix of trained health professionals, infrastructure and financial resources [65] (see also Coast *et al.*, Chapter 6, this volume).

For those that offer some services for neurological conditions, the cost of care is prohibitive. Globally, the direct and indirect cost of managing dementia and PD is estimated to be very high [66, 67]. In 2003, the worldwide direct costs of dementia – including medical consultations, investigations, pharmaceuticals, provision of personal and nursing care, and residential care in the later stages of dementia – was estimated to be US$156 billion [66]. This was based on a worldwide prevalence estimate of 27.7 million people with dementia. In 2010, based on a worldwide estimate of 36 million people with dementia, the global cost of dementia had almost quadrupled to US$604 billion [68]. In the USA, a study that followed 20,016 people living with PD for an average of 853 days showed that the total annual direct costs were US$23,101 per person with PD [69]. In India, a study of 175 people living with PD showed that the annual income of nearly half of these individuals was less than US$1,148.63 and they spent 16–41.7% of their annual income on medicines [70]. In LMICs, a significant proportion of people pay for healthcare out of their own pocket [71]. Our review suggests that the majority of elderly individuals living with PD or dementia are likely to be of low socio-economic status. This presents major challenges in terms of access and affordability of formal healthcare services. For many individuals living with neurodegenerative diseases, care tends to be provided by family members or community-based carers, and the high cost of care raises the risk of poverty for

affected families [2]. An important new trend is the growth of support groups for people living with dementia across LMICs (see de-Graft Aikins *et al.*, Chapter 9, this volume). However the impact of dementia support groups on quality and continuity of care is yet to be evaluated, and there remains a need for support groups for other neurological disorders.

The second challenge is ensuring the quality and sustainability of social care and social support. Social care and support also raise the burden of chronic physical and mental health risks within families, as caregivers are likely to experience caregiver stress and associated problems. Much of the research on caregiver stress has come from high-income countries, and the research suggests that in addition to the financial burden of care, caregivers experience physical and mental health problems [72–75]. The type and level of stress depends on the kind of condition the recipient of care has and the level of disability arising from the condition. This has implications for caring for elderly individuals with neurodegenerative conditions who are likely to live with other chronic physical conditions (e.g. hypertension, diabetes, heart disease). The combination of financial strain and caregiver stress can lead to family and social tensions that may affect the quality and sustainability of care and support.

Finally, the evidence from studies on ageing in LMICs suggests that the aged are themselves providers of care and support to young family members [1]. In Africa, for example, HIV/AIDS morbidity and mortality among the productive adult African population has created insecure conditions for older people who, in most affected countries like South Africa, now live in 'missing generation households' [76] or 'skip generation households' [77] and have to take on caregiving responsibilities for grandchildren. In some communities in South Africa, 76% of older people are the sole providers of household necessities, and they care for the sick in their families and for their grandchildren [77]. Within these contexts, elderly caregivers who develop neurodegenerative diseases might experience social isolation if they lack access to broader social networks beyond their households.

Neurodegenerative conditions constitute a ticking public health time bomb for LMICs because their prevalence is rising, they affect a rapidly rising demographic in many countries and their impact is interlinked with major challenges in health financing, social security and social care for the aged. It is important that health systems are strengthened to address the current double burden of infectious and chronic non-communicable diseases affecting LMIC populations. However, the response to the public health challenge of neurodegenerative diseases must go beyond strengthening of health systems to tackle the broader social, structural and public policy dimensions of ageing. The response must also be context specific because of the unique social, cultural and policy dynamics operating across countries. At present, the evidence has been generated from research conducted in a limited number of countries. The African region, for example, is poorly represented. Yet current evidence suggests that the socio-economic and cultural challenges resulting from population ageing are likely to be disproportionately experienced in sub-Saharan Africa. Help Age International [78] released its 2014 Global AgeWatch Index, which ranked 96 high-, middle- and low-income countries (representing 91% of people over 60) in terms of social and economic well-being. The indicators included income security, health status, capability and

enabling environment. Most LMICs scored poorly on income security, with only one in four people aged 65 and above having access to pensions. However, African countries (Ghana, Morocco, Nigeria, Rwanda, Zambia, Uganda, Tanzania, Malawi and Mozambique) occupied the lowest quarter and within this quarter made up 'half of those with low security rankings and poor health results' [78]. Researchers observed that rapid urbanization, the breakdown in family and community structures, and rising costs of living and healthcare deepen the vulnerabilities experienced by elderly Africans [79, 80].

Interventions targeting the rising burden of neurodegenerative diseases must be developed with a focus on the broader health and socio-economic challenges facing elderly populations in LMICs. As the 10/66 Dementia Research Group [6] suggest, key issues will include improving access to good-quality age-appropriate healthcare, addressing the problem of disability and strengthening social protection for the most vulnerable groups.

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