

## GUEST EDITORIAL

# Can some aspects of the epidemiology of elderly suicides be applied to dementia

### Introduction

Two important aspects of the epidemiology of suicides in the elderly people can potentially be applied to dementia. The first is the well-established observation of the independent effects of age, birth cohort membership, and the period on the risk of suicide in the elderly people (Murphy *et al.*, 1986; Surtees and Duffy, 1989; Snowdon and Hunt, 2002). The second is the recently developed concept of the epidemiological transition hypothesis of suicide in the elderly people (Shah and Bhat, 2009; Shah, 2010; Shah *et al.*, 2008). These epidemiological aspects, in addition to the theoretical aspects, may also have clinical and public health implications for dementia.

### Age, period, and cohort effects

Several studies, from different countries, have clearly demonstrated the independent effects of age, birth cohort membership, and the period of study on suicide rates at any given time (Murphy *et al.*, 1986; Surtees and Duffy, 1989; Shah and De, 1998; Snowdon and Hunt, 2002). Can this concept be applied to the prevalence of dementia?

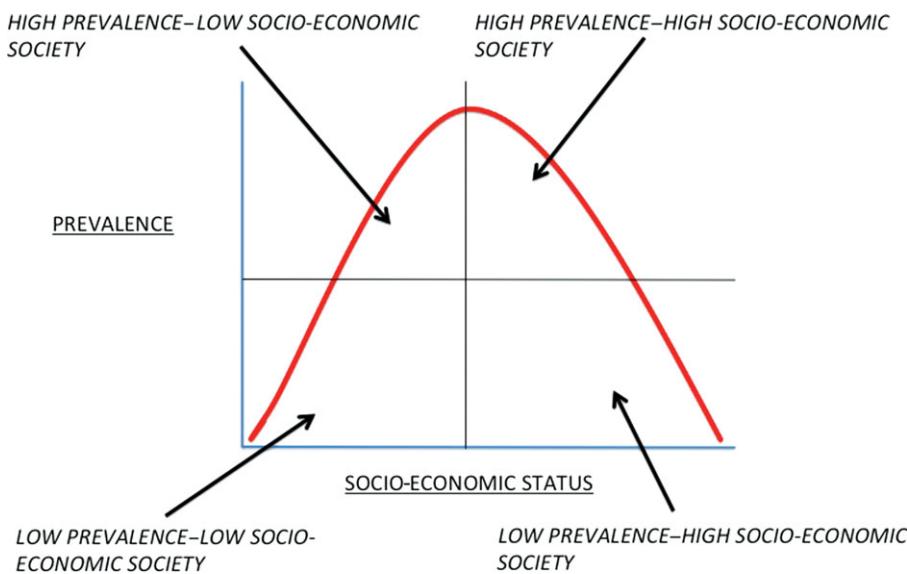
Dementia is an age-related disorder with the prevalence doubling every 5.1 years increase in age after the age of 60 years in developed countries (Jorm *et al.*, 1987; Hofman *et al.*, 1991) and every 7.3 years in developing countries (Llibre Rodriguez *et al.*, 2008). Moreover, the prevalence of dementia significantly increased in Swedish women from the same birth cohort sample between the ages of 85 and 88 years (Aevarsson and Skoog, 2005). Furthermore, the prevalence of dementia in Sweden was significantly higher in those aged 95 years compared to those aged 85 years from the same birth cohort using similar methodology (Borjesson-Hanson *et al.*, 2004). These observations suggest that age may have an impact on the prevalence of dementia independent of the influence of the birth cohort membership. Also, the three-year change in time period in the above study of Swedish women from the same birth cohort sample between the ages of 85 and 88 years (Aevarsson and Skoog, 2005) is unlikely to have influenced the prevalence of dementia.

Another Swedish study examined the prevalence of dementia in birth cohorts of 85-year-olds in 1986–1987 (born 1901–1902) and 2008–2010 (born 1923–1924; Skoog, 2012). The preliminary data from this study suggested that the prevalence of dementia decreased by almost a third in the later birth cohort despite an increase in the prevalence of stroke. This suggests that birth cohort membership may have an impact on the prevalence of dementia independent of the influence of age.

Taken together these findings suggest that the impact of age and birth cohort membership on the prevalence of dementia may occur independently. However, another variable, the actual time period of the study, may also independently influence the prevalence of dementia, and this may also potentially explain the above findings. Thus, there is a need to adapt and further develop the statistical techniques, already used to demonstrate independent effects of age, birth cohort membership, and period on suicide rates, for use in prevalence studies of dementia. Such development is emerging: the independent effect of age on health transitions in a Swedish and a Canadian birth cohort of 70-year-olds, assembled 20 years apart, was examined using statistical modeling techniques (Mitnitski *et al.*, 2007).

### The epidemiological transition model

A developmental model of epidemiological transition for elderly suicide rates with four sequential stages was theoretically developed to simultaneously explain cross-national variations in elderly suicide rates, trends over time for elderly suicide rates, and age-associated trends in suicides rates reported in the literature (Shah and Bhat, 2009). This model was adapted from similar epidemiological transition models for dementia (Suh and Shah, 2001) and other mental disorders in old age (Shah, 2007). The four sequential stages in this model were as follows: low elderly suicide rate–low socio-economic society stage; high elderly suicide rate–low socio-economic society stage; high elderly suicide rate–high socio-economic society stage; and low elderly suicide rate–high socio-economic society stage. This model has subsequently been substantiated to be accurate using cross-sectional data on elderly suicide rates



**Figure 1.** (Colour online) Epidemiological transitions in dementia.

and two separate measures of socio-economic status in cross-national studies (Shah *et al.*, 2008; Shah, 2010). The relationship between socio-economic status and suicide rates followed an inverted U-shaped curve defined by the quadratic equation  $Y = A + BX - CX^2$ , where  $A$ ,  $B$ , and  $C$  were constants,  $Y$  was the suicide rate, and  $X$  was a measure of socio-economic status.

A variant of this model was theoretically applied to the prevalence of dementia over a decade ago (Suh and Shah, 2001). This original model of epidemiological transition in dementia has now been further developed using approaches from the above model for elderly suicides and emerging epidemiological data for dementia. It is likely that the concept of age, birth cohort membership, and the period of study discussed earlier may also be absorbed into this model.

### The epidemiological transition model for dementia

There is wide variation in the prevalence of dementia across different countries (O'Connor, 2010). This variation may be explained by methodological differences between different studies. However, as prevalence is a function of incidence and duration of illness, it is possible that some of the variation may be due to differing incidence and differing duration of illness, particularly in cross-national studies using identical methodology (Hendrie *et al.*, 1995; Chandra *et al.*, 1998; Prince *et al.*, 2012). As dementia is a progressive disorder, with little chance of recovery, the duration of illness can be represented by the duration of survival after the onset of dementia. Thus, the prevalence of dementia is a function

of the incidence and the duration of survival after the onset of dementia.

This model was based on several theoretical assumptions:

- Different countries will be at different stages of development within this model.
- Each country would sequentially progress through the hypothetical four stages over time with progress in socio-economic development.
- Both socio-economic status and the prevalence of dementia can be dichotomized into two groups: high and low.
- Dementia is considered as a unitary diagnosis rather than a label for a heterogeneous group of disorders.
- The theoretical concepts in this hypothesis essentially depend upon the prevalence of dementia being a function of the incidence of dementia and the duration of survival after the onset of dementia.

This hypothetical model is illustrated in Figure 1, whereby the relationship between socio-economic status (plotted on the X-axis) and the prevalence of dementia (plotted on the Y-axis) is shown to follow an inverted U-shaped curve (although, as discussed later, this may not necessarily be the case). Each of the four potential stages of this model is critically examined below.

#### Stage 1. Low prevalence and low socio-economic society stage

Societies with low socio-economic status have poorly developed healthcare services (Jacob *et al.*, 2007; Shah, 2007; 2009; Jacob, 2008; Shah *et al.*, 2008; Shah and Bhat, 2008a; 2008b). Poorly developed healthcare services may mediate an increase in child mortality rates by being unable to provide primary preventative measures for diseases in

childhood (e.g. immunization programs) and general population mortality rates due to reduced treatment for diseases that are directly related to low socio-economic status (e.g. infectious diseases; Suh and Shah, 2001). This will reduce life expectancy; there was a positive linear relationship between societal socio-economic status measured by gross national domestic product (GDP) and life expectancy (Shah, 2007; Shah *et al.*, 2008). Given that dementia is an age-related disorder, reduced life expectancy will result in fewer people reaching the age of increased risk for developing dementia. Additionally, selective survival of those at reduced risk of dementia in old age, due to genetic or constitutional factors, may further compound this trend (Suh and Shah, 2001). Moreover, there is evidence that in societies with low socio-economic status, adversity early in life affords a protective effect on suicides later in life (Seiden, 1981; McIntosh, 1984; Lindesay, 1991); it is possible that similar protective mechanisms may operate in dementia. These factors could lead to a low incidence of dementia in societies with low socio-economic status. Some of the lowest figures for the incidence of dementia were reported in India (Chandra *et al.*, 2001) and Nigeria (Hendrie *et al.*, 2001). Studies from Brazil (Nitrini *et al.*, 2004) and China (Li *et al.*, 1991) also reported low incidence rates. Similarly, the 10/66 incidence studies, using similar methodology across all studied countries and when using the less controversial DSM IV diagnosis of dementia, reported low incidence for dementia in several Latin American countries and China (Prince *et al.*, 2012).

The poorly developed health- and social care services (Jacob *et al.*, 2007; Shah, 2007, 2009; Jacob, 2008; Shah *et al.*, 2008; Shah and Bhat, 2008a; 2008b) in low socio-economic countries reduce life expectancy (Shah, 2007; Shah *et al.*, 2008). This impact is likely to be even greater among those with dementia. Mortality rates in dementia were increased in Nigeria and Brazil over five-year and three-year follow-up, respectively (Perkins *et al.*, 2002; Nitrini *et al.*, 2005). They were also increased in China and several Latin American countries (Prince *et al.*, 2012), and these mortality rates were higher than in developed countries (Dewey and Saz, 2001).

The combination of low incidence and shorter duration of survival after the onset of dementia will lead to a low prevalence of dementia. Very low prevalence rates for dementia have been reported in India (Chandra *et al.*, 1998; Vas *et al.*, 2001) and Nigeria (Hendrie *et al.*, 1995). Studies from Brazil (Nitrini *et al.*, 2004) and China (Li *et al.*, 1991) also reported low prevalence rates. Similarly, the 10/66 studies, using identical methodology across the studied countries and when using the less con-

troversial DSM IV diagnosis of dementia, also reported very low prevalence rates in several developing countries: urban Peru, 3.1%; rural Peru, 0.4%; rural Mexico, 2.2, rural China, 2.4%; urban India, 0.9%; and rural India, 0.8% (Llibre Rodriguez *et al.*, 2008). The authors concluded that the DSM IV prevalence of dementia, when compared with pooled European data, was less than a quarter in India, about half in China, and about four-fifths in Latin America. Moreover, the prevalence rates were particularly low in rural areas. Such a society could be labeled as a low prevalence and low socio-economic society.

## **Stage 2. High prevalence and low socio-economic society stage**

With improvement in the socio-economic status of countries, the degree of development of health- and social care services will also improve (Zhang, 1998; Jacob *et al.*, 2007; Shah, 2007, 2009; Shah *et al.*, 2008; Shah and Bhat, 2008a; 2008b). This improvement in health- and social care services may facilitate reduction in child mortality rates because of improved ability to provide primary preventative measures for diseases in childhood (e.g. immunization programs) and general population mortality rates related to poor treatment of diseases that are directly related to low socio-economic status (e.g. infectious diseases; Suh and Shah, 2001). This will lead to an increase in life expectancy; there was a positive linear relationship between societal socio-economic status measured by GDP and life expectancy (Shah, 2007; Shah *et al.*, 2008). This, in turn, will result in greater number of participants reaching the age of increased risk for dementia. Moreover, the effects of selective survival of those at reduced risk of dementia in old age, due to genetic or constitutional factors, will be weakened (Suh and Shah, 2001). This will lead to an increase in the incidence of dementia. The wide variation in the incidence of dementia using the less controversial DSM IV diagnosis across different Latin American countries and between urban and rural areas within the same country in the 10/66 study (Prince *et al.*, 2012) suggests that, even in socio-economically less-developed countries, improvement in socio-economic status is associated with an increase in the incidence of dementia. Furthermore, this improvement in health and social care is likely to increase the duration of survival after the onset of dementia. There was heterogeneity between mortality rates across different developing countries and between rural and urban sites in the 10/66 study (Prince *et al.*, 2012). This heterogeneity suggests that, even within socio-economic less-developed countries, improvement in socio-economic status is associated with

reduced mortality in dementia. Both these factors will tend to increase the prevalence of dementia. The increased prevalence of dementia, and comparable to that in developed countries, in some Indian studies (Rajkumar and Kumar, 1996, 1998; Shaji *et al.*, 2005), Sri Lanka (De Silva *et al.*, 2003), and in some Latin American countries in the 10/66 prevalence studies (Llibre Rodriguez *et al.*, 2008) suggests that there may be an association between improved socio-economic status and increasing prevalence of dementia. Such a society could be labeled as a high prevalence and low socio-economic society.

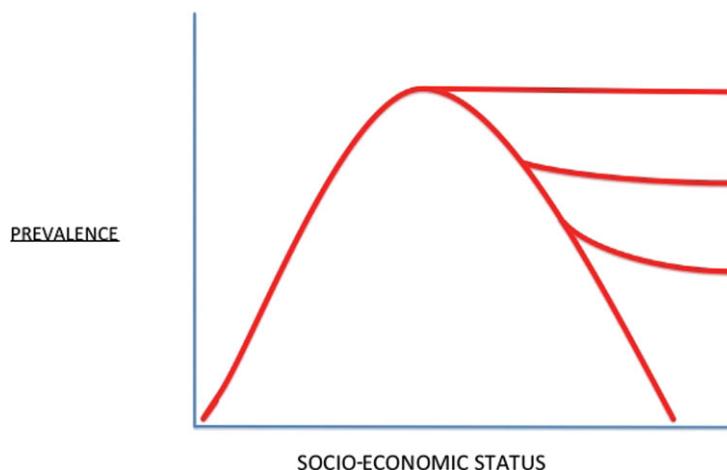
### **Stage 3. High prevalence and high socio-economic society stage**

As societies develop, they are likely to change from being socio-economically less developed to being socio-economically more developed. Further improvement in health- and social care services may facilitate further reductions in child mortality rates because of improved ability to provide primary preventative measures for diseases in childhood (e.g. immunization programs) and general population mortality rates due to treatment of diseases that are directly related to low socio-economic status (e.g. infectious diseases; Suh and Shah, 2001). This will lead to further increase in life expectancy. This, in turn, will result in increasing number of participants reaching the age of increased risk for dementia. This will also weaken any effect of selective survival of those at reduced risk of dementia due to constitutional or genetic factors. Thus, the incidence of dementia will increase. The incidence rate for DSM III R dementia was higher in Eurodem study (pooled data from Denmark, France, Netherlands, and United Kingdom; Launer *et al.*, 1999) compared to those for DSM IV dementia in the 10/66 study (Prince *et al.*, 2012). Furthermore, the improvement in the availability of health and social care is likely to increase the duration of survival after the onset of dementia. Relatively recent studies from high-income countries have reported higher survival duration than two decades ago (Williams *et al.*, 2006; Xie *et al.*, 2008). Both these factors will tend to increase the prevalence of dementia. The prevalence of dementia in high-income countries is generally higher than in low-income countries (Hendrie *et al.*, 1995; Llibre Rodriguez *et al.*, 2008). The prevalence of DSM IV dementia in a pooled study of 12 European countries (Lobo *et al.*, 2000) was higher than that observed in Latin America, India, and China in the 10/66 study (Llibre Rodriguez *et al.*, 2008). Comparatively high prevalence rates in Europe were also reported in another pooled study of 23 European data sets (Hofman *et al.*, 1991).

Such a society could be labeled as a high prevalence and high socio-economic society. It is likely that most high-income countries are currently at this stage of epidemiological transition because of reasons discussed next.

### **Stage 4. Variable prevalence and high socio-economic society stage**

Theoretically, in socio-economically well-developed societies, due to improved health and social care leading to further reduction in child mortality rates and increase in life expectancy, greater number of people would reach the age of increased risk for dementia, and consequently lead to a higher incidence of dementia. This improvement in health and social care would also increase the duration of survival after the onset of dementia. Thus, the prevalence of dementia would increase further. However, the picture in socio-economically very well-developed societies is complex because such societies are much more likely to have developed primary preventative strategies. For example, in England and Wales there is a national Dementia Strategy, which incorporates many aspects of primary prevention; similar strategies have been developed in several high-income countries. Also, primary, secondary, and tertiary prevention programs for hypertension, heart disease, cerebrovascular disease, and diabetes are much more likely to be established in socio-economically well-developed countries; these are also likely to reduce the incidence of dementia further. Thus, the incidence of dementia may be reduced further by improved efforts to control the risk factors for dementia and enhance the protective factors for dementia. For example, the prevalence of dementia was a third less, despite an increase in the prevalence of stroke, in a Swedish birth cohort of 85-year-olds compared to a birth cohort of 85-year-olds from 20 years before (Skoog, 2012). At the same time, better provision of health and social care and advances in medical care may increase the duration of survival after the onset of dementia. In this scenario, the incidence of dementia and duration of survival after the onset would have opposite effects on the prevalence of dementia. Thus, the relative balance between the amount of reduction in the incidence and the amount of increase in the duration of survival after the onset would determine whether the prevalence would decrease, remain the same, or increase. Figure 2 illustrates the possible scenarios that may occur in this fourth stage. Such a society could be labeled as a variable prevalence and high socio-economic society. This last stage for dementia differs significantly from the last stage for elderly suicides as the prevalence of dementia may



**Figure 2.** (Colour online) Variations in epidemiological transitions in dementia.

not continue to decline. It is unlikely that there are any countries at this stage of epidemiological transition in dementia.

### The relationship between age, birth cohort and period effects, and epidemiological transition in dementia

It is possible that the effects of the socio-economic status hypothesized above may operate through the independent effects of age, birth cohort membership, and the time period studied. First, improvements in socio-economic status can increase life expectancy. Second, socio-economic status can shape both the early and current collective experiences of a birth cohort. Third, the prevailing socio-economic status at the time of the study may also be important. These three factors, in turn, may influence the prevalence of dementia. Alternatively, it is also possible that the independent effects of age, birth cohort membership, and the time period of study may operate through the epidemiological transition hypothesis.

Both these hypotheses, and their inter-relationship and the direction of this relationship as applied to dementia require rigorous testing. For the epidemiological transition hypothesis, ideally, a given country should be followed up over time as the socio-economic status improves, but this is not a practical option as several decades may be needed. The alternative is to examine this hypothesis in a cross-sectional study across different countries at varying stages of socio-economic development – a model used in elderly suicides. There are mathematical models to examine the first three stages and the different scenarios in the fourth stage.

### Implications for service providers, service planners, and policy-makers

Both the hypotheses have important long-term implications for policy-makers, service providers, and service planners. These hypotheses, if substantiated, provide an evolving framework for estimating the scale of the burden of dementia over time as countries develop socio-economically. This, in turn, would allow policy-makers to develop long-term strategies that account for changes over time for primary prevention, early identification, and secondary and tertiary prevention, and treatment of dementia. Such strategies would allow service planners to constantly develop and evolve the provision of dementia services based on anticipated epidemiological changes and consequent disease burden. Moreover, service providers would have the ammunition to guide service planners, on an ongoing basis, to continually evolve the provision of services. This would enable the ambitions of the long-term strategies to become a reality. If such an ambitious longitudinal plan is not followed, the existing huge disparities across countries in the provision of services for dementia will continue and may even widen.

### Conflict of interest

None.

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